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# WestJEM

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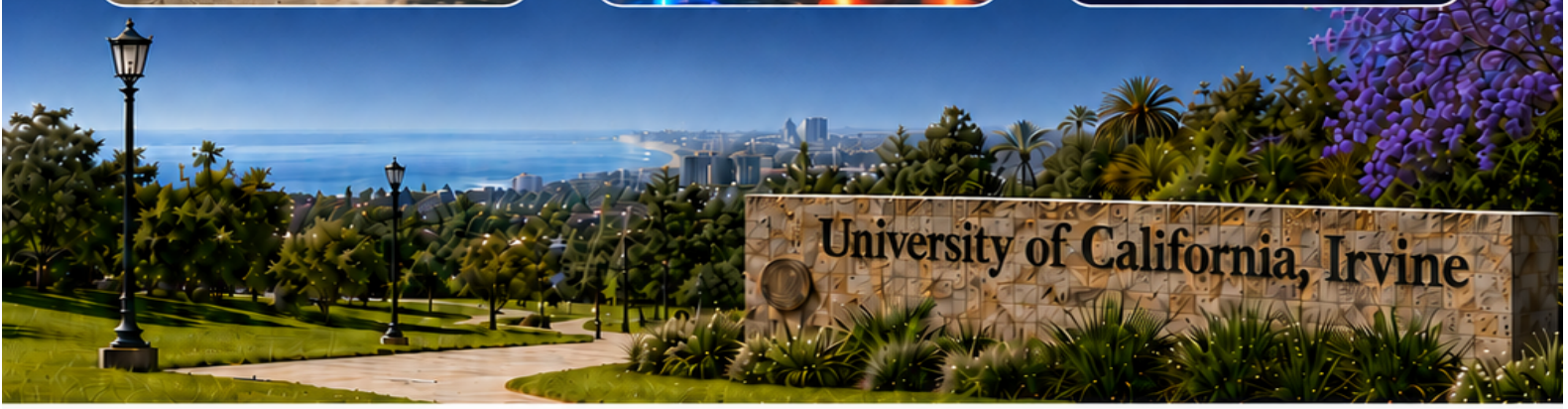


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# MEMC 2025 - Jointly Organized by the American Academy of Emergency Medicine (AAEM) and the Mediterranean Academy of Emergency Medicine (MAEM)

XIIIth Mediterranean Emergency Medicine Congress, Budapest, Hungary 14-17, August, 2025

The XIIIth Mediterranean Emergency Medicine Congress (MEMC), jointly organized by the American Academy of Emergency Medicine (AAEM) and the Mediterranean Academy of Emergency Medicine (MAEM) was held in Budapest, Hungary on August 14-17, 2025.

We strive to grow the global development of our specialty around the Mediterranean basin, and indeed around the world. We endorse physician wellness, residency training, and quality, lifelong education in emergency medicine. All patients should have access to care by qualified emergency physicians and systems of care. MEMC25 is an opportunity to share the very best practices from high-resource countries with mature systems, countries that have recently achieved specialty status, and low-resource countries delivering care even in austere environments.

Our sessions covered aspects such as acute cardiac conditions, critical care, basic and advanced ultrasound, immigrant and refugee health, tactical and military medicine, trauma resuscitation, toxicology, prehospital care systems, and much more.

The Journal of Emergency Medicine (JEM) is sponsoring the oral abstract competition, and the Western Journal of Emergency Medicine (WestJEM) is sponsoring the research poster competition. The 50 abstracts with the highest scores by the Abstract Review Committee are being published. WestJEM is publishing here the top 25 population health related abstracts, and JEM is publishing the top 25 clinical abstracts. The primary authors of the top three scoring abstracts delivered ten-minute oral presentations during the opening ceremony.

Our curriculum for the Congress is impactful to both new and seasoned physicians, residents and medical students. as well as to nurses, researchers and scientists, prehospital providers, pharmacists, nutritionists, and anyone involved in the delivery of emergency care.

We are delighted to contribute to the MEMC25 in Budapest and invite you to explore the abstracts from this historic meeting. We welcome you, your families, and colleagues to the best international conference of the year!

Mark I. Langdorf, MD, MHPE, FACEP, FAAEM
Professor of Clinical Emergency Medicine
University of California, Irvine
Editor-in-Chief, *Western Journal of Emergency Medicine*

The *Western Journal of Emergency Medicine: Integrating Emergency Care with Population Health* would like to thank the Mediterranean Academy of Emergency Medicine and the Academic Research and Educational Organization for helping to make this collaborative special issue possible.

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CPCEM Clinical Practice & Cases

# Introducing the Climate Change Special Issue

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The *Western Journal of Emergency Medicine* (*West*JEM) is pleased to present its Climate Change Special Issue. These 23 manuscripts explore how choices in emergency department (ED) operations and processes affect climate change drivers, including greenhouse gas emissions. This special issue grew out of my suggestion to Editor-in-Chief Mark Langdorf, MD, MHPE, that the journal focus on climate issues, similar to its periodic special issues on medical education. Several factors prompted this suggestion:

- In the United States, the healthcare industry contributes about 8.5% of all greenhouse gases produced in our economy.[1]
- Choices in emergency care delivery directly influence greenhouse gas production. When I first proposed this issue, I had recently served as Decision Editor for a *West*JEM manuscript quantifying how the use of reusable, sterilizable oximeter probes in the ED could favorably reduce these emissions.[2]
- When the journal issued its "Call for Papers," the American Medical Association (AMA) had already adopted at least 12 policies addressing climate change.[3] These policies include the following:
    - Policy D-135.966 (last modified in 2024) declares climate change to be a public health crisis. It further states, the AMA "will protect patients by advocating for policies that:
        - Limit global warming to no more than 1.5 degrees Celsius
        - Reduce US greenhouse gas emissions aimed at a 50 percent reduction in emissions by 2030 and carbon neutrality by 2050."
    - Policy D-440-912 (last modified in 2023) advocates for a "net zero" carbon society by 2050.
- Increased implementation of "telemedicine" since the onset of the COVID-19 pandemic has had a small but measurable and salutatory effect upon the healthcare industry's net output of greenhouse gases.

Subsequently, at the June 2026 Annual Meeting of the House of Delegates of the AMA, Resolution 404-A-26 was adopted, adding to the impetus to make climate-conscious resources more available to clinicians. Its "Resolved" clauses include the following:

- RESOLVED, that our American Medical Association support compiling and maintaining a resource for US physicians, focused on education physicians and other healthcare professionals about the health impacts of climate change and the role of the healthcare sector in contributing to greenhouse gas emissions; and be it further
- RESOLVED, that our AMA support providing practical, evidence-based recommendations for reducing the environmental footprint of clinical practices and healthcare systems; and be it further
- RESOLVED, that our AMA support offering resources and tools to support physicians in advocating for environmentally sustainable policies and practices within their organization and communities; and be it further
- RESOLVED, that our AMA facilitate collaboration and sharing of best practices among healthcare professionals and institutions committed to addressing climate change and promoting sustainability.

We hope this issue will support the AMA's goals within our emergency medicine community. Mitigating healthcare industry greenhouse gas emissions to eventually achieve carbon neutrality will require multiple strategies rather than a single "magic bullet." However, important incremental steps are already uuderway. For example, the University of California, Irvine, recently opened the first "all-electric" hospital in the United States.[4] Substantial, and perhaps surprising, progress is also occurring in emergency services delivery:

- Great Britain's National Health Service (NHS) committed to a "net-zero" carbon footprint by 2040, followed by a net-zero target for its wider supply

chain and influenced emissions by 2045.[6] As part of this initiative, the NHS is systematically phasing out emergency medical service (EMS) vehicles powered by fossil fuels and replacing decommissioned units with zero-emission models.[5]
    - While both Great Britain and the US have extensive rural areas, the British advantage lies in the fact that the NHS operates all ambulance services, compared with the "patchwork" of agencies operating in the US.
- Nonetheless, this EMS vehicle goal is being rapidly met within some British EMS systems, surprisingly in areas that are not densely populated metropolitan centers like Central London.
    - The NHS Hillingdon Hospitals, located west of London and north of Heathrow Airport, have already transitioned their EMS vehicles to 100% electrically powered.[6]
    - In Yorkshire, a largely rural northern area of the United Kingdom that also includes the cities of York and Leeds, 35 of a planned 108 renewably powered ambulances are already in service.[7]

*West*JEM's attention to climate change is not unique. As a regular reader of the *Journal of the American Medical Association,* I know that as of June 2026, *JAMA* had published at least 20 climate-related articles and news items. So, in closing, when viewed from the perspective of 2030 or even 2050, this "Special Issue" will hopefully be viewed as a vital first step taken by our emergency medicine community toward reducing our collective greenhouse gas production. As the proverb states, "A journey of 1000 miles begins with but a single step."

In that spirit, we present our Special Climate Change Issue.

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# Evaluating the Impact of a Sustainability Education Intervention on Emergency Medicine Residents

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**Introduction:** Healthcare is a significant contributor to global greenhouse gas emissions, with emergency departments being among the most resource-intensive settings. Despite increasing awareness of climate change and its health implications, structured sustainability education remains lacking in emergency medicine graduate medical education training. We evaluated the impact of a brief, educational intervention on emergency medicine (EM) residents' knowledge, attitudes, and self-reported behaviors related to sustainability.

**Methods:** We conducted a prospective pre/post interventional study at two community-based EM residency programs. Emergency medicine residents completed a baseline survey assessing sustainability-related knowledge, attitudes, and self-reported behaviors, followed by a video on sustainable clinical practice and a peer-reviewed paper on the environmental impact of inhalers. Immediate postcourse and one-month follow-up surveys were administered to evaluate short- and intermediate-term changes. Our primary outcome measure was change in sustainability-related knowledge scores. Secondary outcomes included changes in attitudes toward sustainability and self-reported sustainability-related clinical behaviors. Survey responses were analyzed using descriptive statistics, paired *t* tests and repeated-measures analysis of variance, as appropriate.

**Results:** Of 41 eligible EM residents across two residency programs, 34 completed the baseline survey (82.9%), 28 completed the immediate post-intervention survey (68.3%), and 30 completed the one-month follow-up survey (73.2%). Knowledge scores at baseline were 55.0% and increased to 68.0% immediately after the intervention ($P < .001$). At one month, knowledge scores remained higher than baseline (65.0%) ($P = .003$). Attitudes improved significantly immediately post-intervention ($P = .001$), despite already neutral-to-positive baseline levels. Two self-reported behavior items improved at one month: preferential prescribing of dry-powder inhalers, which were described in the educational materials as having less of an environmental impact than aerosolized inhalers (12.0% to 37.0%, $P < .050$) and self-reported efforts to reduce unnecessary waste (56.0% to 87.0%, $P < .050$), with overall self-reported behavior change ($P = .001$). Nebulizer-related prescribing did not significantly change. The open-ended item showed similar thematic patterns at both baseline and after one month, with most residents describing simple waste-reduction actions (eg, minimizing disposables), and no significant shift in qualitative categories.

**Discussion and Conclusion:** A brief, structured sustainability module delivered via a video format was feasible and well-received by EM residents. Preliminary data suggest improvements in knowledge, attitude, and self-reported behaviors, highlighting the potential for scalable sustainability education within graduate medical training. However, these findings should be interpreted in the context of a small sample size and self-reported outcomes. [West J Emerg Med. 2026;27(5)1118–1125.]

## INTRODUCTION

The healthcare sector accounts for nearly 9% of total greenhouse gas emissions in the United States, with hospitals and clinical care settings representing major contributors due to substantial energy demands and consumption, extensive use of supplies, and significant waste generation.[1,2] Among these settings, emergency departments (ED) are particularly resource intensive. They operate continuously and rely heavily on disposable supplies and high-emission clinical processes such as diagnostic imaging, all of which contribute substantially to healthcare-related emissions.[3,4] While the relationship between healthcare delivery and climate change has received growing attention in recent years, formalized sustainability training remains limited across undergraduate, graduate, and continuing medical education levels.[5]

Environmental sustainability in healthcare is increasingly being recognized as a core competency for health professionals.[6] Previous studies have highlighted that physicians often lack formal training on how clinical decision-making influences environmental outcomes, including emissions associated with pharmaceuticals, single-use devices, and over-used imaging.[7] Quality improvement projects in anesthesia, such as Project SPRUCE, have shown that providing educational modules, clinical decision support, and real-time feedback can lead to substantial reductions in emissions from inhaled anesthetics, with educational interventions being a key driver of sustained practice change.[8] However, few published studies have evaluated how sustainability training can be effectively integrated into the fast-paced, high-acuity environment of emergency medicine. A recent perspective from the United Kingdom highlighted growing momentum for sustainable healthcare within EM and outlined actionable strategies to improve environmental practices in EDs, including reducing the use of inhaled agents with high potential for global warming, optimizing waste segregation, and incorporating telemedicine to limit travel-related emissions.[9]

Despite these developments, a significant gap regarding the integration of formal sustainability training into U.S.-based residency programs remains. To address this gap, in this study we evaluated the feasibility of an educational intervention and its impact on EM residents' knowledge, attitudes, and self-reported behaviors as related to sustainability—delivered via a brief, video-based educational module and a peer-reviewed paper— aimed to provide foundational knowledge on the environmental impact of clinical care and encourage reflection on sustainable practices in the ED.[10, 11]

Residency training represents a particularly high-leverage opportunity, as it shapes long-term clinical decision-making patterns and practice habits.[12] Introducing sustainability concepts at this stage may facilitate early integration of environmentally conscious practices into routine care.

*Population Health Research Capsule*

What do we already know about this issue?
*Healthcare contributes significantly to greenhouse gas emissions, yet sustainability education in emergency medicine (EM) training remains limited.*

What was the research question?
*Does a brief educational intervention improve EM residents' sustainability knowledge, attitudes, and behaviors?*

What was the major finding of the study?
*Knowledge improved from 55% to 68% immediately post-intervention (P < .001) and remained higher at one month (65%, P = .003).*

How does this improve population health?
*Integrating sustainability education into residency training may promote environmentally responsible clinical practices and reduce healthcare-related emissions.*

## METHODS

### Study Design and Setting

This study was a prospective, single-arm educational intervention conducted across two community hospitals within the same hospital system in New York State. Both sites host accredited EM residency programs that share a common academic structure and didactic schedule. The study was designed to evaluate the impact of a structured sustainability education module on EM residents' knowledge, attitudes, and self-reported behaviors related to environmentally sustainable clinical practice.

### Participants

All postgraduate year (PGY) 1–3 EM residents scheduled for weekly didactic sessions during the study period were invited to participate. Participation was voluntary, and survey results were anonymous. Only residents present during the assigned educational session were eligible to complete the surveys. No identifying information was collected at any stage of the study.

### Intervention

The intervention consisted of a 60-minute video module, *Healthcare Sustainability – Transforming Clinical Practice in the Face of Climate Change*, developed by Mass General

Hospital and publicly available on YouTube[10] and an accompanying peer-reviewed paper on the environmental impact of asthma inhalers by Wilkinson and Woodcock.[11] Together, these resources provide a comprehensive overview of the environmental impact of healthcare delivery, principles of sustainable clinical decision-making, and practical strategies to reduce waste in EM. For both community hospitals, the intervention was delivered in person without additional facilitation or discussion components to ensure consistency across sites.

**Survey Instrument**

We developed a structured survey instrument and sent it electronically using REDCap (Research Electronic Data Capture) to assess participants' knowledge, attitudes, and self-reported behaviors related to environmental sustainability in healthcare. Surveys were distributed at three timepoints: baseline (preintervention); immediate postintervention; and one-month follow-up, with survey content tailored to the intervention's learning objectives and knowledge-retention assessment at each stage. Each survey began with an eligibility and consent confirmation, requiring participants to verify that they were ≥ 18 years of age and voluntarily agreed to participate. All responses were collected anonymously.

**Survey Development and Rationale**

The survey was developed to target high-yield concepts in clinical sustainability that align with the content of the educational module and with evidence-based practices in healthcare environmental impact. We selected knowledge items to address common areas of limited awareness among clinicians, including the environmental consequences of personal protective equipment selection (Q1); inhaler propellants and prescribing decisions (Q2, Q4–Q6, Q9); sterilization practices and device reprocessing (Q3, Q12, Q13); and the effects of low-value care such as unnecessary imaging or routine testing (Q7, Q14).[7] Several questions (Q10, Q15–Q17) were included to contextualize the scale of healthcare-related emissions using widely recognized benchmarks, including the Scope 1–3 framework for measuring an organization's greenhouse gas emissions in which supply-chain emissions (Scope 3) represent the dominant contributor to healthcare's carbon footprint.[13]

Certain items (eg, inhaler-related questions) were simplified for educational purposes and may not have fully captured nuances such as differences between dry-powder and metered-dose inhalers. Attitude items assessed perceived relevance, feasibility, and educational value of sustainability in EM, while behavior items captured prescribing choices, self-reported waste-reduction practices, and personal sustainability strategies. All items underwent content review by faculty members with expertise in EM and sustainability to ensure clarity and alignment with the intervention's learning objectives.

**Baseline Survey**

The baseline survey collected demographics (PGY level, sex, additional academic degrees, and age), 17 knowledge items, eight attitude items, and four behavior items, including one open-ended question regarding personal sustainability practices.

**Immediate Postintervention Survey**

The immediate postintervention survey repeated the knowledge and attitude items verbatim from the baseline survey to measure short-term learning gains and attitudinal shifts following the educational module. Behavioral questions were excluded at this stage as meaningful changes in clinical practice behavior require time to develop.

**One-Month Follow-Up Survey**

The one-month survey included brief demographic verification (PGY level and sex) to confirm respondent consistency and repeated the knowledge and behavior domains to assess retention of learning and translation into self-reported clinical practice changes after one-month postintervention. At one month, behavior items, which reflect the downstream application of attitudes, were prioritized over repeating attitudinal questions.

**Scoring**

We calculated knowledge scores as the percentage of correct responses. Attitude items were summarized using mean Likert values per item, and behavioral responses were reported as categorical frequencies. For graphical visualization, Likert responses (1–5) were converted to a normalized 0–1 scale. Open-ended responses were reviewed qualitatively to identify recurring sustainability themes.

**Data Collection**

Surveys were distributed and completed through a REDCap link. The baseline survey was administered immediately prior to the video session, the postintervention survey immediately afterward, and the one-month survey distributed via email reminder. Responses were automatically stored in REDCap and exported for analysis.

**Statistical Analysis**

The primary outcome was change in sustainability-related knowledge scores across time points. Secondary outcomes included changes-in-attitude composite scores and self-reported sustainability-related behaviors. All analyses were performed in Python v3.11 (Python Software Foundation, Wilmington, DE). Descriptive statistics were used to summarize demographic data and response distributions. Repeated measures analysis of variance was used to evaluate changes in knowledge across the three time points (baseline, immediate, one month), followed by Bonferroni-adjusted paired *t*-tests when the omnibus test was significant. Paired

*t*-tests were used to compare attitude scores between baseline and immediate post-intervention. Behavioral outcomes measured at baseline and one month were analyzed using paired *t*-tests and the McNemar test for paired categorical variables. A two-tailed $P < .050$ was considered statistically significant.

Effect sizes (Cohen *d*) were calculated for primary comparisons to provide estimates of magnitude of change.

### Ethical Considerations

This study was reviewed and approved by the institutional review board (IRB-2026-355) and deemed exempt under educational quality-improvement criteria. Because all data were collected anonymously and no patient-level information was used, separate IRB review by the participating EM training sites was not required. All identifying information was removed to maintain double-blinded peer review per journal requirements.

## RESULTS

Of 41 eligible EM residents across two programs, 34 completed the baseline survey (82.9% response rate), 28 completed the immediate postintervention survey (68.3%), and 30 residents completed the one-month follow-up survey (73.2%), reflecting variation in participation across time points due to attendance and follow-up survey completion. Baseline demographic information, including postgraduate year level, sex, and additional academic degrees, is presented in Table 1.

### Knowledge Results

Seventeen multiple-choice and true/false questions assessed residents' knowledge of sustainability in healthcare. The mean percentage of correct responses increased from 55.0% at baseline to 68.0% immediately postintervention, corresponding to a large effect size (Cohen *d* =. 1.048) (Figure 1). At the one-month follow-up survey, the average percentage of correct responses was 63.0%, with a similarly large effect size compared to baseline (Cohen $d = 0.988$), indicating sustained improvement over time. The small negative effect size between immediate and one-month follow-up (Cohen $d = -0.253$) suggests slight attenuation over time, although the overall effect remained substantial. Detailed item-level data are presented in Supplemental Table S1, and a concise summary of the most notable item-level changes is provided here to contextualize the overall score trends.

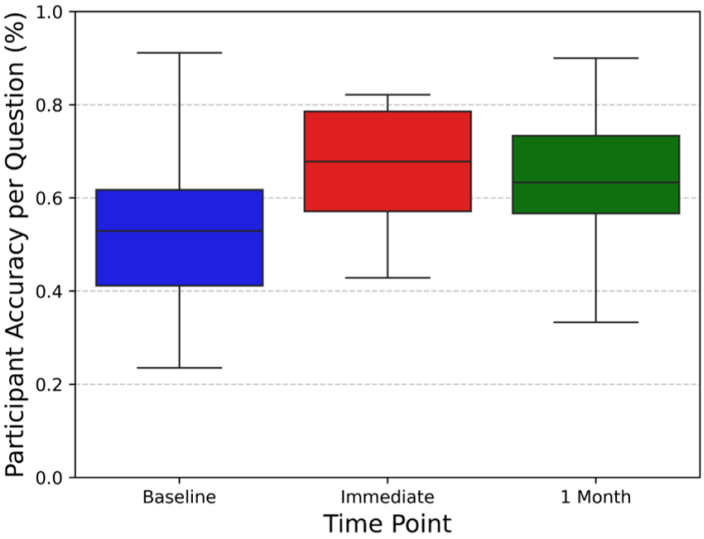


**Figure 1.** Overall score trends following a brief educational module on sustainable clinical practice delivered in two community-based emergency medicine residency programs.

Across 17 items, several domains demonstrated statistically significant improvements. Notably, significant increases from baseline to immediate postintervention surveys were noted in the knowledge of hospital emission sources (Q10), sterilization hazards (Q12), and the relative magnitude of healthcare-associated pollution harm (Q15) ($P < .001$, $P = .020$, and $P = .009$, respectively), with gains in knowledge maintained at one month in the same three domains ($P = .030$, $P = .010$, and $P = .040$). Awareness of the global ranking of healthcare emissions (Q17) also improved significantly at one month compared with baseline ($P = .040$). A single item related to life-cycle analysis (Q13) showed a modest decline from immediate to one-month follow-up ($P = .050$). All other items demonstrated non-significant differences across time points ($P > .050$), indicating stable retention for most concepts.

**Table 1.** Demographic characteristics of emergency medicine residents who completed the baseline survey before participating in a sustainability education intervention in a study of sustainability training.

| Characteristic | Category | N = 34 (%) |
|---|---|---|
| PGY level | PGY-1 | 14 (41.2%) |
| | PGY-2 | 14 (41.2%) |
| | PGY-3 | 6 (17.6%) |
| Gender | Male | 22 (64.7%) |
| | Female | 12 (35.3%) |
| | Non-binary / prefer not to say | 0 (0.0%) |
| Additional degrees | Yes | 14 (41.2%) |
| | No | 20 (58.8%) |

*PGY,* postgraduate year.

### Attitude Results

Eight Likert-scale items (1 = strongly disagree to 5 = strongly agree) assessed residents' attitudes toward sustainability in EM at baseline (N = 34) and immediately postintervention (n = 28). Median scores across all items

ranged from 3 ("neutral") to 4 ("agree"), reflecting generally neutral-to-positive attitudes prior to the intervention. When attitude items were averaged into a composite score, residents demonstrated a statistically significant improvement immediately postintervention ($P = .001$), as shown in Figure 2.

Despite this overall increase, item-level analyses did not show statistically significant changes, with most items exhibiting small directional shifts toward greater agreement, particularly regarding the importance of sustainability in clinical care and interest in further learning. Agreement with the negatively worded item assessing perceived impracticality of sustainability in the ED decreased slightly, indicating a modest shift toward lower agreement with the impracticality statement. These item-level findings are presented in Supplementary Table S2.

**Self-Reported Behavior Results**

Three self-reported behavior items were assessed at baseline and at the one-month follow-up. A paired *t*-test comparing overall self-reported behavior scores demonstrated a statistically significant improvement from baseline to one month ($P = .001$) consistent with the differences illustrated in Figure 3.

Two items showed significant change. Residents were more likely to report that they would preferentially prescribe dry-powder inhalers over metered-dose inhalers at one month (12.0% versus 37.0%; $P < .050$), and significantly more residents reported actively trying to reduce unnecessary waste in their clinical practice (56.0% versus 87.0%; $P < .050$). No significant change was observed in preferences for prescribing a nebulizer over an inhaler.

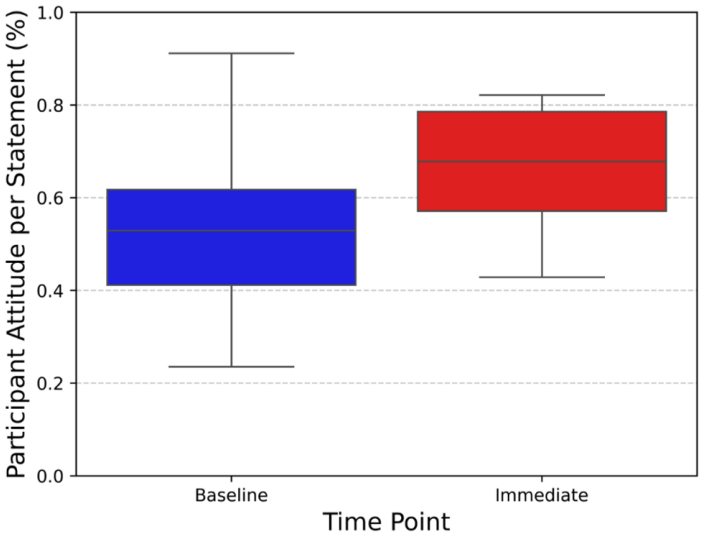


**Figure 2.** Shifts in perceptions of the importance, feasibility, and relevance of environmental sustainability in clinical practice among emergency medicine residents.

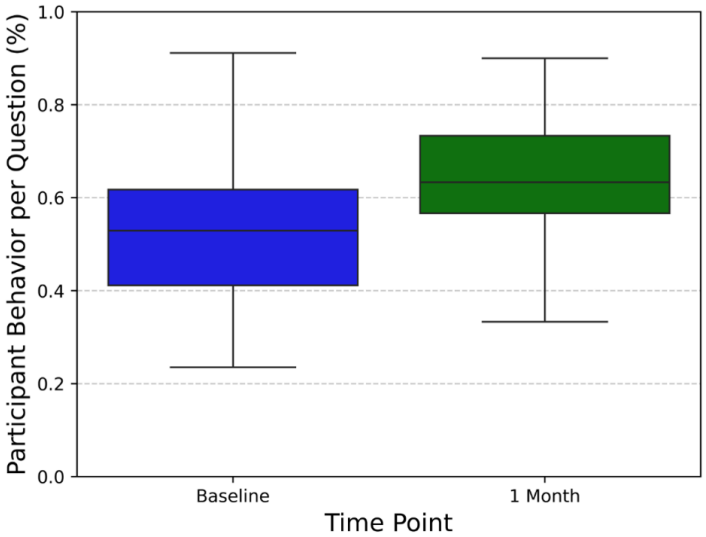


**Figure 3.** Changes in sustainability-related clinical behaviors following a brief educational intervention among 34 emergency medicine residents.

For the open-ended item, thematic patterns remained stable. "Reduce" was the most common response at both time points (50.0% baseline; 60.0% one month), followed by smaller proportions referencing reuse strategies or describing tension between sustainability and patient care. The proportion of noninformative responses remained unchanged. All behavior results, including thematic frequencies, are summarized in Table 2.

## DISCUSSION

This study evaluated the impact of an educational intervention on EM residents' knowledge, attitudes, and self-reported behaviors related to environmentally sustainable clinical practice. Sustainability remains largely absent from traditional EM training, despite healthcare's substantial contribution to greenhouse gas emissions and growing national calls for climate-conscious clinical decision-making.[9] Our findings demonstrate that residents' attitudes toward sustainable practices, while already generally neutral to positive at baseline, showed a significant improvement immediately after the intervention. This attitudinal shift corresponded with meaningful changes in self-reported sustainability-related behaviors at one month. A low-burden, single-session module can meaningfully improve residents' understanding of key sustainability concepts and influence an intention to change certain practice behaviors, even within the constraints of a busy residency curriculum.

Residents demonstrated meaningful improvements in sustainability-related knowledge immediately following the intervention, with overall retention at one month. The strongest gains occurred on question items addressing hospital

**Table 2.** Item-level self-reported sustainability behaviors at baseline and one-month follow-up of emergency medicine residents after completing a sustainability education module.

| Question | Behavior item | Baseline % (N = 34) | 1-Month % (n = 30) | Significance |
|---|---|---|---|---|
| Q.1 | Preferentially prescribe DPI over MDI (Yes) | 12% | 37% | $P < .050$ |
| Q.2 | Preferentially prescribe nebulizer over inhaler (Yes) | 26% | 40% | ns |
| Q.3 | Actively try to reduce unnecessary waste (Yes) | 56% | 87% | $P < .050$ |
| Q.4 | Sustainability practices (open-ended) | | | |
| | • Reduce | 50% | 60% | n.s. |
| | • Reuse/Recycle | 12% | 7% | |
| | • Tension/Impact on patient care | 9% | 7% | |
| | • Not Informative | 29% | 33% | |

*DPI,* dry-powder inhaler; *MDI,* metered-dose inhaler; *ns,* nonsignificant.

emission sources, sterilization safety, and healthcare's contribution to pollution, concepts that are rarely emphasized in EM training and are generally unfamiliar to clinicians.[4] These findings suggest that brief, structured instruction can effectively close foundational knowledge gaps, particularly in domains lacking clinical exposure or experiential reinforcement. The question item addressing the understanding of Scope 3 emissions—the indirect, supply-chain emissions that make up most of the healthcare's carbon footprint—also improved.[13] In contrast, Scope 1 (direct emissions from onsite fuel use) and Scope 2 (indirect emissions from purchased electricity) represent a much smaller share of total healthcare emissions.[13] Notably, increased awareness of the disproportionate impact of Scope 3 emissions is particularly relevant to everyday decision-making in the ED, where equipment, pharmaceuticals, and disposables contribute to the overall environmental impact. Knowledge gains that persisted at one month further support the durability of the intervention and reinforce the value of integrating sustainability content into formal resident education.

Residents' attitudes toward sustainability were generally neutral to positive at baseline, typically 3–4 on a five-point Likert scale and demonstrated a statistically significant improvement immediately postintervention. Although the median Likert values shifted only modestly, the paired statistical comparison showed consistent upward movement across multiple attitude items, reflecting a meaningful attitudinal shift despite a relatively high baseline starting point. Such ceiling effects can partially mask visible changes and limit the measurable impact of a single educational exposure, particularly when learners already agree with the underlying concepts. Prior research consistently shows shifting attitudes to be more resistant to change than improving knowledge or self-reported behaviors, often requiring repeated reinforcement, hands-on experience, or institutional cues to produce measurable movement.[14] The small directional shifts toward greater agreement, particularly regarding the importance of sustainable practice and the desire to learn more, may suggest ongoing receptivity and potential for cumulative change with repeated or more immersive educational touchpoints.

Self-reported behaviors were also evaluated in this study. Two of the three self-reported behavior items demonstrated significant improvement at one month, underscoring the practical impact of the intervention. Residents became more likely to preferentially prescribe dry-powder inhalers over metered-dose inhalers and more frequently reported actively attempting to reduce unnecessary waste in their clinical practice. These findings reflect shifts in clinical practice, highlighting the importance of education and its ability to translate into modifiable and actionable habits. The lack of change in nebulizer versus inhaler prescribing is unsurprising, as this decision is typically driven by patient acuity, airway dynamics, and institutional protocols rather than physician preference.[15] Overall, the observed behavior changes suggest that brief, targeted education can influence day-to-day decision-making in the ED, even in the absence of broader structural or policy modifications.

These findings align with emerging literature demonstrating that targeted educational interventions can improve sustainability-related knowledge and clinical decision-making in other specialties, particularly anesthesia and perioperative care.[16] Prior initiatives, such as the adoption of low–global warming potential anesthetic agents or waste-reduction programs in operating rooms, have similarly shown that clinicians respond positively to structured, evidence-based sustainability training.[17] However, published data within EM remains limited. Existing literature consists largely of conceptual reviews, case examples, and proposed frameworks rather than evaluated interventions with measurable outcomes, as reflected in prior reviews identifying a gap in the EM evidence base and calling for further research to inform

practice.[9] By providing quantitative evidence that a brief, scalable module can meaningfully improve knowledge, enhance EM residents' attitudes toward sustainable healthcare, and influence practice behaviors among them, this study fills an important gap and supports the feasibility of incorporating sustainability education into routine residency training.

The observed improvements in knowledge, attitude and the reported practice behaviors of residents highlight the feasibility of integrating sustainability content into EM education with minimal disruption to existing curricula. Because the intervention used freely available, asynchronous materials, it represents a low-cost and easily scalable approach that residency programs can adopt as part of didactics, onboarding, or annual competency training. The findings also underscore the potential for sustainability principles to become embedded within routine clinical decision-making when learners are provided with clear, actionable guidance. As hospitals increasingly aim to reduce their environmental footprint, aligning resident education with institutional sustainability initiatives may further reinforce behavior change and promote a consistent culture of resource stewardship across emergency care settings.

## LIMITATIONS

This study has several limitations. It was conducted within a single hospital system, which may limit generalizability to other EM programs with different resources, workflows, or institutional cultures. Participation was based on attendance at scheduled didactics, creating potential selection bias and modest sample sizes at each time point. Although response rates were modest, this is consistent with survey-based research among medical trainees. Importantly, response rate alone does not necessarily indicate nonresponse bias, as nonresponse bias depends on whether the characteristics or opinions of nonrespondents differ meaningfully from those of respondents. Prior work has demonstrated that response rate and nonresponse bias are related but distinct constructs and that low response rates do not inherently invalidate survey findings in medical education research.[18] Sex-stratified analyses were not performed because differences by sex were not hypothesized; however, the study included both male and female residents.

Behavioral outcomes were self-reported and may not fully reflect objective practice patterns. The survey instrument was developed for this project and was not previously validated, which may limit the precision and interpretability of the knowledge, attitude, and behavior measures. Additionally, the one-month follow-up period limits insight into long-term retention or sustained self-reported behavior change. Furthermore, the intervention consisted of a single, standalone video module and a peer-reviewed paper without facilitated discussion or reinforcement, which may explain the modest improvement of attitude scores and highlight the need for more longitudinal curricula. Despite these limitations, the study provides early, quantitative evidence supporting the feasibility of sustainability-focused education in EM.

## CONCLUSION

A brief educational intervention was associated with improvements in emergency medicine residents' knowledge of healthcare sustainability, strengthened their attitudes toward environmentally responsible clinical care, and influenced key self-reported clinical behaviors. These findings demonstrate that sustainability education can be feasibly integrated into existing residency training using low-cost, scalable materials. As healthcare systems increasingly pursue environmental accountability, incorporating structured sustainability curricula into EM training may help prepare future clinicians to make informed, environmentally conscious decisions in everyday practice. Future studies should evaluate multicenter implementation, objective measures of behavior change, and the impact of repeated or longitudinal educational exposure.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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# Climate Change and Heat-related Illness in Older Adults: Implications for Emergency Medicine

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Climate change is increasing the frequency, duration, and intensity of extreme heat events, creating a growing public health threat for older adults. Age-related physiologic decline, comorbid chronic diseases, polypharmacy, and social vulnerability all contribute to reduced heat tolerance and higher rates of heat-related morbidity and mortality. Emergency departments (ED) are increasingly encountering older adults presenting with minor heat illness, heat stroke, and exacerbations of chronic illnesses triggered by heat exposure. This review synthesizes current evidence describing why older adults are disproportionately affected by extreme heat, highlights key social and environmental determinants of vulnerability, and outlines clinical and public health strategies that emergency clinicians and EDs can assist with to reduce risk. As global temperatures rise, proactive prevention, early recognition, and coordinated community interventions are essential to protect this high-risk population. [West J Emerg Med. 2026;27(5)1126–1130.]

## INTRODUCTION

Climate change has led to a rise of 1.5 ºC in mean global temperature since the Industrial Revolution, with projected increases of 2.5-2.9 ºC by the end of this century[1] and is accelerating the burden of heat-related illness worldwide, with older adults among the most affected. Rising average temperatures and more frequent, severe, and prolonged heat waves have led to marked increases in heat-related morbidity and mortality. The majority of deaths due to heat waves globally are in those > 65 years of age.[2] In adults ≥ 65 years, heat-related deaths have risen by more than 50% in the past two decades, with climate change accounting for a substantial share of warm-season mortality.[3,4] In the United States, those > 65 years of age account for 40% of all heat-related deaths.[5] In addition, older individuals are likely to constitute a higher percentage of the population, with those at least 69 years old projected to increase from 11% in 2024 to 17% in 2050. This population is particularly concentrated in the Northeast, Midwest, and South Atlantic.

Shared socioeconomic pathways are climate-population scenarios used to project how demographic change, economic development, and inequality may influence future heat exposure and health risk.[6] In this context, these models suggest that older adults, particularly those with medical comorbidity, limited resources, or reduced access to cooling, will face progressively greater heat exposure and heat-related health consequences over time.[4,7-10] For emergency clinicians, the relevance of these models is that they anticipate a growing number of older adults at risk for heat-related illness and heat-triggered exacerbations of chronic disease, underscoring the need for improved recognition, prevention, and systems-level preparedness.[11]

Older adults face unique vulnerabilities due to impaired thermoregulation, higher rates of chronic disease, polypharmacy, and use of medications that impair heat dissipation, reduced physiologic reserve, and social factors such as isolation mobility issues that limit access to cooling resources.[12,13] The emergency department (ED) is often the first point of contact for patients experiencing heat-related illness or exacerbations of heat-sensitive conditions. This review summarizes the physiologic, pharmacological, environmental, and social contributors to heat vulnerability in older adults and provides guidance for emergency clinicians caring for this growing at-risk population.

## PHYSIOLOGIC AND PHARMACOLOGIC VULNERABILITY OF OLDER ADULTS

Aging significantly reduces the body's ability to thermoregulate. Older adults experience diminished sweat

production, reduced skin blood flow, impaired cardiovascular responses, and decreased renal concentrating ability, all of which contribute to heat retention.[14,15] Additionally, older adults underestimate their vulnerability to extreme heat.[15]

Comorbidities common in older age, such as cardiovascular disease, diabetes, chronic kidney disease, chronic respiratory illness, obesity, and dementia, further limit thermoregulatory efficiency and increase the risk of dehydration, hypotension, and organ dysfunction during heat exposure.[13,16] Heat exposure not only causes classic heat-related illnesses but also exacerbates underlying chronic conditions, such as diabetes, hypertension, chronic kidney disease, and cardiovascular disease, increasing the risk of hospitalization and death. Studies consistently report an increase in cardiovascular and respiratory mortality in elderly persons during hot days.[17]

Polypharmacy is another major driver of vulnerability. Frequently prescribed medications, including diuretics, beta-blockers, calcium channel blockers, anticholinergics, antipsychotics, antihistamines, and antidepressants, can impair sweating, alter fluid balance, blunt cardiovascular compensation, or affect cognitive awareness, thereby increasing susceptibility to heat-related illness.[8,18-21]

Taken together, age-related physiologic decline, chronic medical conditions, and medication effects substantially elevate the risk of heat exhaustion, heat stroke, and decompensation of existing illnesses during extreme heat events. Key physiologic changes and medication classes that increase heat vulnerability in older adults are summarized in Table 1.

Population Health Research Capsule

What do we already know about this issue?
*Older adults account for most heat-related deaths due to impaired thermoregulation, chronic disease, medications, and social vulnerability.*

What was the research question?
*Why are older adults especially vulnerable to extreme heat, and what can EDs do to reduce risk?*

What was the major finding of the study?
*Heat-related deaths in adults ≥65 years increased >50% over two decades.*

How does this improve population health?
*Identifies prevention, early recognition, and community interventions to reduce heat-related illness and death in older adults.*

## ENVIRONMENTAL AND SOCIAL DETERMINANTS OF HEAT VULNERABILITY

Heat risk in older adults is strongly shaped by environmental, demographic, and socioeconomic factors. Individuals living in poverty or on fixed income, in older housing without air conditioning, or neighborhoods with dense infrastructure and minimal green space (known as urban heat islands) face disproportionate exposure to extreme heat.[5,19] Additionally, older Americans living in northern cities may be particularly vulnerable to the effects of heat waves due to the relative lack of acclimatization and air conditioning.[22] Geographic "hotspots" where older Americans may be sensitive are the deep South and upper Midwest.[11]

Social isolation, limited mobility, and lack of access to transportation or community cooling centers further increase vulnerability; in fact, isolation has been identified as a key risk factor for death during extreme heat events.[23] Those living in isolation, especially with cognitive impairments, may not receive or understand the severity of emergency information. Marginalized racial and ethnic groups face additional risk due to structural inequities, including limited access to healthcare, fewer cooling resources, and residence in hotter urban microclimates.[8]

These intersecting vulnerabilities amplify the likelihood of heat-related hospitalizations and deaths in older populations. Recognizing these social and environmental risks is essential for effective prevention and targeted outreach during heat waves.

## CLINICAL IMPLICATIONS FOR EMERGENCY MEDICINE

Clinical implications of extreme heat for emergency medicine include both system- and department-level, and patient-level considerations. Associations between extreme heat events and increases in ED visits and hospitalization are well documented. One study noted an increase of nearly 8% in the relative risk for ED visits for any cause, equating to 24 excess visits per 100,000 persons at risk per day.[24] An analysis of approximately 50 million summertime admissions showed an increased rate of admission correlating to increases in daily maximum heat index across the U.S.[25] Mortality also increases with significant heat events, with high ambient temperatures and multiple heat waves causing an estimated 61,000 heat-related deaths in Europe in 2022.[26]

Clinically, older adults often present with atypical or subtle manifestations of heat-related illness. Confusion, weakness, decreased oral intake, falls, syncope, or worsening of chronic conditions may precede classic symptoms such as hyperthermia or anhidrosis; additionally, classically described features, such as anhidrosis, are not always present. The symptoms often overlap with or occur simultaneously with other common conditions, such as sepsis. During heat waves, emergency physicians should maintain a high index of suspicion, particularly in patients with known comorbidities or those taking heat-sensitive medications that increase the risk of heat illness.

**Table 1.** Physiologic and pharmacologic factors contributing to heat vulnerability in older adults.

| Category | Factor | Mechanism | Emergency medicine relevance |
|---|---|---|---|
| Physiologic factors | Diminished sweat production | Reduced evaporative cooling | Higher risk of heat retention and delayed heat dissipation |
| | Reduced skin blood flow | Impaired peripheral vasodilation limits heat transfer to skin | Less effective thermoregulation during heat exposure |
| | Impaired cardiovascular response | Reduced cardiac reserve limits circulatory compensation | Greater risk of hypotension, syncope, and decompensation |
| | Decreased renal concentrating ability | Reduced ability to conserve water and maintain fluid balance | Increased risk of dehydration, electrolyte abnormalities, and acute kidney injury |
| | Reduced physiologic reserve | Lower tolerance for thermal stress | More rapid deterioration with modest heat exposure |
| | Chronic comorbid disease | Cardiovascular, metabolic, renal, pulmonary, and cognitive disease may impair adaptation to heat | Higher risk of atypical presentation, delayed recognition, and worse outcomes |
| Pharmacologic factors | Diuretics | Increase fluid loss and electrolyte derangements | Higher risk of dehydration, hypotension, and acute kidney injury |
| | Beta-blockers | Blunt cardiovascular compensation | Reduced physiologic response to heat stress |
| | Calcium channel blockers | May impair hemodynamic adaptation | Possible worsening of heat-related instability |
| | Anticholinergics | Decrease sweating | Impaired heat dissipation and greater overheating risk |
| | Antipsychotics | Disrupt thermoregulation and cognition | Delayed recognition and more severe presentation |
| | Antihistamines | May impair sweating and cause sedation | Reduced symptom awareness and heat tolerance |
| | Antidepressants | May alter sweating, cognition, or fluid balance | May contribute to subtle or mixed presentations |

Rapid assessment, including accurate core temperature measurement and prompt management such as active cooling, volume resuscitation, electrolyte correction, and careful review of medications, are critical to preventing progression to heat stroke and multiorgan dysfunction. Acute mild and moderate heat-related illnesses include heat rash (pruritic papules resulting from blocked eccrine sweat glands), heat cramps (painful involuntary muscle cramping resulting from sweating-induced dehydration and electrolyte imbalances), heat edema (which may occur in the hands and feet), heat syncope (generally associated with prolonged standing or a change to a standing position in the setting of hot temperatures), and heat exhaustion. Heat exhaustion typically presents as weakness, dizziness, nausea, headache, and muscle cramps, with heavy sweating and rapid pulse evident; the core body temperature may be elevated, but mental status remains normal. Heat stroke is a severe form of heat illness, in contrast to heat exhaustion, involves alterations in central nervous system functioning in association with a core body temperature exceeding 40 °C. Heat stroke is a true medical emergency and can rapidly progress to multiorgan failure and death. Recent clinical reviews provide an excellent summation of the full spectrum of heat-related illnesses, associated medications effects, and evidence-based treatment approaches.[3,18] The clinical presentation and treatment of heat illness, from mild heat edema and heat syncope to heat exhaustion and the more severe heat stroke, should be familiar to all emergency clinicians.

Emergency clinicians also play a role in prevention by educating patients and caregivers, identifying those at risk for recurrent heat-related illness, and coordinating with outpatient clinicians and community resources. Emergency physicians can specifically provide information on cooling centers and discuss the risks and benefits of certain medications during heat waves. Common and atypical presentations of heat-related illness in older adults, along with a high-level emergency department approach, are summarized in Table 2.

## PREVENTION AND PUBLIC HEALTH STRATEGIES

Heat-related illnesses in older adults are highly preventable. Effective strategies include anticipatory guidance before heat waves, early warning systems, accessible cooling centers, home air-conditioning assistance, and social outreach programs that check on isolated older adults during periods of extreme heat.[16,19,20]

**Table 2.** Heat-related illness in older adults: common presentations and emergency department approach.

| Category | Typical features in older adults | Emergency department approach |
|---|---|---|
| Atypical early presentation | Confusion, weakness, decreased oral intake, falls, syncope, or worsening of chronic disease; classic findings such as anhidrosis may be absent | Maintain high suspicion during heat events, especially in patients with comorbidities or heat-sensitive medications; obtain accurate core temperature and assess volume status, electrolytes, and end-organ injury |
| Heat rash / heat edema / heat cramps | Pruritic rash, dependent swelling, painful muscle cramping | Supportive care, cooling, oral or IV hydration as needed, and correction of electrolyte abnormalities |
| Heat syncope | Brief loss of consciousness or presyncope, often after prolonged standing or abrupt standing in hot conditions | Supine positioning, cooling, hydration, and evaluation for alternative or concurrent causes of syncope |
| Heat exhaustion | Weakness, dizziness, nausea, headache, muscle cramps, heavy sweating, tachycardia; temperature may be elevated, but mental status remains normal | Remove from heat, active cooling, fluid resuscitation, electrolyte correction, medication review, and reassessment for progression |
| Heat stroke | Core temperature typically > 40 °C with altered mental status or other CNS dysfunction; may rapidly progress to multiorgan failure | Immediate emergency treatment with rapid cooling, aggressive supportive care, resuscitation, and close monitoring for organ dysfunction |
| Exacerbation of chronic illness | Decompensation of cardiovascular, renal, respiratory, or metabolic disease during heat exposure | Evaluate for concurrent heat-related illness while treating the underlying exacerbation; review contributing medications and disposition carefully |
| Disposition and prevention | Older adults may remain vulnerable after apparent stabilization | Provide counseling on hydration, medication risks, early symptoms, and avoidance of peak heat; connect patients and caregivers with cooling centers and community resources |

*CNS*, central nervous system; *IV*, intravenous.

Clinicians can help reduce risk by reviewing medications during hot weather, encouraging adequate hydration, promoting awareness of early heat illness symptoms, and advising patients to avoid outdoor or strenuous activities during peak heat hours. In addition, media interviews with emergency clinicians are a frequent request during heat spells and can be effective at reaching older audiences over a large local area. Furthermore, emergency physicians can provide knowledge of local resources, such as location of cooling centers, during heat waves.

Partnerships between EDs, public health agencies, emergency medical services, and community organizations are essential to building climate resilience and protecting vulnerable older adults.

## CONCLUSION

Older adults face disproportionate and growing risks from climate change-related heat exposure. Physiologic decline, chronic medical illness, medication effects, and social vulnerability all contribute to increased susceptibility to heat-related morbidity and mortality. Emergency clinicians are uniquely positioned to recognize at-risk individuals, initiate timely management, and support prevention efforts. As climate change accelerates, integrating heat-risk awareness into emergency care and collaborating with public health systems will be crucial to safeguarding the health of the growing demographic of older adults.

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# Implementation Science to Advance Equity in Climate-Driven Disaster Response

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Climate hazards are causing increasingly frequent and severe disasters. The populations most impacted by the health and social costs of disasters include language minorities, displaced individuals, and low-income communities. This commentary explores three key issues. First, climate hazards lead to displacement and increase vulnerability by disrupting housing, livelihoods, and access to care. Second, current emergency and disaster frameworks often overlook equity in communication, access to care, and recovery. Third, practical solutions can prioritize equity across mitigation, preparedness, response, and recovery. We review evidence on climate displacement, legal protections, and the roles of the health system. We highlight recurring operational opportunities, such as language access, navigation barriers, and fragmented recovery efforts. We also propose feasible strategies aligned with implementation science, including multilingual warning systems, interpreter-ready triage, mobile clinics, community health worker networks, simplified recovery navigation, and policy changes to reduce documentation barriers. This commentary aims to help emergency leaders, public health agencies, and community partners turn intentions into measurable, sustainable equity improvements. Prioritizing language access and legal realities in disaster planning can reduce preventable health issues and accelerate recovery for groups most affected by climate change. [West J Emerg Med. 2026;27(5)1131–1140.]

## INTRODUCTION

Climate change acts as a threat multiplier. It accelerates global temperature rise and increases the frequency, severity, and unpredictability of climate-driven hazards with a disproportionate impact on language minority, immigrant, and low-income populations (Table 1).[1–7] Elevated risks of morbidity stem from structural vulnerabilities, such as substandard housing and limited access to health care, often worsened by pre-existing medical conditions, all of which increase exposure to disasters, escalate health impacts, and diminish recovery capacity.[8,9] The Global South and underserved populations in high-income countries face amplified physical health burdens and mental health strains postdisaster, worsened by environmental injustice and weak adaptive infrastructure.[10–12] Without deliberate, equity-centered adaptation, the climate may amplify health inequities and deepen systemic vulnerabilities as extreme weather intensifies.

The human toll of increased frequency and severity of disasters is not shared equally. International standards, such as the United Nations (UN) Guiding Principles on Internal Displacement and the Global Compact for Safe, Orderly, and Regular Migration, affirm the right to protection and

nondiscrimination in humanitarian response.[13] Despite these commitments, many international and domestic disaster management systems lack explicit operational safeguards to ensure equity in communication, shelter access, medical care, and long-term recovery support.[14–18] Existing policies often address vulnerability in general terms but fail to account for the intersecting effects of language, displaced status, and socioeconomic marginalization. This commentary aims to discuss how climate change drives displacement and entrenches vulnerability, identify structural inequities within current disaster systems, and explore scalable, equity-focused innovations for preparedness, response, and recovery.

In this commentary, "language minority" refers to populations whose preferred language differs from that of the dominant social group, including those with limited English proficiency and multilingual communities worldwide. The term "displaced people" includes both refugees who cross international borders and internally displaced persons who remain within their country of origin. Finally, "climate migrants" are those forced to move due to environmental changes that make their home regions uninhabitable or unsafe. While our discussions draw examples from both global and United States (U.S.) contexts, the analysis centers on lessons relevant to emergency medicine, public health, and policy leaders who design or implement disaster response systems. This commentary seeks to inform a cross-disciplinary audience on how implementation science can strengthen equity across all phases of climate-related disaster preparedness and response by bridging humanitarian definitions with operational realities.

*Population Health Research Capsule*

What do we already know about this issue?
*Climate disasters disproportionately harm language minority, displaced, and low-income communities, yet equity remains inconsistently integrated into disaster response.*

What was the research question?
*How can implementation science help build more equitable climate disaster preparedness, response, and recovery?*

What was the major finding of the study?
*PRISM and RE-AIM offer a practical framework to integrate equity into disaster planning and implementation.*

How does this improve population health?
*An implementation science approach may strengthen equitable disaster systems by improving communication, access to care, and recovery for vulnerable populations.*

## CLIMATE AND DISPLACEMENT

Climate-related disasters are no longer seasonal anomalies but recurring crises that erode community resilience and cause large-scale displacement. According to the Internal Displacement Monitoring Centre, sudden-onset weather events internally displaced more than 26.4 million people within their countries in 2023 alone, and projections from the World Bank suggest that by 2050, over 216 million people could be forced to move within their countries due to climate-related impacts.[19–21] Rising sea levels, for example, are gradually making coastal areas uninhabitable and threatening entire island nations, while persistent droughts, aridity, and intensifying wildfire seasons are displacing millions globally and in the U.S.[22–24] Drought also fuels both rural depopulation and political instability, and extreme storms trigger mass evacuations.[25,26] This sustained and repeated displacement creates prolonged recovery cycles, destabilizes local economies, and undermines long-term adaptation capacity, making climate-linked migration one of the defining humanitarian and policy challenges of this century.

Structural inequities in housing, labor, and access to services often place low-income, at-risk of displacement, and language minority populations in areas most exposed to environmental risk.[12] For example, dense urban areas often amplify heat exposure via the urban heat island effect.[27] At the same time, low-lying coastal or floodplain housing is subject to recurring inundation and storm damage.[28–30] These communities are further disadvantaged by limited adaptive capacity, including inadequate insurance coverage, limited financial reserves, and restricted mobility, all of which can prolong postdisaster hardship during both evacuation and recovery.[12] These patterns reveal that vulnerability is socially produced and geographically reinforced. Building equitable climate adaptation through resilient infrastructure, affordable housing reform, and targeted disaster planning is, therefore, a core public health priority.

Displacement disrupts nearly every dimension of health and social stability. It breaks continuity of care, medication access, mental health stability, and social bonds, especially in communities already facing systemic barriers and low trust in institutions. The loss of consistent health care is especially damaging for individuals managing chronic diseases such as diabetes, asthma, and hypertension, conditions that often worsen after disasters.[31,32] The trauma of losing a home or loved one is intensified by secondary trauma from navigating unfamiliar systems, dealing with xenophobia or racism, and confronting restrictive health care policies.[33–35] For children, forced relocation interrupts education and mental health support and destabilizes their development during crucial years, leading to long-term health and psychosocial issues.[36,37] The loss of

**Table 1.** Climate-driven hazards and impacts.

| Hazard | Description | Proximal Impact (Direct or Individual) | Distal Impact (Indirect or Structural) |
|---|---|---|---|
| Sea-level rise | Coastal inundation, freshwater contamination, and salinization of freshwater. | Injuries from flooding, diarrheal disease from water contamination, and mental health disorders from displacement. | Permanent loss of habitable land, displacement of communities with no relocation resources, cultural erasure, long-term livelihood collapse (fishing, coastal farming), and intergenerational trauma. |
| Extreme weather events | Intensified hurricanes, floods, and wildfires. | Physical trauma (burns, drowning, crush injuries), acute respiratory illness, infectious disease outbreaks, PTSD, and depression exacerbation. | Housing insecurity, economic destabilization, disrupted education systems, and cycles of poverty are tied to recurrent disaster exposure. |
| Drought and desertification | Persistent water scarcity, soil, and land degradation. | Acute malnutrition, dehydration, diarrheal illness, vector-borne outbreaks, and mental health impacts from food insecurity | Food insecurity and forced migration among subsistence farmers, as well as economic collapse in communities reliant on informal labor, are linked to declines in farming, fishing, and herding. |
| Environmental degradation | Air quality, drought, aridity, soil erosion, water quality/scarcity, and biodiversity loss. | Heat illness, asthma/COPD exacerbations, cardiovascular events, and mental health disorders are linked to chronic exposures. | Long-term biodiversity-driven nutritional decline and reduced adaptive capacity of health care systems. |

*COPD*, chronic obstructive pulmonary disease; *PTSD*, post-traumatic stress disorder.

familiar networks and community supports weakens social cohesion, a critical factor for recovery and resilience.[38,39] Workers exposed to climate extremes, including agricultural and construction laborers, experience heat stress, unsafe conditions, and income loss.[40] These intersecting disruptions reveal how displacement extends beyond physical dislocation; it fractures systems of care, livelihoods, and trust. Strengthening trauma-informed, culturally responsive health and social services within disaster planning frameworks is essential to protect displaced individuals and rebuild resilient communities.

Climate migrants are individuals forced to relocate because of climate-related events that make their home environments unsafe or uninhabitable.[41] Policymakers increasingly recognize this population as one of the fastest-growing groups of displaced people worldwide. At the end of 2024, 123.2 million people worldwide had been forcibly displaced by conflict, persecution, or events that disturb public order; of these, 42.7 million were refugees who crossed borders, while 73.5 million were internally displaced persons who remained inside their own countries.[42] The predominance of internal displacement emphasizes that most displaced individuals travel short distances rather than crossing borders. Because international refugee law applies only to those displaced by persecution or conflict, not environmental change, internally displaced climate migrants often lack the legal recognition and access to international protection given to refugees. These distinctions highlight a critical policy gap that will influence future humanitarian and health equity responses to climate-driven migration.

Currently, there is no binding international legal recognition or protection for climate refugees (Table 2).[43–51] Under existing law, the 1951 Refugee Convention does not cover those displaced solely by environmental factors, leaving externally displaced climate migrants in a legal void.[52,53] Some frameworks, such as the UN Global Compact for Migration, the Sendai Framework for Disaster Risk Reduction, and the Guiding Principles on Internal Displacement, provide soft-law guidance, but they lack enforceable rights and obligations.[54,55] Climate-related disasters are one of the main drivers of internally displaced persons, forcing individuals to move within their own borders in search of safety.[56] Internally displaced persons often lose homes, livelihoods, and access to care while remaining outside the scope of international refugee protections. The UN High Commissioner for Refugees (UNHCR) climate action framework emphasizes that national governments must strengthen resilience, protect rights, and integrate climate displacement into disaster risk reduction and humanitarian response planning.[57] Proposed solutions include expanding the definition of refugees to include climate displacement, creating a dedicated climate migration treaty, or embedding protections within human rights frameworks.[58,59] However, these proposals face political resistance, concerns over state sovereignty, and limited consensus on burden-sharing, which hinder progress.[60] In practice, most protections remain nonbinding, fragmented, and reactive, leaving climate migrants vulnerable to inconsistent treatment, xenophobia, and exclusion from resettlement programs. These gaps underscore the need for a coherent, enforceable global standard that integrates migration policy with climate adaptation and human rights protections.

## HEALTH EQUITY IN EMERGENCY DISASTER RESPONSE: GAPS AND OPPORTUNITIES

Health equity in disaster response means that all people

**Table 2.** Current legal and policy protections for people displaced by climate change.

| Legal or Policy Approach | Mechanism of protection | Regulatory body | Strengths | Gaps |
|---|---|---|---|---|
| 1951 Refugee Convention and 1967 Protocol | Defines "refugee" based on persecution; the principle of non-refoulement. | UNHCR / States Parties | Binding, widely ratified international status and protections. | The definition does not cover displacement solely from climate or environmental causes. |
| UN Guiding Principles on Internal Displacement (1998) | Soft-law human-rights standards for IDPs, including those displaced by disasters. | UN (OCHA), implemented by states | Explicitly applicable to disaster-related IDP; widely used normative guide. | Nonbinding, no enforcement, applies only within a person's own country. |
| Kampala Convention (2009) | Regional treaty protecting IDPs due to conflict and natural disasters. | African Union / States Parties | A binding regional law that explicitly covers disaster and climate-related displacement. | Regional (Africa-only) |
| Paris Agreement - Article 8 & WIM (2015) | Political framework to address loss or damage and displacement, WIM coordinates workstreams and support. | UNFCCC / Conference of the Parties | Formally recognizes displacement associated with climate impacts and provides an institutional home for coordination and finance discussions. | Lacks enforceable individual rights, finance, and operationalization remain limited. |
| Global Compact for Safe, Orderly and Regular Migration (2018) | Non-binding cooperation framework acknowledging climate and environmental drivers of migration. | UN system (IOM/ UN Migration Network) | Recognizes climate as a migration driver, encourages policy coordination and data. | Voluntary creates no legal status or justiciable rights. |
| Teitiota v. New Zealand (UN, HRC, 2020) | HRC found climate impacts can, in some cases, trigger non-refoulement under ICCPR (right to life). | UN HRC | First UN treaty body view recognizing climate risk may bar removal where life risk is substantial. | Views do not capture other "climate refugee" statuses, are case-by-case, and are non-binding on all states. |
| G20 LEMM Fortaleza Declaration (2024) | Re-affirms just transition, commits to addressing labor inequities, occupational safety (heat stress), and social protection in the context of climate change. | G20 and Employment Ministers | Global political momentum is linked to climate change, work, a just transition, and worker protections. Endorses the ILO Decent Work Agenda. | Non-binding declaration, relies on national uptake and G20 follow-through. |

*HRC*, Human Rights Council; *ICCPR*, Initialism of International Covenant on Civil and Political Rights; *IDP*, internally displaced persons; *ILO*, International Labour Organization; *IOM*, International Organization for Migration; *LEMM*, Labour and Employment Ministers' Meeting; *OCHA*, Office for the Coordination of Humanitarian Affairs; *UN*, United Nations; *UNFCCC*, United Nations Framework Convention on Climate Change; *UNHCR*, United Nations High Commission for Refugees; *WIM*, Warsaw International Mechanism.

have equal access to timely warnings, emergency care, and recovery resources regardless of language, income, or legal status. Emergency departments (EDs) often serve as a first point of care during crises and are designed to provide acute stabilization. However, sometimes, EDs are also the only point of care for those impacted by climate disasters. When ED care is not followed by longitudinal care or postdisaster follow-up by pre-existing or temporarily activated systems, critical gaps in ongoing health management can arise for affected populations.[61] International health care systems are increasingly strained by climate-related events such as heat waves, floods, and storms, and many are still working to develop the necessary infrastructure, staffing, and preparedness systems to effectively incorporate climate resilience into their daily operations.[62] While there are increasing efforts to incorporate focused consideration of vulnerable populations in disaster response planning, refugee and immigrant populations have been historically excluded and face additional barriers to participation, such as fear of immigration and enforcement and lack of trust in health systems.[63–65] Without sustained investment for interpreter services, culturally informed care models, and long-term recovery mechanisms, EDs and disaster systems will continue to fall short of providing equitable care during and after climate-related events.

Disaster response systems face interconnected barriers that operate across communication, policy, and workflow

levels. These challenges increase risk for linguistic minorities, undocumented immigrants, and low-income communities, contributing to preventable illness, delayed recovery, and systemic exclusion (Table 3). Emergency communications are often issued only in the dominant language, leaving many unable to receive timely evacuation orders, health advisories, or hazard updates.[66,67] In Australia, mortality rates among people born overseas during disasters were nearly three times higher than for those born locally, mainly due to language barriers and limited English or digital literacy.[68] Similar issues occur in multilingual regions of the U.S., where residents with limited English proficiency report missing critical alerts or misunderstanding evacuation instructions when messages are not translated or delivered through digital platforms inaccessible to older, rural, or low-income populations.[66,69] Adding to these barriers is a reliance on superficial cultural competency. Training is often viewed as a mere compliance requirement rather than an integral part of implementation that genuinely incorporates multilingual, culturally-tailored communication strategies into disaster response.[70–72]

Emergency operations plans and emergency preparedness guides rarely incorporate immigration status, language access, or health literacy into planning, defaulting to a "one-size-fits-all" approach that incompletely accounts for inequities influencing exposure, evacuation, and recovery.[73] Recovery services, including housing assistance, medical care, and financial aid, are more difficult for non-English speakers to access due to a lack of multilingual navigation support, exacerbating disparities long after the disaster impact.[11,74] Even when cultural competency is included in preparedness frameworks, it remains challenging to operationalize, given the many layers of disaster response.[75] The result is a persistent inequity, where populations with limited access before a disaster often experience delayed recovery afterward, reinforcing structural vulnerability rather than resilience.

Addressing these inequities requires reframing disaster response as an equity-centered system rather than simply a logistical operation. Disasters reveal, rather than create, the structural weakness of health and social systems. Embedding equity into disaster planning demands more than translation services or temporary outreach. It requires the consideration of the factors underlying who are most affected and why they are vulnerable. This shift helps lay the foundation for innovation that applies implementation science to sustain equitable outcomes across all phases of the disaster cycle.

## INNOVATIONS AND SOLUTIONS: CENTERING EQUITY IN DISASTER RESPONSE

A structured framework is essential to translate equity from principle to practice in disaster response. The Practical, Robust Implementation and Sustainability Model (PRISM) and the Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) framework together offer a pragmatic, evidence-based approach for designing, evaluating, and sustaining interventions in the real world.[76,77] While PRISM identifies how contextual, organizational, and recipient-level factors shape the feasibility and sustainability of disaster interventions, RE-AIM provides measurable domains for assessing reach, adoption, and long-term impact. Applying these models to disaster planning allows policymakers and practitioners to identify equity gaps early, tailor interventions to local needs, and monitor implementation of integrated strategies across policy reform,

**Table 3.** Multi-level barriers to equitable disaster response and their proximal and distal impacts.

| Barrier | Proximal Impact | Distal Impact |
|---|---|---|
| Language access gaps | Missed warnings, miscommunication during medical care, and difficulty locating shelters or evacuation routes. | Reinforcement of systemic inequities in disaster communication, erosion of trust in institutions, and widening health disparities among language minority communities. |
| Fear of immigration enforcement or documentation concerns | Avoidance of shelters and medical care, delayed or forgone treatment during emergencies. | Entrenchment of exclusionary systems that discourage immigrant populations from engaging with disaster infrastructure. |
| Poverty and resource limitations | Inability to purchase supplies, evacuate, or rebuild, and greater exposure to unsafe conditions. | Cyclical dependency on overstretched aid systems, slower community recovery, and intergenerational loss of wealth and stability. |
| Preparedness and workforce capacity | Lack of trained interpreters, multilingual responders, and culturally responsive clinicians during crises. | Systemic underinvestment in equitable preparedness infrastructure and limited institutional capacity to adapt to diverse populations in repeated disasters. |
| Data collection challenges and situational awareness gaps | Lack of recognition of disparities at the individual level, and invisibility of vulnerable populations in immediate disaster statistics. | Persistent gaps in preparedness planning and policy-making, structural neglect in resource allocation, and recovery funding. |

*COPD*, chronic obstructive pulmonary disease; *PTSD*, post-traumatic stress disorder.

community-based response, and technology innovation to advance equitable disaster systems (Figure).

The domains of PRISM could offer a structured approach to align context-specific needs with sustainable interventions, reducing the fragmentation that often undermines disaster response at all stages (Table 4). By mapping environmental, organizational, and recipient factors to each disaster phase, PRISM helps planners anticipate barriers such as funding gaps, workforce shortages, or cultural misalignment before they derail implementation. Integrating this framework with RE-AIM ensures that interventions are both deployable under crisis conditions and evaluated for long-term impact. Policy reforms rooted in PRISM principles can embed equity audits into zoning and funding decisions; community innovations can train and deploy culturally responsive responders; and technology solutions can standardize multilingual communication systems. Together, these approaches demonstrate how implementation science transforms disaster management from reactive aid delivery to a sustained, equity-driven system of preparedness, response, and recovery.

## Policy and System-Level Interventions

Applying PRISM and RE-AIM to disaster policy offers a structured way to operationalize equity across systems that have historically prioritized speed over inclusion while recognizing how sustainability and health equity are critical metrics for program success.[78,79] These frameworks encourage policymakers to analyze how environmental context, organizational readiness, and community engagement influence program sustainability and reach. Embedding this perspective into climate-informed disaster planning enables agencies to map priority populations into preparedness protocols and funding mechanisms. Integrating PRISM and RE-AIM principles can also align policy interventions with existing infrastructure and trusted local networks, supporting equitable scale-up while maintaining feasibility.[77] Practical applications include expanding emergency health financing and codifying language access requirements into emergency operations plans and drills. Institutional accountability through performance metrics that are tied to equity outcomes ensures these reforms move beyond symbolic commitments toward measurable, system-level change.

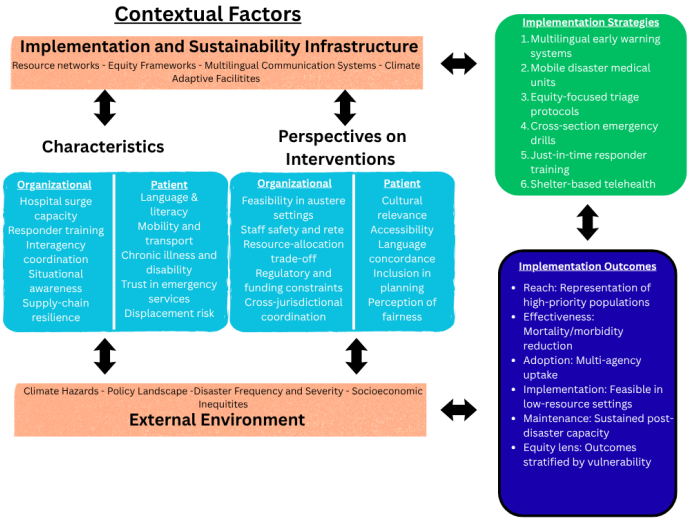


**Figure.** *Conceptual Practical, Robust Implementation and Sustainability Model/Reach, Effectiveness, Adoption, Implementation, Maintenance* framework illustrating integrated policy, community, and technology strategies to advance equity in climate-related disaster preparedness and response. The model links contextual factors, organizational and community perspectives, targeted implementation strategies, and equity-focused outcomes to guide design, scaling, and sustainability across austere settings.

## Community-Based Innovations

The PRISM framework has demonstrated value in community health worker and clinical settings where interventions were adapted to local realities while maintaining measurable outcomes.[80] One illustrative example comes from Haiti's 2010 cholera outbreak, where a national health agent-led surveillance and education program effectively reduced mortality through community trust and locally embedded training.[81] Although disease-specific, the model's success demonstrates how community-trusted intermediaries can strengthen disaster systems in low-resource settings.

Applied to climate-related disasters, this approach involves deploying community health workers trained to identify climate-sensitive hazards, coordinate early response, and deliver culturally and linguistically aligned outreach.[82] The focus of PRISM on the external environment and recipient engagement provides a framework for tailoring community health worker deployment to community networks, such as churches, shelters, and neighborhoods. Just-in-time responder training, focused on cultural humility, operational stress injury, and bias, could help responders rapidly adapt to the social and cultural context while mitigating and preventing trauma caused by discrimination or miscommunication.[83–85] Crisis navigation hubs that integrate legal aid, health care, and housing services in one-stop centers could address the fragmentation that often undermines recovery for displaced individuals.[86] These multi-sector models exemplify how implementation frameworks bridge the gap between policy vision and lived community experience.

## Communication and Technology

An implementation science approach can identify contextual barriers such as language, digital access, and trust, which often determine whether communication strategies succeed or fail. By applying these principles, planners can ensure that technology-based interventions are adapted to community capacity and cultural context rather than imposed from the outside. Practical strategies include mobile,

**Table 4.** Practical, Robust Implementation and Sustainability Model-aligned disaster phase-specific innovations examples.

| Disaster Phase | External Environment | Recipients | Design and Adaptation | Infrastructure |
|---|---|---|---|---|
| Mitigation and Prevention | Long-term policy reforms, land-use planning, and investment in climate projects such as resilient housing and infrastructure. | Linguistic minorities and undocumented communities in high-risk zones. | Inclusion of equity audits in zoning and housing codes, and expansion of flood insurance access, integrated exercises with linguistic minority individuals | Sustainable funding for resilient infrastructure, integration of climate migration into urban planning. |
| Preparedness | Community risk mapping | CHW outreach to linguistic minority and/or undocumented residents | Multilingual early warning systems | Language-trained hotline staff, mobile alert platforms |
| Response | Coordination with local and state government agencies, NGOs, and the community | Displaced and medically complex patients | Mobile clinics, pop-up pharmacies | Cross-trained interpreters in care areas, telehealth-enabled triage |
| Recovery | Policy reform for ID-free aid access | Linguistic minority and low-literacy populations | Simplified aid applications, peer or cultural navigator programs | Sustained funding for CHW networks, legal aid partnerships |

*CHW*, community health worker; *ID*, identification; *NGO*, non-governmental agencies.

multilingual response units that deliver real-time updates and triage support after disasters, and hyper-localized, multilingual warning systems using short message service (SMS), radio, and trusted community messengers. Artificial intelligence-enabled translation and natural language processing tools can enhance accessibility in clinical workflows by generating personalized, easy-to-read discharge summaries in multiple languages or community alerts, thereby embedding language accessibility into digital health solutions.[87] These solutions must be deployed within transparent governance models for digital health research that aim to enhance data quality and translate research findings into integrated frameworks for planning, executing, and assessing public health initiatives.[88]

Integrating technology with policy reform and community innovation within the PRISM and RE-AIM frameworks provides a unified model for equitable disaster preparedness and response. This model explicitly maps vulnerable populations within preparedness plans, aligns interventions with trusted local infrastructure, and embeds language accessibility into both policy and practice. Deploying multilingual response units, community health workers, and culturally adapted training creates a multi-level approach that connects communication, clinical care, and recovery support. When equity becomes a design requirement rather than a retrospective correction, disaster systems move closer to achieving resilience that includes every community.

## CONCLUSION

Displacement, disconnection from care, and systemic neglect fall heaviest on those individuals without legal protections, linguistic minorities, and economically marginalized communities. Existing disaster management frameworks, designed for speed rather than equity, can leave these populations disproportionately vulnerable to disaster impacts. By aligning community-based solutions, policy reforms, and technology innovations within implementation science frameworks, disaster response can be transformed to incorporate a proactive approach to improve equity. The climate crisis is inseparable from the equity crisis; only by addressing both together can disaster response systems be built to truly safeguard every community when the waters rise.

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# Sustainability in Quality Improvement: Outcomes of a Novel Pediatric Virtual Urgent Care in Ontario, Canada

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**Introduction:** Virtual care is expected to play an increasingly important role in the Canadian healthcare system, with the 2023-2024 Health Canada Departmental Plan outlining the advancement of digital health solutions as a focal point. However, key outcomes of transitioning from traditional in-person healthcare appointments to a virtual model of care are not yet well-described. Here, we apply the Sustainability in Quality Improvement (SusQI) framework to patients seen in a novel pediatric virtual urgent care (VUC) program to quantify the environmental, economic, and social impacts of virtual care.

**Methods:** We conducted a retrospective analysis of provincial pediatric VUC visits staffed by pediatric emergency physicians and nurse practitioners during the 2020-2025 fiscal years. We focused on three key metrics: (1) economic value, measured as travel costs avoided; (2) environmental value, measured in fuel saved (L) and carbon emissions reduced (kg $CO_2$ eq); and (3) social value, assessed using Ontario Marginalization (ON-Marg) Index quintiles.

**Results:** A total of 12,900 virtual visits were completed during the study period, 99.9% via the Webex platform. Net savings totaled $998,100. Environmental benefits included 128,700 L of fuel saved and 384,200 kg $CO_2$ eq emissions avoided. Summary ON-Marg Index scores were similar between groups (2.87 for in-person emergency department (ED) visits; 2.91 for virtual visits). Data collected between July 2023-April 2025 show that 10.6% (353) of visits resulted in subsequent in-person ED presentation.

**Conclusion:** Virtual urgent care resulted in significant financial and environmental savings per visit. These benefits included reduced financial and time burdens for families, lower hospital-related expenditures, improved environmental performance, and diversion of low-acuity cases from the ED. Comparable ON-Marg scores between patients seen virtually and in-person suggest accessibility across socioeconomic groups. These findings indicate that pediatric VUC is a viable complement to traditional care, providing meaningful cost and environmental savings while ensuring equitable access. [West J Emerg Med. 2026;27(5)1141–1148.]

## INTRODUCTION

Climate change is an area of significant concern within healthcare. The effects of climate change pose an imminent threat to human health, increasing morbidity and mortality, widening existing social disparities, and increasing the burden on healthcare services.[1] The development of sustainable healthcare systems can be achieved through mitigation policies aimed at reducing carbon emissions and by identifying ways to create more robust healthcare infrastructure.[2] Virtual care is one promising avenue for carbon reduction, as it eliminates the need for patients to travel to clinics, reducing their reliance on fossil fuels.[3,4] Virtual care may also improve access by reducing the time, distance, and effort required by patients attending appointments.[5,6] Understanding the profile of carbon emissions associated with virtual and in-person care can guide the development of a more sustainable healthcare system.[7] In 2020, as part of the COVID-19 pandemic response, the Ontario Ministry of Health approved $4 million in funding for regionally coordinated virtual urgent care (VUC) initiatives across Ontario.[8] A 2023 cross-sectional survey evaluating patients using VUC services in Ontario found that 94% of patients rated their experience as 8/10 or greater, with more than 80% saying they felt confident managing their presenting concern.[9] Virtual care continues to be used across multiple medical specialties. In 2021, during the pandemic, approximately 40% of all healthcare visits in Canada were virtual.[10] The 2023-2024 Health Canada Departmental Plan outlined the advancement of digital health solutions as a focal point, indicating the increasingly important role virtual care is expected to play in the Canadian healthcare system.[11]

The primary goal of this paper was to examine the value of VUC in patients who would otherwise present to a pediatric emergency department (ED) by quantifying associated savings. A secondary goal was to explore the various impacts of its continued use as a substitute for in-person emergency medicine in applicable patients. We also aimed to evaluate disparities in access to care by comparing the demographic makeup of patients accessing virtual versus in-person emergency services. This assessment focused on three key areas: financial; environmental; and social considerations. This analysis was guided by the Sustainability in Quality Improvement (SusQI) framework, developed by the Centre for Sustainable Healthcare (CSH) in the United Kingdom.[12] The SusQI framework focuses on the CSH principles of sustainable clinical practice and measures the health outcomes of a service against the Triple Bottom Line model introduced in 1997 by economist John Elkington. This model examines sustainable development through a multifaceted lens of social, environmental, and economic sustainability.[13] Here, we used the SusQI framework to provide an understanding of the value of virtual care and the potential for expansion and application within other healthcare domains.

*Population Health Research Capsule*

What do we already know about this issue?
*Virtual care is expected to play an increasing role in healthcare, but its broader environmental, economic, and social impacts remain poorly characterized.*

What was the research question?
*To quantify the financial, environmental, and social impacts of pediatric virtual urgent care using the Sustainability in Quality Improvement framework.*

What was the major finding of the study?
*Virtual urgent care saved $998,100, 128,700 L of fuel and 384,200 kg $CO_2$ across 12,900 visits with 10.6% directed to the emergency department.*

How does this improve population health?
*Virtual urgent care reduces emissions and financial burden while improving access to care, which supports the development of more sustainable and resilient healthcare systems.*

## METHODS

### Study Design

We conducted a retrospective analysis of patients presenting to the pediatric Ontario VUC program operating out of the hospital. This was part of a joint pilot initiative to offer virtual services to residents in southwestern Ontario. The service was publicly available and promoted through institutional communications and news articles. Individuals accessed the VUC through the Urgent Care Ontario website. Virtual visits were conducted using the Webex application, a secure videoconferencing platform. Pediatric patients were defined as individuals ≤ 17 years of age at the time of their visit. No exclusion criteria were applied. Data were sourced from the hospital virtual care dashboard, developed by the hospital decision support team. The dashboard collects data on all patients who received outpatient care at the hospital since 2020. All patients who used pediatric VUC during the fiscal years of April 2020-March 2025 were captured in our analysis.

Clinical variables were extracted automatically; therefore, no manual chart review was deemed necessary. Available variables include the volume of in-person and virtual visits, financial and travel savings associated with virtual visits, and Ontario Marginalization (ON-Marg) Index scores. We also collected ON-Marg scores for in-person ED visits occurring

during the same time periods. Data on subsequent presentation to ED was captured by standardized fields within the clinical virtual care note indicating clinician recommendation to seek further care at an ED. In addition, we invited all patients who used pediatric VUC to complete a feedback survey one month after their visit which included questions regarding serious adverse events.

### Calculation of Savings

Postal codes were used to calculate travel distances, which were approximated based on the straight-line distance between the home address and the location of the children's hospital.

Monetary savings were calculated using the 2022 mileage reimbursement rate of $0.69 CAD per km set by the Canadian Revenue Agency.[14] Fuel savings were estimated using the average fuel consumption rate of 8.9 L per 100 km from the Canada Energy Regulator.[15] A conversion factor of 0.2656 kg $CO_2$-equivalent per km sourced from Canada Health Infoway was used to quantify carbon emissions avoided.[16]

### Calculation of Ontario Marginalization Index Scores

We calculated ON-Marg quintile scores according to the methodology outlined by Paczkowski et al (2024).[17] We used the ON-Marg index to evaluate disparities in access to virtual care within the study population. Developed by Public Health Ontario from the Canadian Marginalization Index, the index groups area-level census indicators into four dimensions: households and dwellings; material resources; age and labor force; and racialized and newcomer populations.[18]

Households and dwellings include indicators that measure the following: the type and density of a residential accommodation, such as the percentage of rental dwellings and apartments; price of property; and structural characteristics of the family, such as the percentage of residents living alone, the percentage of residents who moved within five years, the number of residents per dwelling, and percentage of residents who are widowed or divorced. Material resources include indicators that measure the access and attainment of material needs such as income, the percentage of employed individuals, and the percentage of individuals with a high school degree. Age and labour force includes the dependency ratio (children < 15 and adults > 65 relative to the general population), proportion of seniors and children, and labor force participation. Racialized and newcomer populations includes the percentage of recent immigrants and the percentage of individuals who self-identify as belonging to a minority group.

We assigned each Ontario neighborhood a quintile score from 1 (least marginalized) to 5 (most marginalized) for each domain. Higher values indicate greater levels of marginalization, where each quintile represents one-fifth of the geographic units. A score of 5 therefore represents the most deprived 20% of regions in Ontario. We compared ON-Marg quintile scores for the above domains between patients who attended in-person and those who opted for virtual care to evaluate disparity in access to virtual care. Comparisons were based on postal code data and conducted across the four-fiscal-year study period. Additionally, we examined ON-Marg scores annually to address changes in the sociodemographic characteristics from year-to-year.

### Data Analysis

We summarized study outcomes with descriptive statistics including frequency statistics, means, and standard deviations. Unpaired *t* tests were conducted to compare outcomes between in-person and VUC visits. Mann-Whitney U tests were conducted to compare ON-Marg quintile values as quintile values are ordinal. One-way analysis of variance (ANOVA) with a post hoc Bonferroni test was used to assess differences between savings across fiscal years. Statistical significance was set at $\alpha = .05$.

## RESULTS

A total of 12,900 VUC visits were completed during the study period, 99.9% of which were conducted via the Webex platform. Although data was not available for the entire study period, data collected between July 2023-April 2025 indicate 10.6% (353) of VUC visits resulted in a recommendation to seek care in-person at an ED. No serious adverse events were reported through the standardized postvisit feedback surveys during this period.

### Economic Outcomes

Across all five fiscal years (2020-2025), the pediatric VUC program generated an estimated $998,100 in cost savings (Table 1). Although the total savings varied in proportion to the number of visits per year, average per-visit savings increased steadily, peaking at $118.30 in 2024-2025 (Table 2).

### Environmental Outcomes

The program was associated with cumulative savings of 128,700 L of fuel and a reduction in emissions of 384,200 kg $CO_2$ eq (Table 1). Per-visit savings increased

**Table 1.** Total savings associated with virtual urgent care during the fiscal years of 2020-2025.

| Total Savings | |
|---|---|
| Number of Visits | 12,900 |
| Cost Savings ($) | $998,100.00 |
| $CO_2$ (t) | 384.20 |
| Fuel (L) | 128,700 |

*$CO_2$,* carbon dioxide; *L,* litre; *t,* tonne.

**Table 2.** Annual Savings with average per visit savings. For each outcome, the total value for each fiscal year is presented, with the average saving per visit shown in parentheses. Per-visit values were calculated by dividing the yearly savings by the number of visits in that fiscal year. Outcomes include total cost savings (in $CAD), total carbon emissions avoided (kg $CO_2$ equivalent), and total fuel savings (litres).

| Fiscal Year | 2020-2021 | 2021-2022 | 2022-2023 | 2023-2024 | 2024-2025 |
|---|---|---|---|---|---|
| Number of visits | 1421 | 4195 | 3703 | 1624 | 1957 |
| Total cost savings ($) | $50,400 ($36.60) | $237,600.00 ($59.50) | $298,700 ($83.40) | $183,800 ($115.40) | $227,600 ($118.30) |
| Total $CO_2$ (kg $CO_{2\,eq}$) | 19,400 (14.11) | 91,400 (22.91) | 115,000 (32.1) | 70,800 (44.42) | 87,600 (45.52) |
| Total fuel savings (L) | 6,500 (4.7) | 30,600 (7.7) | 38,500 (10.8) | 23,700 (14.9) | 29,400 (15.3) |

*kg $CO_2$ eq,* kilograms of carbon dioxide equivalent; *L,* litre.

annually, reaching 15.3 L of fuel and 45.52 kg of $CO_2$ per visit in 2024-2025 (Table 2). Figure 1 illustrates both the annual total savings and the annual per-visit savings. While total savings generally reflected program volume, the increase in per-visit savings over time suggests that the average travel distance avoided per virtual visit increased during the study period.

### Social Outcomes

There were no significant differences in ON-Marg index quintile scores between patients presenting to VUC versus in-person ED visits for household and dwelling, age and labor force, or racialized and newcomer populations domains (Table 3). Summary ON-Marg scores were similar overall (2.91 for VUC vs. 2.87 for in-person visits) (Table 4).

### Travel Distance

Figure 2 depicts visit density by patient travel distance. The mean travel distance was 40.6 km, with greater per-visit fuel and $CO_2$ savings observed year-over-year.

## DISCUSSION

To our knowledge, this is the first study to evaluate a pediatric VUC program using the SusQI framework. Our findings show that VUC is a cost-effective, environmentally sustainable, and accessible model of care. We found that the vast majority of cases did not result in in-person presentation, suggesting VUC can reduce the burden on healthcare systems by addressing low-acuity patient concerns. Over the five-year study period, VUC was associated with an estimated reduction of 384,200 kg $CO_2$ eq and an estimated $998,100 CAD in avoided patient travel costs. For context, the total 384,200 kg $CO_2$ eq is equivalent to the annual electricity consumption of about 80 households or 426,775 lbs of coal burned, according to the Greenhouse Gas Equivalencies calculator.[19]

The VUC program's reductions represented 0.73% of total hospital emissions as given by our hospital's 2021 annual emissions of 54,439 tonnes $CO_2$.[20] It is worth noting that this number may significantly underrepresent the actual environmental benefit, as it does not account for decreased $CO_2$ emissions from travel avoided by clinicians, or the consumption of electricity and medical resources associated with in-person care. There were also clear economic benefits, with an estimated $998,100.00 in travel costs saved over the five fiscal years. Our findings are consistent with the literature. A previous cost analysis of VUC in an American setting found an associated savings of $93.657 USD ($132.80 CAD) per visit.[21] Similarly, a study of 63 million

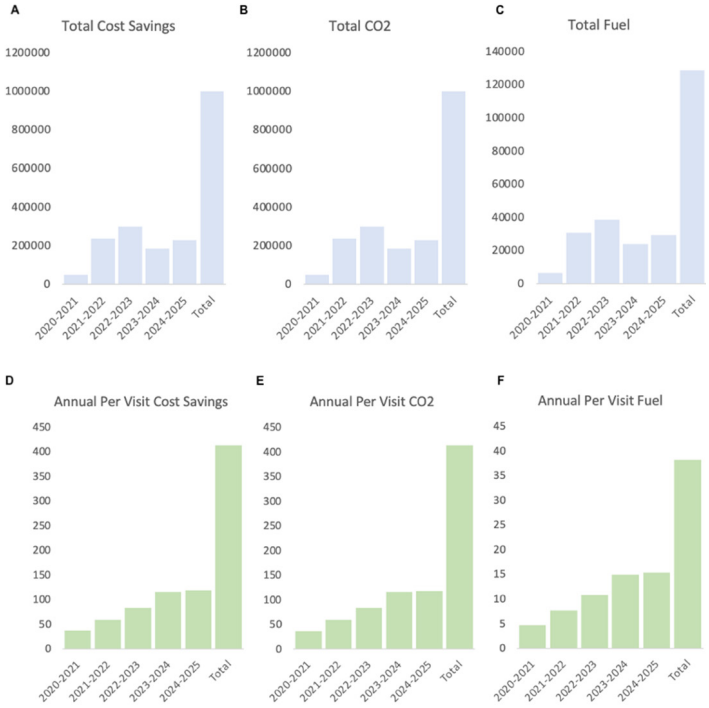


**Figure 1.** Financial and environmental savings of virtual care. Graphs A–C show annual total cost, $CO_2$ eq, and fuel savings, while graphs D–F show corresponding annual per-visit savings. Total savings were driven by both the number of virtual visits and the average travel distance avoided.
*$CO_2$,* carbon dioxide.

**Table 3.** Annual Ontario Marginalization Index Scores of patients seen virtually.

| Outcome | Fiscal Year 2020-2021 | Fiscal Year 2021-2022 | Fiscal Year 2022-2023 | Fiscal Year 2023-2024 | Fiscal Year 2024-2025 |
|---|---|---|---|---|---|
| Household and dwellings | 2.98 | 2.99 | 3.09 | 3.13 | 3.08 |
| Material resources | 2.81 | 2.83 | 2.92 | 2.9 | 2.94 |
| Age and labor force | 2.46 | 2.59 | 2.75 | 2.95 | 2.94 |
| Racialized and newcomer populations | 3.14 | 3.08 | 3.04 | 2.87 | 2.75 |
| Summary score | 2.85 | 2.87 | 2.95 | 2.96 | 2.93 |

virtual care visits in Ontario found that virtual care averted approximately 3.2 billion km of patient travel, or 545-658 million kg of $CO_2$ eq.[22]

We found that VUC usage peaked between the 2021-2022 and 2022-2023 fiscal years, likely reflecting the COVID-19 pandemic. Virtual health and telehealth visits increased significantly during the COVID-19 pandemic, likely reflecting both public health measures and widespread attitudes towards in-person care during the pandemic.[25] Although the total number of visits in 2024-2025 was below peak usage, usage increased from 2023-2024 to 2024-2025, reflecting sustained interest over time. Interestingly, total cost savings grew more rapidly than the number of patient encounters. We found that the savings per-visit increased annually, even when overall VUC usage declined from peak levels. This reflects a shift in the demographics of VUC users towards individuals living further away. It may also indirectly reflect the increasing economic burden of commuting which includes rising fuel and operating expenses.

**Deferred Emergency Department Visits**

Only 10.6% (353) of VUC visits during July 2023-April 2025 resulted in an in-person ED visit. This number is lower than the 17.2% of visits resulting in ED referral found by a 2020-2021 prospective study analyzing data from VUC services at 14 ED-led pilot sites in Ontario, Canada.[9] The higher rate of in-person presentation during that period may reflect the unique social environment of the pandemic which was not captured in our analysis of in-person visits. We hypothesize more patients presented to VUC with concerning symptoms because they were afraid to access in-person care.

It is important to note that VUC services are inherently different than the services provided at an in-person ED. Virtual urgent care clinicians are not able to provide a physical examination or access real-time laboratory testing or imaging. In addition, VUC clinicians are often unable to access previous medical records, all of which limit their ability to provide an accurate diagnosis.[23] Similarly, the population of patients who use VUC services may also be intrinsically different than the population presenting to in-person EDs. Research has shown that the majority of VUC visits were by patients with low-acuity concerns who have access to primary care.[24]

**Equity and Access**

A 2023 study by Williams et al found that telehealth was associated with widening health inequalities, with lower household income and ethnic minority associated with lower use of video health services, attributable to the cost of technology and the costs associated with missing work.[25] Contrary to these findings, we observed no discrepancy in access to care across sociodemographic domains, as measured by the ON-Marg index, indicating that VUC remained accessible to patients with lower household income or those living in rural or underserved locations. Our results also indicated non-English speakers were equally likely to use both deliveries to access care.

Our findings also did not substantiate the findings of Hall et al who found that patients who use the ED for low-acuity problems were unable to use VUC because they did not have access to a computer or smartphone.[23] Although we did not find a significant difference in marginalization status between patients using virtual and in-person care, we recognize that technological barriers remain a substantial challenge. Individuals accessing VUC must have WIFI and access to a device with video and microphone capability. They must also be able to install the Webex mobile application and have an email address to access the appointment link. It is possible that the small subset of patients who are most affected by technological barriers were not fully captured in our analysis, highlighting the need for more research specifically focused on accessibility.

Transportation barriers have also been shown to significantly restrict healthcare access, particularly for patients with lower incomes.[26] Longer travel times correlate with a greater number of missed appointments and lower treatment adherence.[27] Our analysis of travel distances complements these findings. During the 2023-2024 fiscal year, the mean travel distance was 40.61 km from the children's hospital, suggesting VUC may decrease the burden of longer travel times. Virtual urgent care may also be more accessible because it eliminates

**Table 4.** Average Ontario Marginalization Index Scores of patients seen virtually versus in person across all years.

| Outcome | In-Person Mean (SD) | Virtual Mean (SD) | |
|---|---|---|---|
| Household and dwellings | 3.10 (0.38) | 3.05 (0.07) | (*P* = .70) |
| Material resources | 2.73 (0.52) | 2.88 (0.06) | (*P* = .57) |
| Age and labor force | 2.45 (1.00) | 2.73 (0.22) | (*P* = .90) |
| Racialized and newcomer populations | 3.22 (0.51) | 2.97 (1.15) | (*P* = .49) |
| Summary score | 2.87 | 2.91 | |

*SD,* standard deviation.

barriers such as transportation costs and childcare, which can make attending in-person appointments prohibitive. In addition, VUC may also provide access to specialists and services not available in rural or underserved locations.

### Strengths

This study addresses an important gap in the literature by providing one of the first multi-year evaluations of pediatric VUC. To our knowledge, this is the first study that focuses on the economic and environmental impacts of VUC in pediatric emergency care.

### Clinical Implications

The findings suggest that pediatric VUC is a viable strategy to reduce unnecessary ED visits while alleviating some of the financial and logistical burdens placed on families. Cost savings extend beyond direct travel expenses to include indirect benefits such as reduced need for childcare, less time off work, and greater flexibility for families. Importantly, VUC appears to be accessible to marginalized populations, particularly those in rural areas. The use of virtual care may also provide additional benefits to both clinicians and patients, such as a reduction in unnecessary appointments, leading to decreased wait times and increased efficiency. Similarly, VUC may also increase flexibility and work-life balance. Research has shown that emergency physicians appreciated the opportunity to interact with patients outside the chaotic environment of the ED.[23]

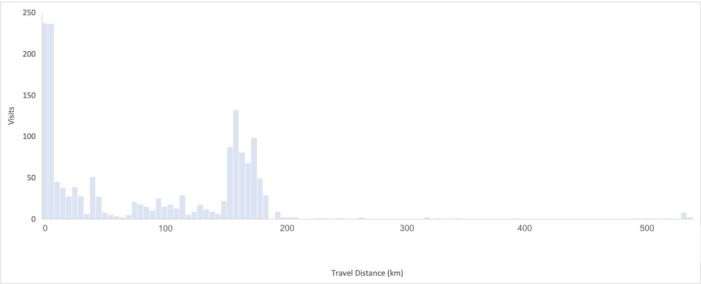


**Figure 2.** Travel distance (km) and number of visits in the 2023-2024 fiscal year.
*km,* kilometre.

Finally, the broader environmental benefits extend beyond quantifiable environmental savings. Virtual care signifies a transition toward more sustainable and more robust healthcare systems. The U.S. Agency for International Development (USAID) Health System Strengthening Vision 2030 outlines the need for resilient healthcare systems to adapt to "acute, time-bound events; and longer-term destabilizing dynamics."[28] In many regions in Canada, healthcare services have become increasingly centralized in larger urban centers, leaving smaller communities with limited local options. The reliance on urban facilities creates significant challenges for patients, even under normal conditions. Climate-related disruptions may therefore severely compromise access to care. We found that the greatest proportion of emission reduction occurred in patients living in rural areas. The reduction in travel associated with urgent care can improve overall access to care while also bolstering the continuity of care during climate-related disruptions. Virtual urgent care may also alleviate pressure on the healthcare system by diverting less urgent cases, allowing EDs to better adapt to increased demand. Our findings support the implementation of VUC as an important step towards more resilient healthcare systems.

### Research Implications

Future research should further explore the long-term cost-effectiveness of VUC. More robust environmental evaluations are also warranted, particularly research which examines the consumption of hospital resources associated with in-person care. From a social perspective, further investigation is needed into barriers such as digital literacy, technology access, and language support, as these remain potential obstacles to equitable use. In addition, the ED presents a confusing and often frightening experience for children, and it would be interesting to explore how pediatric patient experience differs between VUC and ED, as well as the attitudes and experiences of their families.

## LIMITATIONS

This study has several limitations. Although we captured

clinician recommendations for in-person care and monitored adverse events through patient feedback surveys, we did not perform a formal chart review to verify clinical outcomes. As this study was designed to estimate financial and environmental savings using administrative dashboard data, it was not powered or structured to formally assess safety. Therefore, we are unable to draw definitive conclusions regarding diagnostic accuracy, missed diagnoses, or the overall safety profile of the VUC model.

Furthermore, the retrospective nature of this study meant that only data collected by the hospital virtual care dashboard could be included. While our research has shown a substantial cost savings per visit, it may not capture the full range of expenses typically associated with travelling to in-person ED visits, such as parking, travel costs, lost wages, and other indirect expenses such as food or accommodations. We also were not able to quantify patient-specific choices, such as patients who may have chosen to take alternative methods of transportation (eg, public transport or walking) or patients who might have chosen to present to their family doctors or closer nonpediatric EDs instead of our institution.

In addition, an in-person visit to a pediatric ED often incurs additional costs compared to a visit to a general ED, as parents or caregivers may need to arrange childcare for other children. The need to take time off work may compound the financial and logistical burden for families presenting to pediatric urgent care, leading to the potential for additional loss of income not associated with adult urgent care. As these variables were not included in the hospital virtual care dashboard, they unfortunately could not be included in our analysis. As our methodology used straight line distances to approximate travel distances, it is very likely it underrepresents travel time needed by car. Similarly, we estimated monetary and fuel savings using set rates. While these provide good approximations, they do not fully capture the volatility of gas prices across multiple years. Given this, and our inability to calculate indirect expenses, it is therefore likely that our results underestimate the full cost savings of VUC.

## CONCLUSION

At a time when we are facing a climate crisis, with healthcare systems seeking to reduce their environmental footprint, our findings demonstrate that pediatric VUC is a sustainable model of care. In our multi-year evaluation, VUC generated significant reductions in fuel consumption, travel time, and $CO_2$ emissions, while also alleviating the burden on the ED. Importantly, VUC remained accessible across marginalized and rural populations. The real-world applications of our findings are significant and support the broader adoption of virtual care across the healthcare sector. Virtual urgent care should be considered a key component of future care models as healthcare systems build sustainability and resilience.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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# Impact of Increasing Ambient Temperatures on Emergency Department Trauma Presentations at a Level I Trauma Center

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**Introduction:** Global temperatures are increasing because of climate change, affecting human health. Elevated ambient temperature has been shown to increase rates of trauma presentations in emergency departments and to increase antisocial behavior, such as violent crime. To better understand how to reduce the burden on trauma hospitals, we must better understand the relationship between ambient temperature, trauma patients, and intentional injury. We sought to examine the relationship between trauma rates and minimum and maximum daily temperatures and assess whether the assault trauma mechanism had the strongest association between weather and trauma rates.

**Methods:** We conducted a retrospective cohort study of full and partial trauma team activations that presented to a Level I trauma center in New York from 2012 to 2019, inclusive. Daily maximum and minimum temperatures were divided into quintile ranges. Traumas were classified by injury type and mechanism as either unintentional, assault, or intentional self-harm. We used generalized linear models with a Poisson distribution to examine the relationship between maximum and minimum temperature ranges and trauma rates, controlling for precipitation.

**Results:** Increasing daily minimum and maximum temperatures positively correlated with increasing trauma activations. While all trauma types increased with increasing temperature, assault traumas showed the highest rate of increase ($P < .001$). Compared to the lowest temperature quintile (< 46 °F), the two highest maximum temperature quintiles (> 73 °F and 83 °F) showed an increase in assault rates of 83% and 65% (incident rate ratio 1.83 [95% CI, 1.46–2.29] and 1.65 [95% CI, 1.32–2.07], respectively).

**Conclusion:** Trauma rates have a positive association with increasing ambient temperature rates. This temperature effect is largest among the assault group, suggesting that as temperatures continue to increase, so too will traumas that are the result of interpersonal violence. [West J Emerg Med. 2026;27(5)1149–1159.]

## INTRODUCTION

The ongoing climate crisis is changing both weather patterns and our society. Initial estimates from the 2015 Paris Agreement predicted that the planet will warm to 1.5 ºC above pre-industrial levels between 2030 and 2052.[1] However, data shows that the average temperature in 2024 reached 1.5 ºC above pre-industrial levels, suggesting that the 1.5–2 ºC limit of the Paris Agreement may be reached sooner.[2] In 2024,

weather disasters cost US $402 billion globally; 2024 was also noted as the hottest year on record for the contiguous United States.[2,3] The changes in our climate and monetary costs of weather events may impact processes as disparate as the food supply and transportation needs.[1]

Elevated temperatures have important impacts on human behavior. Increasing temperatures have been shown to correlate with increases in civil conflict in Sub-Saharan Africa,[4] online hate-speech in the United States,[5] and violent crime rates in the United States and globally.[6–9] A meta-analysis of studies of temperature and violent crime in 2024 found an increase of 9% in risk of violent crime for every 10 ºC increase in mean temperature,[6] and temperature has been shown to have a greater association with violent crime than overall crime.[7]

Temperature changes have also been shown to influence trauma hospitals' admission rates. Trauma rates are noted to increase substantially in summer months.[10–14] This is likely in part due to higher temperatures, as rates of adult and pediatric trauma presentations increase with increasing maximum temperatures.[10,11,15–23] Total emergency department (ED) presentations have been shown to increase with increasing temperature,[24–26] as well as the proportion of those visits made up of trauma patients.[27] Given the increase in trauma admissions, civil unrest, and violence when temperatures increase, it is likely that acts of violence are a significant contributor to the increase in traumatic injuries.

In this study, we performed a retrospective analysis of records of ED visits from the trauma database of a Level I trauma center in a large urban center and National Oceanic and Atmospheric Administration (NOAA) climate data to determine whether trauma rates increased with increasing ambient temperatures, and whether temperature-related effects on trauma rates were driven by intentional injuries (either violence or self-harm). Our hypothesis was that as ambient temperatures increase, trauma rates increase, with intentional injuries driving a large portion of this increase.

*Population Health Research Capsule*

What do we already know about this issue?
*Trauma rates are impacted by weather patterns, with higher rates during warmer weather.*

What was the research question?
*Does the assault trauma mechanism have the strongest association between weather and trauma rates?*

What was the major finding of the study?
*Compared to the lowest temperature quintile (< 46 ºF), the two highest temperature quintiles (> 73 ºF and 83 ºF) showed an increase in assault rates of 83% and 65% (incident rate ratio 1.83 [1.46–2.29] and 1.65 [1.32–2.07], respectively).*

How does this improve population health?
*We found an association between rates of assault trauma and increasing temperature, which may reflect the need to focus on intervention, as the climate changes.*

## METHODS

### Data Collection

After institutional review board approval for informed consent exemption waiver was obtained, we conducted a retrospective cohort study[28–30] of all full and partial ED trauma activations at Elmhurst Hospital, an urban Level I trauma center in New York, from January 2012–December 2019, inclusive. Inclusion criteria included patients ≥ 18 years of age who arrived as full and partial trauma activations. Consistent with performance improvement methodology and best practices in trauma literature, patients who arrived dead (no discernible blood pressure, pulseless, apneic) were excluded; these patients are considered to have low-to-no chance of survival, and their inclusion could introduce potential confounding variability and distract from targeting quality improvement opportunities.[31–33] We excluded from the analyses records with missing data for injury date and time or injury mechanism.

We collected data from our trauma registry, which contains extensive clinical data for all trauma patients who present to our ED. This includes Injury Severity Scale (ISS) and blood alcohol level, metrics required by the American College of Surgeons for trauma patients at Level I trauma centers.[34,35] Trauma activation is defined at our institution as the alerting of the trauma team of emergency physicians and nurses and trauma surgery physicians when a patient is deemed to have moderate or severe risk of injury based on institutional trauma guidelines. Patients meeting red trauma criteria led to full trauma team activations, while patients meeting yellow trauma criteria led to partial activations (Supplemental Figure 1). Partial trauma activations include emergency and trauma surgery physicians, while full activations include physicians from orthopedics, anesthesiology, the surgical intensive care unit, and operating room staff.

Weather data was obtained from the NOAA climate database for the LaGuardia Airport station, located approximately 2.3 miles from our hospital. Data included daily high (maximum) and low (minimum) temperatures in degrees Fahrenheit and daily precipitation in inches.

### Classification of Trauma Intent of Injury

We classified each trauma record into Centers for Disease

Control and Prevention (CDC)-defined intent of injury categories[36] using their assigned Centers for Medicare & Medicaid Services (CMS) *International Classification of Diseases* (ICD) mechanism billing codes from both the *Ninth Revision, Clinical Modification* (ICD-9-CM)[37] and *Tenth Revision* (ICD-10-CM) documentation.[38] Specifically, for each record, primary and secondary mechanism ICD-9-CM codes (from the *icd.data* R package[39]) and ICD-10-CM codes (*useicd10cm* R package[39]) codes were evaluated and matched to determine trauma mechanism and intent type. These ICD codes were then pattern-matched to external cause-of-injury codes (E-codes)[40,41] and then mapped to intent categories using the CDC's External Cause of Injury Mortality Matrix.[42,43] The intent of injury categories are as follows: 1) Unintentional; 2) Intentional Self-Harm; 3) Assault; 4) Legal Intervention/War Operations; and 5) Undetermined. Unmatched records were labeled as unspecified or other. We focused on Unintentional, Intentional Self-Harm or Assault injuries for subsequent analyses. Injury type (blunt, penetrating, burn) was precoded in our institution's trauma registry based on ICD-10 E-codes as determined by the New York State Trauma Registry.[44]

### Descriptive Analyses

Patient and trauma characteristics were summarized using descriptive statistics. For continuous variables, we compared between-group medians using the non-parametric Wilcoxon rank-sum test for two groups and the nonparametric Kruskal-Wallis rank-sum test for three or more groups. Categorical variables were checked with the chi-squared test, or Fisher exact test if the number of observations was < 20. Spearman correlation method was used to assess the nonlinear relationship between daily maximum (TMAX) and minimum temperatures (TMIN). We examined the relationship between trauma frequency and temperature changes daily and seasonally over the time period using scatterplots.

### Regression Analyses

To quantify the relationship between temperature and trauma frequency, we used generalized linear models with a Poisson distribution using TMAX and TMIN as categorical predictors (divided into quintiles based on empirical cut points from the full dataset) and mean number of daily trauma cases as the outcome, controlling for precipitation. Reference quintiles were 15 °F to 46 °F for TMAX and 1 °F to 46 °F for TMIN. Sensitivity analyses were conducted by repeating the regression analyses on subgroups of sex, race and ethnicity as reported in the data. We determined incidence rate ratios (IRR), their 95% confidence intervals, and *P* values for all models.

### Statistical Analyses

Throughout our analysis, statistical significance was defined as $P < .05$ for significance at the 95% CI, $P < .01$ at the 99% CI, and $P < .001$ at the 99.99% CI. All tests were two-tailed. We analyzed all data using R v4.4.2 ("Pile of Leaves," released October 31, 2024) (R Foundation for Statistical Computing, Vienna, Austria) in the RStudio integrated development environment v2025.05.1+513 (Posit PBC, Boston, MA).

## RESULTS

A total of 5,113 trauma activations met criteria during the study period, of which 80% were unintentional, 16.7% assaults, and 3.3% from intentional self-harm. Table 1 shows the sample characteristics overall and by trauma intent. There were three times as many men as women in the entire cohort, with the majority of assault patients being men (92%). Differences in sex were statistically significant across intent types ($P < .001$). Median age was 37.1 years, with the assault group being the youngest (29.3 years) and the unintentional group the oldest (40.1 years). The majority of patients were classified as "other" for race (60%). White patients comprised about one-fifth of both unintentional and self-harm groups. In contrast, Black patients were the second most common demographic group among assault cases (14%). Across all groups, non-Hispanic patients were more numerous than Hispanic patients, comprising 66% of patients in both the unintentional and self-harm groups and 53% of those in the assault trauma group.

Most trauma activations were partial activations (72%). Proportions were similar for unintentional traumas, with only 23% being full trauma activations. Assault and intentional self-harm were twice as likely to result in a full trauma team activation than unintentional traumas ($P < .001$).

On average, patients in the assault and self-harm groups had shorter ED length of stay than those in the unintentional trauma group ($P < .001$). Patients in the unintentional trauma and assault groups had comparable rates of discharge from the ED (42% and 47%, respectively) and death in the ED (1.2% and 1.4%, respectively). However, intentional self-harm trauma activations significantly differed from other groups, with only 35% being discharged from the ED and trauma patients who intentionally self-harmed being nearly three times as likely to die in the ED. Notably, trauma patients in the assault group had higher blood alcohol levels than other groups ($P < .001$).

Table 2 shows sample composition by trauma injury type and mechanism. Overall, most patients experienced blunt trauma (84%), although assault victims were twice as likely to have penetrating trauma (68% of assault patients) than blunt trauma (32%). Motor vehicle crashes and falls comprised 57% of all traumas and were the most frequent mechanisms among unintentional injuries, followed by pedestrian injuries (7.1%), bike crashes (5.6%), nontraffic motor vehicle injuries (5.6%), and environmental injuries (5.6%). Assault patients primarily had cutting/piercing injuries (64%), were struck (12%), or had firearm injuries (9.5%). Intentional self-harm cases mostly involved cutting/piercing injuries (54%), suffocation (19%), and falls (13%).

Figure 1 shows regional weather variations over the study

**Table 1.** Patient sample characteristics by primary injury intent in a study examining the relationship between trauma rates and minimum and maximum daily temperatures.

| Characteristic | Overall N = 5,113[1] | Unintentional n = 4,088[1] | Assault n = 855[1] | Intentional Self-Harm n = 170[1] | *P* value[2,3] |
|---|---|---|---|---|---|
| Age | 37.1 (22.3) | 40.1 (23.5) | 29.3 (11.9) | 34.9 (15.6) | <.0001*** |
| Sex | | | | | .0005*** |
| Male | 3,847 (75%) | 2,925 (72%) | 786 (92%) | 136 (80%) | |
| Female | 1,265 (25%) | 1,163 (28%) | 69 (8.1%) | 33 (20%) | |
| Race | | | | | .0005*** |
| Other | 2,932 (60%) | 2,244 (57%) | 593 (73%) | 95 (59%) | |
| White | 1,024 (21%) | 918 (23%) | 72 (8.9%) | 34 (21%) | |
| Asian | 481 (9.8%) | 437 (11%) | 30 (3.7%) | 14 (8.7%) | |
| Black | 438 (9.0%) | 305 (7.8%) | 116 (14%) | 17 (11%) | |
| American Indian | 9 (0.2%) | 7 (0.2%) | 1 (0.1%) | 1 (0.6%) | |
| Native Hawaiian or Other Pacific Islander | 1 (<0.1%) | 1 (<0.1%) | 0 (0%) | 0 (0%) | |
| Ethnicity | | | | | .0035** |
| Non-Hispanic | 2,980 (64%) | 2,467 (66%) | 410 (53%) | 103 (66%) | |
| Hispanic | 1,674 (36%) | 1,257 (34%) | 365 (47%) | 52 (34%) | |
| Not applicable | 2 (<0.1%) | 2 (<0.1%) | 0 (0%) | 0 (0%) | |
| ISS | 4.0 (10.6) | 5.0 (10.8) | 2.0 (9.1) | 4.0 (11.7) | <.0001*** |
| Trauma team activation level | | | | | .0005*** |
| Partial, second level response | 3,667 (72%) | 3,163 (77%) | 428 (50%) | 76 (45%) | |
| Full team activation, highest level response | 1,446 (28%) | 925 (23%) | 427 (50%) | 94 (55%) | |
| ED LOS (hours) | 7.3 (31.7) | 7.6 (35.3) | 6.1 (7.3) | 4.2 (6.9) | <.0001*** |
| ED disposition | | | | | .0005*** |
| Admitted | 2,701 (53%) | 2,184 (53%) | 425 (50%) | 92 (54%) | |
| Discharged to home or self-care (routine discharge) | 2,198 (43%) | 1,736 (42%) | 402 (47%) | 60 (35%) | |
| Died in ED | 67 (1.3%) | 48 (1.2%) | 12 (1.4%) | 7 (4.1%) | |
| Transferred to another hospital ED | 64 (1.3%) | 59 (1.4%) | 5 (0.6%) | 0 (0%) | |
| Died on arrival | 38 (0.7%) | 32 (0.8%) | 3 (0.4%) | 3 (1.8%) | |
| Died within 15 minutes | 27 (0.5%) | 16 (0.4%) | 5 (0.6%) | 6 (3.5%) | |
| Transferred to another hospital in-patient | 18 (0.4%) | 13 (0.3%) | 3 (0.4%) | 2 (1.2%) | |
| Alcohol level (mg/dL) | 0.0 (129.6) | 0.0 (130.0) | 132.0 (125.0) | 0.0 (103.4) | <·0001*** |

[1]Median (SD); n (%)
[2]Kruskal-Wallis rank sum test
[3]*$P < .05$; **$P < .01$; ***$P < .001$
*ED*, emergency department; *ISS*, Injury Severity Scale; *LOS*, length of stay; *mg/dL*, milligram per deciliter.

period. The TMAX and TMIN varied seasonally, with peaks in summer months and troughs in winter months (Figure 1A). Daily TMAX and TMIN showed a strong correlation with each other (Spearman $\rho = 0.96$, $P < .001$). Conversely, there was high variability in precipitation across the study period, ranging from 0–8 inches, without a clear seasonal pattern (Figure 1B). Notably, months with heavier precipitation became more frequent beginning in 2017. There was no significant correlation between TMAX or TMIN and precipitation (Spearman $\rho = -0.03$, $P = .15$). Figure 1C illustrates the distribution of daily TMAX and TMIN, showing that both have a bimodal distribution of values, corresponding to seasonal extremes. The TMAX skews left with a median around 65 °F, while TMIN skews right with a median around 51 °F.

Figure 2 shows the relationship between temperatures and mean daily trauma counts. Figure 2A shows the temperature-trauma relationship over the eight-year study period, fitted using locally estimated scatterplot smoothing (LOESS) curves

**Table 2.** Summary of injuries and mechanisms of cohort in a study examining the relationship between trauma rates and minimum and maximum daily temperatures.

| Characteristic | Overall N = 5,113[1] | Unintentional n = 4,088[1] | Assault n = 855[1] | Intentional Self-Harm n = 170[1] |
|---|---|---|---|---|
| Injury type | | | | |
| Blunt | 4,284 (84%) | 3,926 (96%) | 273 (32%) | 85 (50%) |
| Penetrating | 798 (16%) | 133 (3.3%) | 582 (68%) | 83 (49%) |
| Burn | 30 (0.6%) | 29 (0.7%) | 0 (0%) | 1 (0.6%) |
| Unknown | 1 (0%) | 0 (0%) | 0 (0%) | 1 (0%) |
| Mechanism type | | | | |
| Motor vehicle-Traffic | 1,576 (31%) | 1,571 (38%) | 3 (0.4%) | 2 (1.2%) |
| Fall | 1,336 (26%) | 1,312 (32%) | 2 (0.2%) | 22 (13%) |
| Cut/pierce | 663 (13%) | 26 (0.6%) | 546 (64%) | 91 (54%) |
| Pedestrian, other | 291 (5.7%) | 291 (7.1%) | 0 (0%) | 0 (0%) |
| Pedal cyclist, other | 230 (4.5%) | 230 (5.6%) | 0 (0%) | 0 (0%) |
| Motor vehicle-nontraffic | 228 (4.5%) | 228 (5.6%) | 0 (0%) | 0 (0%) |
| Natural/environmental | 228 (4.5%) | 228 (5.6%) | 0 (0%) | 0 (0%) |
| Struck by/against | 156 (3.1%) | 52 (1.3%) | 104 (12%) | 0 (0%) |
| Firearm | 91 (1.8%) | 5 (0.1%) | 81 (9.5%) | 5 (2.9%) |
| Other specified, not elsewhere classifiable | 84 (1.6%) | 2 (<0.1%) | 72 (8.4%) | 10 (5.9%) |
| Other transport | 67 (1.3%) | 66 (1.6%) | 1 (0.1%) | 0 (0%) |
| Unspecified | 55 (1.1%) | 14 (0.3%) | 41 (4.8%) | 0 (0%) |
| Suffocation | 35 (0.7%) | 2 (<0.1%) | 0 (0%) | 33 (19%) |
| Other specified, classifiable | 22 (0.4%) | 17 (0.4%) | 5 (0.6%) | 0 (0%) |
| Fire/burn | 21 (0.4%) | 18 (0.4%) | 0 (0%) | 3 (1.8%) |
| Poisoning | 7 (0.1%) | 7 (0.2%) | 0 (0%) | 0 (0%) |
| Machinery | 6 (0.1%) | 6 (0.1%) | 0 (0%) | 0 (0%) |
| Other land transport | 5 (<0.1%) | 1 (<0.1%) | 0 (0%) | 4 (2.4%) |
| Overexertion | 5 (<0.1%) | 5 (0.1%) | 0 (0%) | 0 (0%) |
| Hot object/substance | 4 (<0.1%) | 4 (<0.1%) | 0 (0%) | 0 (0%) |
| Drowning/submersion | 2 (<0.1%) | 2 (<0.1%) | 0 (0%) | 0 (0%) |
| Bites and stings, nonvenomous | 1 (<0.1%) | 1 (<0.1%) | 0 (0%) | 0 (0%) |

[1]n (%)

to smooth over day-to-day variability. There was a nonlinear positive association between temperature and trauma frequency, especially in the mid-temperature range. For TMIN, there is an initial downward trend in trauma frequency as temperature increases from 0 to 25 °F, followed by an uptrend in frequency, peaking at approximately 75–80 °F. The TMAX exhibited a similar pattern, with trauma frequency being lower at cooler temperatures, increasing steadily as temperatures increase up to 75–80 °F range and then leveling off past 80 °F. Daily total trauma counts ranged from 0-10 daily and followed similar seasonal patterns as temperature (Figure 2B).

Figure 3 shows the relationship between daily temperatures and trauma frequency stratified by intent type. For unintentional traumas, frequency remained relatively stable across temperature ranges, with only a slight increase at higher temperatures for both TMAX and TMIN. For assault injuries, there was a positive association between temperature and frequency, with higher assault rates at warmer temperatures (30–65 °F). Intentional self-harm rates were generally low and stable across the temperatures, with some isolated spikes at higher temperatures.

Table 3 and Figure 4 shows regression results for TMAX and TMIN quintiles on mean daily number of traumas by trauma intent type (controlling for precipitation). Incident rate ratios increased as TMAX increased. Total trauma frequency increased with TMAX, reaching a 27% increase in the highest

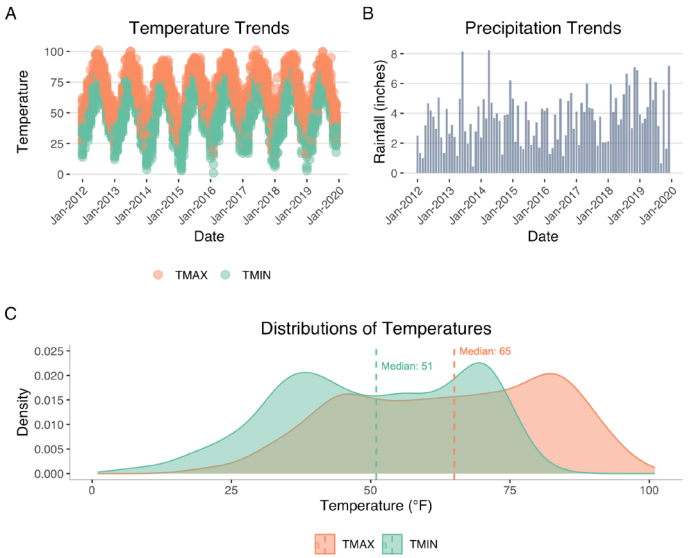


**Figure 1.** Weather trends in Queens, New York, from 2012–2019.

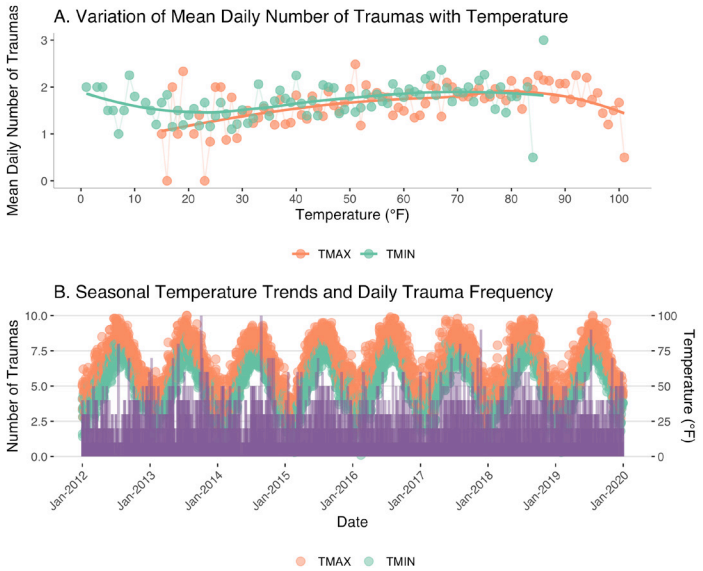


**Figure 2.** Variation of trauma frequency with temperatures in a study examining the relationship between trauma rates and minimum and maximum daily temperatures.

temperature quintile (83 °F to 101 °F) compared to the coolest temperatures ($P < .001$). Assault trauma exhibited the most dramatic temperature-dependent pattern, with rates increasing substantially across temperature quintiles. There was a 39% increase at 47–59 °F ($P < .01$), 49% increase at 60 °F–72 °F ($P < .001$), 83% increase at 73 °F–82 °F ($P < .001$), and 65% increase at 83 °F–101 °F ($P < .001$). The greatest increase in the fourth quintile (73 °F–82 °F) is consistent with the decline in rates above 80 °F seen in Figure 3. Unintentional trauma showed a more moderate temperature effect, with the highest quintile demonstrating a 23% increase in rates ($P < .001$). In contrast, self-harm trauma rates decreased with increasing temperatures (IRR < 1.0, $P \geq .05$).

Results were similar for TMIN, with a 21% and 76% increase in overall and assault trauma frequency, respectively, in the highest temperature quintile (69 °F to 86 °F) compared to the coolest temperatures ($P < .001$). Unintentional trauma again showed a more moderate but statistically significant increase, while self-harm showed a decrease that was not significant. For all models, precipitation showed no significant effect on any trauma type nor overall (IRRs ~ 1.00, $P \geq .05$).

**Sensitivity Analyses**

Regression analyses stratified by sex, race and ethnicity were conducted for subgroup sensitivities (Supplementary Tables 1 and 2, respectively). Note, there were no statistically significant associations between precipitation and injury for any subgroups ($P \geq .05$).

*Sex*

Men showed increased assault risk at higher TMAX, with the 73 °F–82 °F range demonstrating a statistically significant 42% increase in assault incidents ($P < .01$), and risk decreasing thereafter (Supplementary Table 1). Risk of self-harm incidence decreased by 48% in this same temperature range ($P < .05$). There were similar increases in assault risk as TMIN increased, especially in the 46 °F–86 °F ranges ($P < .05$). There were no statistically significant patterns for unintentional or overall trauma rates ($P \geq .05$). Women showed similar trends to men, however there was a nearly nine-fold increase in assault rates in the highest temperature range ($P < .001$)

*Ethnicity*

Hispanic patients saw some notable temperature-injury associations, with IRRs of assaults increasing up to TMAX of 82 °F (Supplementary Table 2). A TMAX of 73 °F–82 °F produced the strongest association with assault risk, showing an 88% increase in risk ($P < .001$). Conversely, TMAX was protective against self-harm, with a significant reduction of 72% in risk in the 47 °F–59 °F TMAX range ($P < .05$). Results were similar for TMIN. The non-Hispanic population exhibited more moderate temperature-injury associations, with increasing but not statistically significant IRRs observed as TMAX increased ($P \geq .05$). Only TMIN of 58 °F–68 °F showed a statistically significant increase of 52% elevation in risk ($P < .01$). There were no statistically significant associations across TMAX or TMIN for self-harm traumas ($P \geq .05$).

## DISCUSSION

This study investigated the effect of ambient temperature on rates of trauma presentations at a Level I trauma center at a

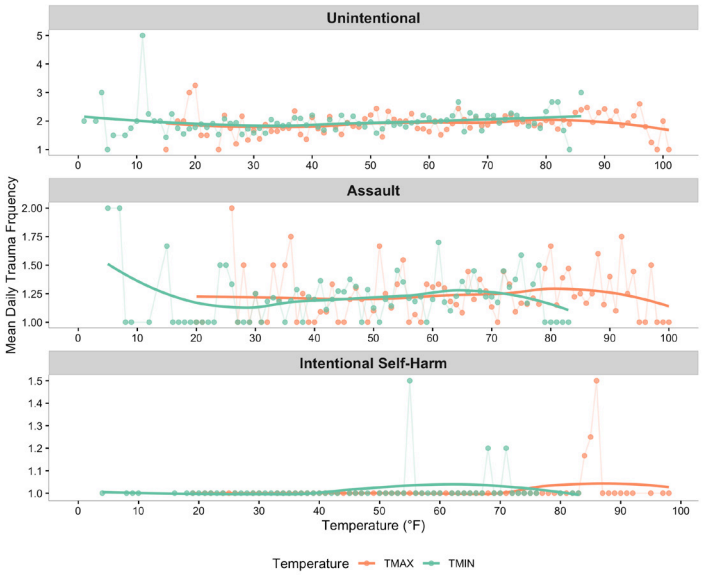


**Figure 3.** Variation of mean daily number of traumas with temperature by trauma intent subtype.

large, urban hospital. We hypothesized that not only would trauma rates increase as temperatures increase, but that this temperature-related increase would be driven by assaults, as opposed to unintentional injuries or intentional self-harm.

Our results suggest that temperature is positively correlated with overall trauma volume, suggesting a temperature-related increase in trauma incidence. This could reflect behavioral or environmental changes such as more people being active outdoors, heat-related stressors, or seasonal risk factors. Further, our regression analysis illustrates that maximum daily temperatures above 83 °F may reflect a temperature threshold beyond which trauma risk does not continue to rise, again possibly due to behavioral or environmental limits. Further, assault trauma frequency showed a strong positive relationship with temperature in dose-dependent manner,[45] while self-harm remains unaffected by temperature variations.[8,9] This suggests that heat is a specific risk factor for interpersonal violence.

Our sensitivity analyses showed a clear sex disparity in weather-injury relationships, with women showing substantially greater sensitivity to temperature-related assault risk. Similarly, Hispanic populations demonstrated substantially greater sensitivity to temperature variations than their non-Hispanic counterparts, particularly regarding assault risk during warmer conditions. This suggests potential vulnerability factors that may include social, economic, or environmental circumstances that interact with weather patterns.

We found that rainfall patterns did not meaningfully influence overall and specific injury rates in this population. Precipitation effects remained minimal across subgroups of sex, ethnicity and race.[46] Additionally, our finding of an elevated median blood alcohol level in the assault group suggests that alcohol use is a significant risk factor for assault.[47–50] Finally, alcohol use in our patient population was not correlated with unintentional trauma that may be frequently associated with alcohol, such as motor vehicle crashes or falls.

## Strengths

This study has several strengths. Firstly, by examining an eight-year period, we avoided drawing conclusions about climate patterns based on anomalous individual years. This approach prevented distortions from irregular weather events such as El Niño,[51] specific disasters such as Hurricane Sandy in 2012,[52] or the volume changes caused by the COVID-19 pandemic that began in 2019, when Elmhurst Hospital became one of the most overwhelmed hospitals in the United States.[53]

Second, we classified traumas by both intent and mechanism, going beyond the common practice of using only broad categories like blunt, penetrating, or burn injuries. This detailed classification allowed us to better understand causality, which can inform more targeted prevention strategies. Our findings revealed that seasonal increase in traumas resulted primarily from rising assault rates; community and governmental violence prevention programs could help reduce this pattern. Additionally, that motor vehicle collisions were the most frequent injury mechanism overall suggests that street redesigns and traffic calming measures in our hospital's catchment area could significantly reduce trauma cases.

Third, our use of temperature ranges rather than absolute temperature values represents a methodologically sound approach that accounts for the nonlinear nature of temperature-injury relationships and provides more robust statistical power by aggregating observations across meaningful temperature categories rather than treating temperature as a continuous variable with potentially sparse data points at extreme values.

## Clinical Implications

Our findings suggest that the rising global temperatures of climate change may impact the practice of emergency medicine by increasing trauma rates and changing trauma patterns. With patients now exposed to twice as many heatwave days as they would have experienced in 1985–2005,[54] the effects of high temperatures on trauma rates is likely to worsen in the coming years. This may warrant seasonal staffing adjustments in trauma centers to account for the greater numbers of trauma presentations. Staffing needs and resource utilization at trauma hospitals is likely to significantly contribute to the estimated US $820 million annual health costs in the U.S. from climate change, and the US $1.1 trillion burden on healthcare systems due to climate change predicted by 2050 by the World Economic Forum.[55,56]

Our results show that these changes may be driven by trauma resulting from interpersonal violence, suggesting a clear target for intervention. The differential patterns in the

**Table 3.** Effect of minimum and maximum daily temperature quintiles on mean daily number of traumas.

| | Total | Assault | Unintentional | Self-Harm |
|---|---|---|---|---|
| Predictor | IRR (95% CI) | IRR (95% CI) | IRR (95% CI) | IRR (95% CI) |
| Maximum Temperature | | | | |
| Reference: 15 °F to 46 °F | — | — | — | — |
| 47 °F to 59 °F | 1.15 (1.05–1.26)** | 1.39 (1.10–1.76)** | 1.14 (1.03–1.26)** | 0.67 (0.42–1.07) |
| 60 °F to 72 °F | 1.15 (1.05–1.25)** | 1.49 (1.18–1.87)*** | 1.12 (1.01–1.23)* | 0.79 (0.50–1.23) |
| 73 °F to 82 °F | 1.16 (1.06–1.27)** | 1.83 (1.46–2.29)*** | 1.08 (0.98–1.19) | 0.66 (0.40–1.06) |
| 83 °F to 101 °F | 1.27 (1.17–1.39)*** | 1.65 (1.32–2.07)*** | 1.23 (1.12–1.36)*** | 0.88 (0.57–1.36) |
| Minimum Temperature | | | | |
| Reference: 1 °F to 35 °F | — | — | — | — |
| 36 °F to 45 °F | 1.13 (1.03–1.23)** | 1.34 (1.06–1.70)* | 1.12 (1.01–1.23)* | 0.73 (0.45–1.15) |
| 46 °F to 57 °F | 1.11 (1.01–1.21)* | 1.60 (1.27–2.01)*** | 1.05 (0.95–1.16) | 0.84 (0.53–1.31) |
| 58 °F to 68 °F | 1.25 (1.14–1.36)*** | 1.78 (1.42–2.23)*** | 1.20 (1.09–1.32)*** | 0.63 (0.38–1.02) |
| 69 °F to 86 °F | 1.21 (1.11–1.32)*** | 1.76 (1.41–2.21)*** | 1.14 (1.04–1.26)** | 0.93 (0.60–1.44) |

Notes:
[1]Temperatures were divided into quintiles based on their daily distribution. The reference range is the first quintile. IRR for this quintile is standardized to 1.00 (no effect).
[2]Statistical significance: * indicates *P* value < .05, ** indicates *P* value < .01, *** indicates *P* value < .001.
*IRR*, incident rate ratios.

sensitivity analyses have significant implications for targeted public health interventions, underscoring the critical importance of incorporating racial and ethnic demographics into environmental health interventions targeting temperature-related injury prevention. These effects reflect complex interactions between environmental exposures, socioeconomic factors, and community-level vulnerabilities that require further investigation to develop effective, culturally appropriate interventions.

### Research Implications

Our study contributes to trauma and climate science literature by showing that increasing rates of trauma occur as outdoor temperatures increase, driven largely by assaults, as opposed to alcohol-related motor vehicle crashes, falls, or self-harm, with variable patterns in different demographic groups. Further research is required to better understand causal factors contributing to differential trauma vulnerability with increasing temperature across demographic subgroups, and to assess the role for and efficacy of different violence prevention interventions.

## LIMITATIONS

The findings of our study must be interpreted within the context of its limitations. As a single-center study conducted in a large urban environment, our findings may not be generalizable to other trauma hospital settings. Moreover, New York City's unique characteristics—including high population density, extensive public transit, and strict gun-control laws—likely influenced our results in ways that differ from other locations. The impact of local gun laws is particularly evident in our data. Nationally, there were over 39,000 fatal and 82,000 nonfatal gunshot wounds in 2019 alone.[57] In contrast, only 81 patients in our sample were injured by firearms in our eight-year study period. Our findings may be further explained by Queens having the lowest per capita gunshot wounds among New York City's boroughs.[58] This limits our study's generalizability to other areas with different crime profiles.

Our analysis is also limited by using clinician-assigned ICD coding to determine injury mechanisms. This is an inherently subjective process and requires clinician's judgment and discretion when assigning ICD codes. Additionally, it is likely that for many patients only a single ICD code was selected when multiple may have been appropriate.

Race and ethnicity in our database are categorized according to National Trauma Standard Data Dictionary. This framework lacks nuance,[59] and includes an "other" race category that may mask distinct injury patterns among diverse populations. In racially and ethnically diverse neighborhoods, many people may consider themselves multiracial or not otherwise fit well into a single racial demographic. Ideally, race is determined by patient self-report; however, in a trauma setting where patients are often in extremis or unresponsive, this is often not possible. Additionally, the American Indian and Native Hawaiian/other Pacific Islander participants were excluded from analysis due to insufficient sample sizes. These constraints may obscure population-specific temperature-injury relationships and reduce generalizability to other

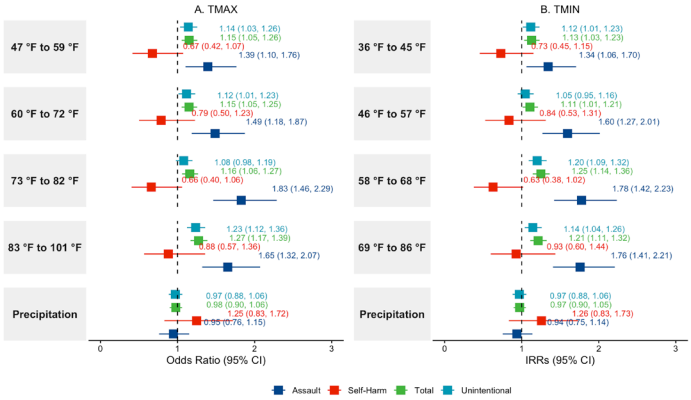


**Figure 4.** Forest plot of effect of temperatures on mean daily number of traumas by intent.

communities with different population differences. The large percentage of patients classified as "other" (60%) significantly limited our ability to assess if the relationship between increasing ambient temperatures and trauma differed across racial groups, and so sub-group analyses by race have not been included in this study.

Further, our study used the daily minimum and maximum temperatures as recorded by NOAA for our analysis of the relationship between ambient temperature and rates of trauma presentations, because this data is recorded in routine weather monitoring. Predictions of daily minimum and maximum temperature are easily accessible to both emergency physicians and hospital administration across the United States, enabling their use to predict trauma volumes and adjust staffing if needed. However, heat stress is not only influenced by air temperature, but also by relative humidity, wind speed, and heat radiation.[60] Thus, the application of a composite index, such as wet-bulb globe temperature,[61] which includes these variables may better reflect the physiologic stress of increasing ambient temperatures.

## CONCLUSION

Increased temperature is associated with an increase in overall trauma incidence, with a potential peak or saturation point in the upper temperature ranges. Trauma rates showed seasonal variation, with more trauma presentations in warmer months, with the largest increase in trauma rates among intentional injuries. As the climate warms, there is a risk for increasing trauma presentations secondary to violence. Thus, both hospital staffing models and public health interventions must anticipate this change.

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# Partial Immersion Using Body Bags for Exertional Hyperthermia: A Randomized Crossover Study

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**Introduction**: Recent recommendations suggest emergency medical personnel should consider rapid whole-body cooling for heat stroke patients. Cold-water immersion maximizes cooling rate and subsequent outcomes following heat stroke. Body bags filled with ice and water may provide portable, accessible partial cold-water immersion for this setting. The purpose of this study was to determine whole-body cooling rates when using body bags to facilitate partial cold-water immersion to treat exertional hyperthermia.

**Methods:** A total of 9 healthy participants (8 male; mean [SD] age, 24 [4] years; height, 175 [7] cm; body mass, 83.6 [21.6] kg) completed our randomized-crossover field study. Following hydration verification, participants completed a self-paced 400 warm-up run, 1,609 m run, and 10-m sprints until rectal temperature ($T\text{-}_{rec}$) reached 39.2 °C or volitional exhaustion. Following exercise, participants were cooled for a maximum of 30 minutes lying supine in the shade (control; CON) or in body bags filled with 20 gallons of ice water (5.2 [1.6] °C). Following cooling, participants sat upright for a 15-minute recovery. $T\text{-}_{rec}$ and heart rate (HR) were taken throughout exercise, every minute of cooling, and every 5 minutes of recovery. Participants completed both trials separated by 1 week in random order.

**Results:** Wet bulb globe temperature between trials was not significantly different (grand mean, 28.43 [1.03] °C; $P = .73$). There was no difference in participant maximum $T\text{-}_{rec}$ (body bag, 38.98 [.23] °C; CON, 38.93 [.39] °C; $P = .45$); HR (body bag, 183 [14] beats per minute [bpm]; CON, 189 [13] bpm; $P = .21$); rating of perceived exertion ($P > .99$); thirst ($P = .62$); or thermal sensation ($P = .73$) during exercise. Fluid consumed ($P = .40$), body mass change ($P = .90$), 400 m run times ($P = .19$) and 1,609 m run times ($P = .17$) were no different between trials. Whole-body cooling rate for body bag was .102 (.04) °C/min, whereas CON produced a cooling rate of .040 (.04) °C/min (95% CI, .030-.095; $P = .002$). Total cooling time was significantly faster (13.2 (5.8) min) with BB compared to CON (27.6 (4.2) min; 95% CI, 9.2-19.5; $P = .002$).

**Conclusion:** In clinical settings where full-body cold-water immersion is not feasible, or during emergency transport, partial immersion via body bags offers acceptable cooling rates for hyperthermic patients. Emergency medical personnel could apply these data for support in updating heat stroke protocols to include partial immersion via body bag during transport, or immediately upon emergency department arrival. [West J Emerg Med. 2026;27(5)1160–1166.]

## INTRODUCTION

Heat stroke represents the most serious heat illness, with potentially fatal consequences unless rapid recognition and treatment are initiated soon after onset.[1-4] Clinical recommendations for the management of exertional heat stroke demonstrate overwhelming success when early recognition and effective treatment are initiated.[5] Evidence-based recognition and management could improve outcomes within military and emergency department (ED) settings. The Army and Marine Corps have higher incidences of exertional heat stroke with .67 per 1,000 person-years and .72 per 1,000 person-years, respectively.[6] However, the feasibility of having cold-water immersion tubs available for all training is limited.[6] In EDs, the recognition and treatment of either classic or exertional heat stroke also present challenges.[7,8] In one analysis, 5.4% of those admitted to the hospital for heat illness were diagnosed with heat stroke.[9] Those who were diagnosed had an admittance rate of 62.0%.[8] In some areas, heat stroke cases represent 28.3% of all admissions and 77% of all deaths for heat illness cases.[8] These numbers are the result of medical personnel on-site not following a "cool first, transport second" protocol, as well as a lack of resources for rapid cooling upon ED arrival.[9,10]

Military and ED settings include specific barriers for compliance with established, recommended practices for exertional heat stroke.[6] Following rapid recognition in the field, effective treatment should be applied to avoid negative outcomes or sequelae.[10-12] Data strongly suggest 100% fatality avoidance with whole-body cold-water immersion.[5,10] In emergent situations, the standard of care is to confirm diagnosis (core temperature > 40.5 °C with central nervous system dysfunction) and immerse the patient. Recent prehospital care recommendations echo these guidelines.[1,11,12] Treatment for classic heat stroke, however, lacks consistent supportive data.[8,12] Recent cases support aggressive cooling for classic heat stroke patients as well.[13-15] In either case, if lifesaving treatment involves reducing hyperthermia as quickly as possible, data support the use of cold-water immersion.[5,13] Further, to facilitate effective cooling, using the coldest water possible and including water circulation should be included. Recent cases demonstrate successful outcomes for patients with exertional or classic heat stroke treated with cold-water immersion.[16,17]

Common issues reported include the logistics of transporting a large rigid tub in various environments and having access to water and ice volumes necessary for effective cold-water immersion. Both venues present a unique opportunity based on likely availability of body bags. Since cold-water immersion in a large rigid tub— the current gold standard for whole-body cooling[17]—is not always feasible at the site of heat stroke or during transport, body bags present a conduit to perform partial immersion.[4,13] According to McDermott et al,[17] ideal cooling rates for patients with exertional heat stroke are ≥ .155 °C/min, acceptable cooling rates are those between .078 °C/min and .154 °C/min, and unacceptable rates are those < .078 °C/min. Data are sparse on cooling rates for hyperthermic individuals in body bags.

*Population Health Research Capsule*

What do we already know about this issue?
*Cold-water immersion provides the fastest cooling rates for hyperthermic individuals and leads to superior patient outcomes.*

What was the research question?
*We sought to compare cooling rates for partial immersion in a body bag against lying in the shade for hyperthermic individuals.*

What was the major finding of the study?
*Cooling rate for body bags was .102 (.04) °C/min, whereas lying in the shade was .040 (.04) °C/min (95% .030-.095; P = .002).*

How does this improve population health?
*Using a body bag to facilitate whole-body cooling via partial immersion is an option for treating hyperthermic patients in remote settings or during transport.*

Studies have been sponsored by a manufacturer of the Polar Life Pod, a body-bag–like device including a pillow and straps (Polar Products, Inc, Stow, OH). Miller and Beck[18] reported efficient cooling using the device with water oscillations (between .10 and .17 °C/min) with varying water volumes. Further, Miller and Amaria[19] reported ideal cooling with constant oscillations using different water temperatures. Nye et al,[20] however, in the only study using the Polar Life Pod without manufacturer funding, found inadequate cooling rates (.04 °C/min). The device may not be a feasible alternative in emergency medical services situations given the cost (> $400); however, traditional body bags, already available in emergency settings, offer a more affordable option.

There are case report data supporting cooling with body bags.[4,10,13-15] However, without documented support with consistent cooling rates, clinicians should use caution when applying body-bag partial immersion. Offering this alternative could demonstrate an effective cooling modality and improve compliance and patient outcomes. Body bags filled with ice and water, which can fully encase a patient, offer an alternative method of cooling while increasing portability and accessibility for other healthcare professionals (emergency physicians, nurses, etc) and tactical settings. An alternative

cooling modality that produces acceptable or ideal cooling rates could be used to treat heat stroke in settings where access to cold-water immersion tubs or a commercial cooling device is limited, or not feasible.

The purpose of this study was to determine whether partial immersion cooling via body bags offers cooling rates that can be deemed appropriate for cooling hyperthermic patients. Our hypothesis was that partial immersion using a body bag would produce acceptable or ideal cooling rates, making them appropriate to recommend for partial immersion as an alternative treatment when cold-water immersion is not feasible.

## METHODS

We used a randomized, crossover research design in the field to test our hypothesis. The University of Arkansas Institutional Review Board (IRB) approved the study. A total of 13 volunteers were recruited from the University of Arkansas and surrounding area. Each participant completed a medical questionnaire screening to determine fitness and health levels as well as assuring inclusion criteria were met. One participant did not meet inclusion criteria (taking medication known to affect thermoregulation) and was excluded from our study. Participants were included if they self-reported physical activity for at least 30 minutes three times a week and were under the age of 40 years. Participants were excluded if they had suffered from heat illness or exertional heat stroke in the prior three years, were taking medication known to alter fluid balance and/or thermoregulation, were sick at the time of testing, or had suffered a recent orthopedic injury or had exercise restrictions due to an injury. Once clearance was given, participants were randomly assigned to participate in two trial conditions, with the order of treatment for trials randomized using an online random number generator. Researchers and participants were unaware of the trial order for each participant until they arrived and signed their consent form. Based on previous data on cooling rates within our lab, and to garner an estimated power of .80 with significance set to < .05, we calculated that a sample size of eight was required.

Participants were randomly assigned to a control (CON) or body-bag cooling trial, with allocation concealed; trials occurred one week apart. We chose not to include a trial of full-body cold-water immersion because those cooling rates have been fully established.[17] Further, because cooling rates from exercise hyperthermia match those from case series data, the established cooling rates following exercise hyperthermia are assumed similar to actual heat illness scenarios.[4,16,17] On the day of the trials, participants reported to the recreational fields at the University of Arkansas at their allocated time. Each subject read through and signed the IRB-approved consent form, and participants could question the research team. Following consent, each participant submitted 24-hour food and fluid logs, which they were instructed to complete for the day leading up to trials to ensure similar fueling and hydration status between trials. They also affirmed that they had not consumed alcohol within 24 hours or participated in exercise within 12 hours of the study trial.

Wet bulb globe temperature was taken every 15 minutes during data collection (Kestrel 4500, Boothwyn, PA). Following consent and paperwork, body mass was measured with a ground scale (Health-o-meter model 349KLX, Buford, GA), height was obtained using a stadiometer, and pretrial urine specific gravity (USG, Master-SUR, Atago Co Ltd, Tokyo, Japan) was obtained to confirm euhydration, which was established as < 1.020. Participants were then instrumented by self-inserting a rectal thermistor (RET-1, Physitemp, NJ) 15 cm past the anal sphincter. To confirm proper instrumentation, a preliminary reading was obtained. If there were invalid readings (< 36 °C or > 38 °C), participants were instructed to further insert the thermistor, or the thermistor was exchanged. Researchers then fit and calibrated participants with a GPS and heart rate (HR) watch (Ironman Triathlon, TIMEX, CT). Both the rectal thermistors and watches were number labeled and matched between trials. Participants were instructed to wear comfortable clothing for exercise and cooling (with potential immersion). Clothing during exercise and cooling was matched for each participant between trials. Participants were considered heat acclimatized due to data collection occurring in September in a mid-southern state.

Our exercise protocol was based on previous work demonstrating safe rectal temperature ($T\text{-}_{rec}$) increases in a relatively short time period (18–20 minutes). Participants began their exercise trial with a 400 m self-paced warm-up. Following the 400 m warm-up, they were instructed to complete a 1,609 m run (1 mile) at their own pace around the fields. Following the warm-up, researchers collected ($T\text{-}_{rec}$), HR, and perceptual measures. Perceptual measures included rating of perceived exertion, thirst, and thermal sensation. Participants had 5 minutes to walk around, rest, stretch, and drink water at their discretion. They were also informed that they were not permitted additional fluids for the remainder of the trial. Water consumed was measured in mL following the 5-minute rest and matched between trials. Then, participants began their 50-yard out-and-back sprints for a total of 100 yard sprints. A set was made up of 5 sprints separated by 30 seconds rest between each out-and-back. Once a set of sprints was completed, $T\text{-}_{rec,}$ HR, and perceptual measures were recorded during a 3-minute rest period. Participants repeated sets of sprints until either (1) $T\text{-}_{rec}$ of 39.2 °C or (2) unwillingness to continue due to exhaustion or signs/symptoms of heat illness presented. When either of those criteria were met, the 5-minute transition to cooling commenced. Transition included a postexercise body mass measure, which was used to calculate sweat rate during exercise.

Cooling was completed in the shade for both conditions, either immersed in a postmortem bag (Cardinal Health Inc, Dublin, OH) with cold water or sitting in the shade. Blinding of participants, researchers and data recorders was not possible during cooling. During the transition, two 10-gallon coolers were filled with one 5-lb bag of ice and water. The body bag was prepped in the grass field under a shaded tent with four seatbelts (Xuesong, China) wrapped around the bag and a half pool-noodle at the participant's head to keep it propped throughout cooling (Figure 1).

Following the 5-minute transition period, perceptual and physiological measurements were taken before cooling began. Body-bag cooling occurred while participants were supine in the bag with 20 gallons of ice water poured on them and the bag zipped and seatbelts closed and cinched around the participant's body.

Four to six researchers surrounded the participant while continuously oscillating the water in the bag. Throughout cooling, $T\text{-}_{rec}$ and HR were measured every minute with perceptual measurements taken following treatment. The. CON cooling occurred with the participant lying in the shade on a tarp. The cooling portion of the study was complete when a $T\text{-}_{rec}$ of 37.9 °C or 30 minutes of cooling was reached, regardless of trial. After cooling ceased, participants sat upright for 15 minutes to assure recovery from cooling.

Following recovery, the trial concluded and investigators removed the monitoring equipment. Participants returned their gear and received hydration and snacks prior to departure. Trials were separated by seven days, and participants who completed both trials were compensated for their time.

Sweat rate was calculated according to recommended assessment.[21] Data were analyzed using SPSS for Mac (version 24.0; IBM Corp, Armonk, NY). Data for variables with two time points including wet bulb globe temperature, hydration status, and sweat rate were compared using paired samples *t*-tests. All data for variables with multiple time points were compared using repeated measures analysis of variance. When sphericity was violated, Greenhouse-Geisser corrections were used for interpretation. When a significant time point or interaction existed, post hoc analyses were conducted using Bonferroni correction. Data are presented using mean (SD), and alpha was set a priori as $P < .05$.

**Figure 1.** Body bag cooling set-up to treat a participant in a field study to determine whole-body cooling rates when using body bags to treat exertional hyperthermia.

## RESULTS

Two participants did not begin either trial due to outside conflicts preventing participation. One participant suffered a musculoskeletal injury outside data collection following the first trial and could not complete the second trial. Any data gathered from these individuals were not used in the final analysis. Data for 9 participants (8 male; 24 [4] years, 175 [7] cm, 83.6 [21.6] kg); body surface area, 1.99 [.11] $m^2$) were included.

Body mass (83.59 [21.61] kg; $P = .90$) and wet bulb globe temperature (28.43 [1.03] °C; $P = .73$) were similar between trials. Mile (1,609 m) times between trials (T1: 515.11 (132.21) seconds vs T2: 491.56 (102.61) seconds) were not significantly different (P = .40). There was no difference in rating of perceived exertion (15.39 [2.72]; $P > .99$), thirst sensation (6.12 [2.11]; $P= .62$), or thermal sensation (6.32 [.873]; $P = .73$) throughout exercise. Physiological measurements of HR (body bag, 183 [14] bpm; CON, 189 [13] bpm; $P = .21$) and maximum $T\text{-}_{rec}$ (body bag, 38.98 [.23] °C; CON, 38.93 [.39] °C; $P = .45$) showed no significant difference between trials.

Cooling rate via body bag was .102 (.04) °C/min whereas CON demonstrated a rate of .04 (.04) °C/min (95% CI, .03-.095; $P = .002$ (Figure 2). Body surface area was not significantly correlated with body bag ($r = .20$; $P = .60$) or CON cooling rate ($r = –.082$; $P = .84$). Water temperature just prior to pouring into the body bag with participants was 5.2 (1.6) °C. During cooling, thermal sensation was significantly lower with body bag treatment than with CON ($P<.001$). Total cooling time for CON was 27.6 (4.2) minutes and 13.2 (5.8) minutes with a body bag (95% CI, 9.2-19.5; $P = .002$). Data for cooling times

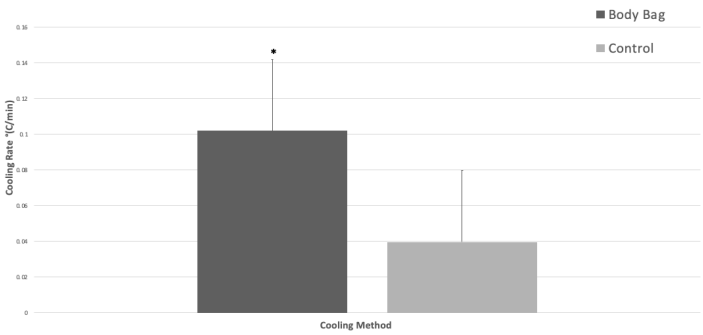


**Figure 2.** Cooling rate of body bag compared to control in study to determine whole-body cooling rates when using body bags to treat exertional hyperthermia.

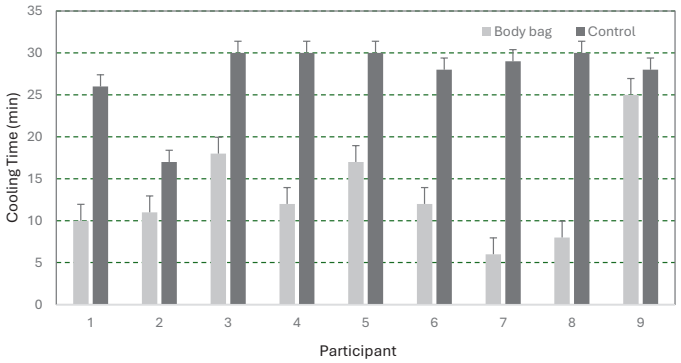


**Figure 3.** Cooling time in a body bag compared to control, based on a crossover study comparing whole-body cooling between partial immersion with body bags and lying in the shade as the control condition.

for each participant between trials are found in Figure 3.

## DISCUSSION

The purpose of this study was to examine the use of partial immersion using a body bag to facilitate whole-body cooling following exertional hyperthermia. Affirming our hypothesis, the body bag method produced faster cooling rates than lying in the shade. Importantly, the body bag produced an "acceptable" (between .078 °C/min and .154 °C/min) cooling rate of .102 (.04) °C/min, making it a viable treatment option that could be included in prehospital care for heat stroke.[1-4,11,17] It is important to recognize that a body bag did not achieve ideal cooling rates often associated with cold-water immersion. Emergency medical personnel should continue using whole-body cooling modalities demonstrating 100% survival rate if presented with heat stroke, when feasible.[1-4]

Body-bag cooling demonstrates successful results due to thermodynamic principles; similar to tarp- assisted cooling with oscillations (TACO).[22,23] The key to success for TACO cooling includes immersing the patient in as much cold water as possible and facilitating oscillations. This fosters convective cooling, which accentuates heat transfer from the body. The body-bag method facilitates both principles, making this modality successful in whole-body cooling. Also, water oscillations are typically facilitated during patient transport (driving, turning) to the ED, which suggests that a body bag is an effective prehospital modality. Further, our results are similar to cooling induced using the Polar Life Pod following exertional hyperthermia.[19,20] It should be noted that these previous studies used approximately 40 gallons of ice water on the participant to accelerate cooling, which may be a prohibitive amount of water for military and ED settings. Based on thermodynamics, body-bag cooling rates should approximate those documented with the Polar Life Pod given consistent clinical application requiring only 20 gallons of ice water.[17] Further, body-bag cooling produces far superior cooling to ice sheet cooling,[7,24] which persists in some military settings. Therefore, a body bag represents an effective and more affordable alternative for partial immersion whole-body cooling.

Ethically, participants were not allowed to reach the temperature threshold required for heat stroke (> 40.5 °C). Pathophysiology shows that while exertional heat stroke overwhelms the thermoregulatory and cardiovascular systems, they do not shut down.[3,8,12] This is similar with exertional hyperthermia, as the thermoregulatory system is overwhelmed but does not fail.[3] This principle allows for a study to simulate comparable heat stress to those who suffer heat stroke. Previous data justify extrapolating exertional hyperthermia cooling rates to those expected for exertional heat stroke.[5] Previous literature presents similar cooling rates between exertional heat stroke and exertional hyperthermia using the same modality, making it acceptable to infer expected cooling rates for diagnosed heat stroke patients based on data from hyperthermic participants.[4,5,17,18]

There are clear benefits for the use of a body bag in certain settings compared to cold-water immersion using a large, rigid tub. Body bags can be folded and stored in confined spaces, offering a portable cooling alternative ideal for prehospital and athletic training settings. They are also readily available and accessible in emergency response situations. Further, internet searches on global shopping websites produce a wealth of options. Based on preliminary pilot testing, two 38-L coolers of ice water were poured over participants to maximize immersion depth while minimizing fluid leakage through the zippered seams of the body bags. Body bags for partial immersion could be used in areas of remote endurance events and in military training. These settings could use partial cold-water immersion in a portable and feasible manner to treat hyperthermic patients. Smaller amounts of water may also be effective[19] but were not tested in our study.

We found it ideal to have approximately five people

involved in cooling a single patient with a body bag. One person should remain at the head, keeping the head elevated, with two people on each side of the patient oscillating the water. Other clinician or volunteer numbers could also work as well. It should also be noted that for this cooling medium, an individual needs to be enclosed within the bag and secured with straps, which can be difficult if they are demonstrating central nervous system dysfunction.[1] It is crucial that there is proper water immersion and oscillation, and if either cannot be achieved due to symptoms, another more effective cooling modality should be considered.

## LIMITATIONS

There are a few limitations associated with our study. An important limitation was the importance of the thermodynamic principle of convection and its relation to body surface area. Cooling modalities that have a larger body. surface area covered with ice water increase heat transfer and cooling rate.[27,28] Given that we standardized the amount of water used in a body bag for each participant, participants with greater body surface area had less depth and partial immersion of ice water. To achieve convection, physical labor was required to move that participant within the body bag.

Participants with a larger body surface area required greater physical effort to oscillate due to the increased total mass of the bag. This mechanical limitation may explain the negative correlation observed between body mass and whole-body cooling rates. Studies show that the ratio of fat mass to fat-free mass may limit cooling rate.[27] This could warrant research on a specific metric of water immersion necessary to achieve effective cooling rates, rather than a standardized amount of water. We selected an ice water volume that optimizes clinical feasibility across a wide range of athletic, military, and emergency medical settings. An additional limitation was minor body-bag malfunctions. Water leaking from the bags and pooling at the feet likely limited the amount of cold water available for convective and conductive heat transfer. In the future, research should be conducted on a type of body bag and cinching material that produces the least amount of water leakage while maintaining maximal immersion around the thorax.

Given our limited sample size of 9 participants who were otherwise healthy, the study may not reflect the effect on actual patients, although cooling rates compared between patients with exertional heart stroke[5] and hyperthermic, healthy participants[18] typically align. Finally, a clinical limitation of the body bag used in this study is its black coloration, which is typically associated with deceased individuals and could potentially induce psychological distress or patient noncompliance. However, our findings suggest that medical equipment manufacturers could produce structurally identical. Pouches in neutral colors explicitly for hyperthermia management.

## CONCLUSION

Research continues to evaluate the outcomes of exertional heart stroke and proper treatment measures. In the ED, during emergency transport, or where cold-water immersion tubs are not readily available, body bags filled with ice water can serve as a medium to adequate cool a heat stroke victim. Based on our data, in settings where full-body immersion is not feasible, partial immersion cooling via a body bag offers an effective alternative for managing hyperthermia. This could be considered for emergency action plans or emergency protocol when heat stroke is an inherent risk.

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# Higher Intensity Quality Improvement Campaign Yields Greater Reduction in Medical Glove Use: The "Gloves Off!" Campaign

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**Introduction:** The healthcare sector contributes 5.4–7.0% of Australia's total carbon dioxide ($CO_2$) emissions. Among the most ubiquitous items used in healthcare organisations, whether it be hospital, clinic, or community health centres, are gloves.

**Methods:** We reviewed two case studies of the "Gloves Off!" sustainability initiative to compare reduction in glove use and improvement in hand hygiene practice—one that featured a "low-intensity" campaign (Hospital A) and the other a "high-intensity" campaign (Hospital B).

**Results:** A comparison of glove use over the year before and after implementation of the Gloves Off! campaign shows that Hospital A achieved a 2.6% reduction (0.4% reduction per patient), while Hospital B achieved an 11.4% reduction in total glove consumption (7.8% reduction in glove use per patient).

**Conclusion:** Sustainability initiatives can be initiated within busy emergency departments with reduced unnecessary use of nonsterile gloves, decreased $CO_2$ emissions, and cost savings. [West J Emerg Med. 2026;27(5)1167–1171.]

## INTRODUCTION

The healthcare sector contributes between 5.4–7.0% of Australia's total carbon dioxide ($CO_2$) emissions.[1,2] Among the most ubiquitous items used in healthcare organisations, whether it be hospital, clinic or community health centres, are nonsterile gloves (NSG). Globally, gloves are used by clinicians for infection control and personal protection. Many reports, including from the World Health Organization (WHO), have indicated that NSG are being used inappropriately.[6] Unnecessary glove use wastes money and increases medical waste, contributing to $CO_2$ emissions from the healthcare sector. In addition, inappropriate glove use has been demonstrated to worsen hand hygiene rates.[6] The WHO World Hand Hygiene Day 2025 focused on proper use of disposable gloves during patient care.

Annually, the Hunter New England Local Health District

in New South Wales, Australia, uses 30 million NSG at a cost of 1.5 million Australian dollars (AUD) and an estimated carbon footprint of one million kilograms of $CO_2$ equivalent (kg $CO_2$ eq). The John Hunter Hospital in Newcastle had a Net Zero clinical lead that first launched the *Gloves Off!* campaign in New South Wales in 2025. Their published study demonstrated[3] a reduction after the campaign was initiated.

In a study in the United Kingdom, NSG contributed to 45% of the carbon footprint of personal protective equipment used in healthcare.[4] An average of 500 million gloves were sent for use in the National Health Service (NHS) and social care per month in 2023, which translates to 16.7 million gloves per day.

Studies have shown that the unnecessary use of gloves is as high as 52.9% of care episodes[5] to 99% of low-risk procedures.[6] The "*Gloves Off!*" campaign has been launched in multiple hospitals in Australia and globally. Busy clinicians are often neither able nor motivated to embark on a quality improvement (QI) journey due to competing clinical demands and lack of dedicated paid time for QI projects.

### Objective

The objective of this study was to evaluate the effectiveness of a high-intensity versus low-intensity staff awareness and culture-change approach within the *Gloves Off!* project, specifically in reducing unnecessary glove use in the emergency department (ED). We examined two case studies: one low-intensity and one high-intensity QI program. We focused on two New South Wales Health hospital EDs, one regional and the other urban metropolitan, with different time constraints and resources.

### Hospital A

Hospital A is an urban metropolitan facility in Sydney that sees approximately 60,000 presentations.

### Hospital B

Hospital B is a regional hospital one hour from Sydney that sees 75,000 presentations/year.

## METHODS

Our primary outcome measure was the reduction of glove use in the ED as evaluated by procurement data. We used procurement data for gloves as a surrogate measure of glove use. These data were obtained thorough a standardised database provided by our district sustainability manager.

The intervention included education about the proper use of gloves, presentation by an infection control nurse, and clinical champions. We compared two cases: a low-intensity model (Hospital A) and a high-intensity model (Hospital B). Using case studies from these two hospitals in separate local health districts in New South Wales, we assessed the roll out of the *Gloves Off!* campaign. We selected this approach to determine the workforce, time, and financial resources required to achieve appropriate glove-use behaviour and quantify the associated cost savings and $CO_2$ reductions for each model. We compared total glove use over a one-year period before and after the intervention to evaluate the impact of the campaign to reduce glove use.

For Hospital A, which commenced the project in October 2024, we defined October 2023–September 2024 as the preintervention period and October 2024–September 2025 as the postintervention period. For Hospital B, which commenced the campaign in February 2024, we defined March 2023–February 2024 as the preintervention period and March 2024–February 2025 as the postintervention period. A full-year timeframe was selected to account for seasonal fluctuations in glove use—recognising that certain months exhibit predictable peaks or troughs—and to ensure a consistent and comparable measure of change across sites.

In addition, the evaluation considered two implementation-intensity models: a low-intensity model at Hospital A that featured an education campaign via email and in person; and a high-intensity model at Hospital B characterised by more comprehensive training and intervention activities, complemented by engagement activities. This allowed us to assess how differences in implementation intensity influenced changes in glove use.

### Hospital A: Low-Intensity Model

The ED of Hospital A established a sustainability working group just prior to the launch of the *Gloves Off!* project in 2024. The members then organised an education campaign to talk about the programme among nurses during usual in-services and doctors during teaching days (only one off). We used a presentation that had been produced by the New South Wales Net Zero Unit in education sessions for nurses and doctors. We included allied health staff and ward orderlies opportunistically. There was no formal launch but rather an announcement in our Microsoft Teams chat and via email. No additional funding was spent for the *Gloves Off!* campaign beyond coordination and utilising existing education sessions that had already been planned. Emergency department sustainability champions within the working group educated clinical staff about appropriate glove use and displayed reminder posters.

### Hospital B: High Intensity Model

The *Gloves Off!* programme was implemented in the Hospital B ED using a multifaceted QI approach. Baseline data collection included direct observation of hand hygiene and glove-use behaviours by ED staff, along with analysis of departmental procurement data for nonsterile gloves. These data informed the development of a targeted education intervention.

A tailored educational package was delivered through multiple formats, including the following: interactive quizzes during junior medical officer orientation; nursing and clinician

huddles; in-service sessions; and an on-site launch-day information stall. Additional reinforcement was provided through email communication and the ED newsletter. Supporting signage was installed in key departmental locations, such as glove dispensers and handwashing stations, and near clinical huddle boards. Post-launch evaluation included direct observation of hand hygiene and glove compliance alongside the collection of NSG) procurement data.

Campaign implementation at Hospital B cost approximately 600 AUD, which funded launch-day educational snacks for staff and to cover printing costs for department signage. Additionally, staff members volunteered a significant amount of unpaid time to complete the project.

## RESULTS

The results include a pre/postintervention comparison of glove use, both in absolute terms and in the number of gloves used per patient.

### Hospital A

At baseline, glove use was higher at Hospital A. Prior to the Gloves Off! campaign, the Hospital A ED used 1,310,180 gloves annually. Post-campaign, yearly glove use fell to 1,276,750—a reduction of 33,430 gloves (2.6% overall; 0.4% per patient), which is a carbon-equivalent to mitigating 1,136.3 kg $CO_2$ eq.

### Hospital B

Before the *Gloves Off!* campaign was launched, the ED in Hospital B used 1,030,800 gloves annually. Post-campaign, glove use fell to 913,400, a reduction of 117,400 gloves (11.4% overall; 7.8% per patient), which equates to approximately 4,000 kg $CO_2$ eq—equivalent to driving 11,000 km in a petrol-powered passenger vehicle.

Results of a comparison of glove use over the year before and after implementation of the campaign show that Hospital A achieved a 2.6% reduction in total glove consumption (0.4% reduction in glove use per patient), while Hospital B achieved an 11.4% reduction (7.8% reduction per patient). These findings suggest that both interventions were effective in reducing glove use, with the higher intensity approach implemented at Hospital B appearing to yield a greater impact. The analysis also highlights the potential influence of intervention intensity and implementation strategies on behavioural change in clinical settings. The education campaign was periodically reinforced to ensure that new and rotating staff were reached, including through orientation sessions and short educational videos distributed via the same communication channels.

In Hospital B, the project was promoted more broadly within the local health district through the intranet, email updates, sustainability forums, and a leadership forum. External dissemination occurred via the Australasian College for Emergency Medicine Sustainable Emergency Medicine Climate Advocacy Network. The project also received coverage through national media.

## DISCUSSION

Nonsterile gloves are an essential part of a healthcare worker's equipment to prevent the spread of nosocomial infections and to ensure patient and staff safety. However,

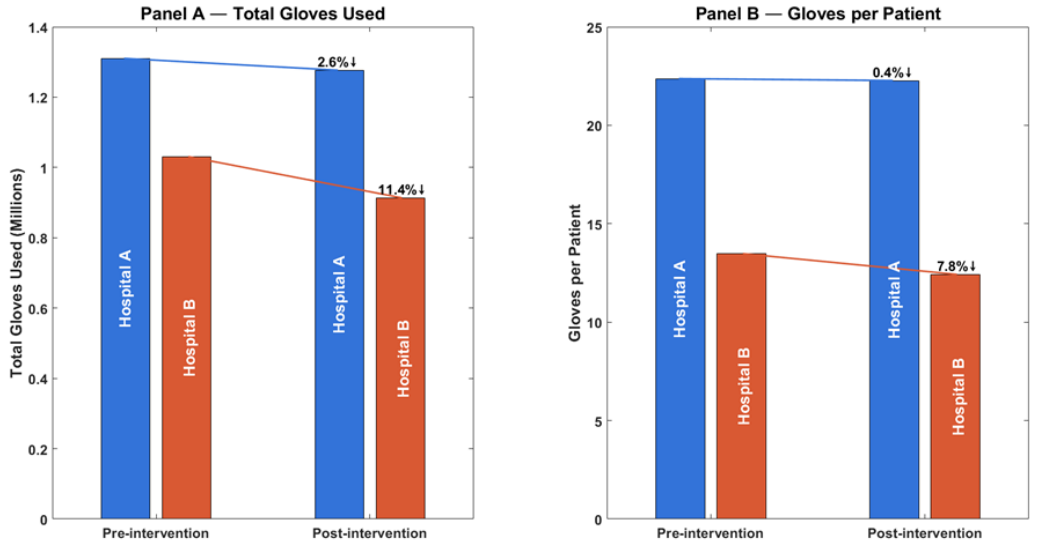


**Figure 1.** Comparison of glove use in Hospital A (low-intensity model) and Hospital B (high-intensity model), in absolute terms (Panel A) and gloves per presenting patient (Panel B), in a review of the effect of two quality improvement initiatives to reduce unnecessary use of nonsterile gloves in the emergency department

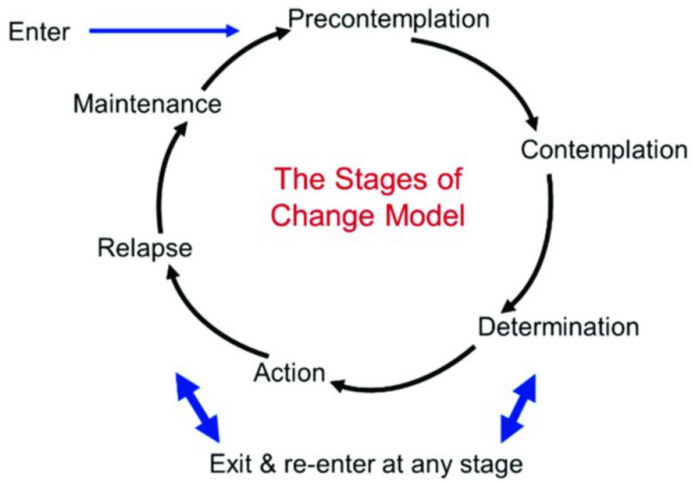


**Figure 2.** Stages of change model (Prochaska and De Clementi).[11]

many studies have shown that NSG are used inappropriately in many healthcare settings.[7,8] Furthermore, studies have shown that the use of NSG is associated with decreased hand hygiene compliance, increased risk of cross-contamination, and transmission of healthcare-associated infections.[9,10]

Our results from the two case studies show a difference in the reduction in NSG use between the the two hospitals. Reasons for this difference are multifactorial. Education alone cannot sustain the behavioural change required to maintain this shift in practice. According to the transtheoretical model of change, behaviour change involves many steps and even more to maintain it.[11] The stages are precontemplation, contemplation, determination, action, relapse, and maintenance. (See Figure 2)

In a busy ED, most staff are focused on delivering patient care. It is difficult to add one more sustainability task in their daily workflow. The action-relapse-maintenance part of the cycle is the most difficult for busy clinicians to maintain. As healthcare professionals, we take an oath to "do no harm." Unnecessary glove use generates emissions that contribute to climate change, thereby harming patients. We as clinicians have a responsibility to reduce this unnecessary harm. This simple *Gloves Off!* project allows us to decrease healthcare's harm on the environment, improve patient care, and fulfill a mandatory job requirement (the QI initiative)—a triple win.

For Hospital B, the *Gloves Off!* project also delivered benefits beyond cost and environmental gains. It is a manageable initiative for busy clinicians that builds practical change-management skills and increases awareness of environmental impacts in the ED. The campaign at Hospital B's ED catalysed the creation of an active sustainability team that has since delivered multiple high-impact projects and helped establish funded positions with protected time for resource-stewardship and clinical-care improvement work.

The annual cost savings associated with these two QI projects amounted to 1,009 AUD at Hospital A and 4,500 AUD at Hospital B, minus the 600 AUD it cost to implement the projects. The advantage of this project is that no additional expenses were required to conduct these QI projects, while encouraging clinicians to commit to a QI initiative that both saves money and benefits the environment.

## LIMITATIONS

Because both studies were conducted in a region where New South Wales Health has a Net Zero Unit, the results might not be generalizable to other states.

## CONCLUSION

Our two case studies using the *"Gloves Off!"* campaign demonstrate that we can easily introduce a sustainability initiative within busy EDs, with reduced use of unnecessary nonsterile gloves, lower $CO_2$ emissions, and increased cost savings. Our comparison of two different "intensities" of intervention, with differing results, demonstrates that a higher intensity program leads to greater reductions and collateral benefits, including better engagement from clinicians and hospital executives, with improved sustainability for EDs. This scalable initiative could be expanded to other EDs in Australia and around the world.

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# Patient vs. Companion Satisfaction in the Emergency Department: Cross-sectional, Telephone-Based Survey

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**Introduction:** In Lebanon, it is common for multiple family members to accompany patients to the ED. In this cultural context, where family is closely involved with patient care, we sought to identify and compare factors associated with satisfaction among patients and their companions during the same emergency department (ED) visit.

**Methods:** This cross-sectional, telephone-based survey compared factors associated with satisfaction among adult patients and their companions, during the same ED visit, at a tertiary-care center in Beirut, Lebanon. Adult patients presenting to the ED with intermediate- or low-acuity complaints were included in the study. We administered a questionnaire to patients and their companions covering six domains, including demographics, general admission, nursing and medical teams, discharge process, and overall satisfaction. Satisfaction was then categorized into high and low. We conducted an analysis of variables associated with high overall satisfaction for each group.

**Results:** A total of 100 patients and 100 companions completed the survey, with a 45.7% response rate. Among companions, the top three factors associated with high overall satisfaction were: respect of confidentiality and privacy (odds ratio 12.98, 95% CI, 4.79-35.19), length of stay before being seen by triage nurse (9.77, 3.68-25.89), and overall ED length of stay (9.56, 3.7-24.37). Among patients, the top three factors associated with high overall satisfaction were: amount of time the physician spent with the patient (20.26, 7.10-57.82); overall ED length of stay (19.71, 5.44-71.39), and length of stay before being seen by the emergency physician team (13.26, 4.84-36.35). All variables were statistically significant for both patients and companions except for the discharge process, which was only significant for companions.

**Conclusion:** This study suggests that patients and companions may have different experiences of their ED visit, highlighting the top factors associated with satisfaction for each group. Emergency department efforts aimed at enhancing patient experience should also consider processes related to companion experience in cultural contexts where family/relatives play an integral role in patient care. [West J Emerg Med. 2026;27(5)1172–1179.]

## INTRODUCTION

Care of patients in the emergency department (ED) can be complex with many competing demands on resources and personnel. In addition, the unpredictability of patient flow and the diversity in case complexity present further challenges. Maintaining a consistent and positive patient experience within the dynamic environment of the ED can be difficult. Patient satisfaction is, therefore, a key quality metric for EDs

and has been associated with patient outcomes including compliance with treatment plans and remission of disease.[1,2]

Similarly, the role of companions and family members in patient care has been shown to impact multiple health outcomes, including shorter hospital stay and faster recovery.[3,4] Companions can provide emotional support, assist in decision-making, advocate for the patient's needs, and communicate concerns.[5] They also help the patient understand the treatment plan, often contributing significantly to overall compliance with care.[5] While the impact of family and companions' involvement on patient outcomes has been well established, little is known about their experience of the care journey and the variables that drive their overall satisfaction with the care received. Multiple studies have explored drivers of patient satisfaction in the ED and identified some key factors that improve patient perception of their ED care.[6] Key among these factors is length of stay (LOS), which has consistently been found to be associated with improved patient satisfaction. Other important variables include satisfaction with the primary treating physician as well as effective communication, both of which have been shown to positively impact the patient experience.[7,8]

Drivers of companion satisfaction, however, have not been as well studied. Research evaluating pediatric populations in the ED found that relieving a child's pain contributed to the satisfaction of both the child and their parent, while shorter waiting time impacted only the parent's satisfaction.[9] Another study identified clinical team performance and system processes as key factors associated with satisfaction for both patients and their companions. The same study, however found that the discharge process, which primarily focuses on the financial clearance of patients prior to discharge, uniquely impacted companion satisfaction.[10] While these studies suggest that different variables may impact companion perception of the patient experience, no study to date has directly compared companion and adult patient experiences within the same visit.

In cultural contexts, where families are closely involved with patient care,[11] understanding the companion's encounter and drivers of their overall satisfaction, compared to that of the patient, is an important step to developing appropriate interventions to improve the experience of care in the ED. This is particularly important in Lebanon, where—unlike in the United States where most patients present to the ED alone[12]—it is common for multiple family members to accompany patients to the ED. Our aim in this study was to identify factors associated with satisfaction among patients and their companions during the same ED visit.

*Population Health Research Capsule*

What do we already know about this issue?
*The factors that drive companion satisfaction with emergency department (ED) care remain understudied compared to those influencing patient satisfaction.*

What was the research question?
*How do patient satisfaction scores compare with those of the companion who accompanies them to the ED?*

What was the major finding of the study?
*Respect for patient privacy was most valued by companions (OR 12.98, 95% CI, 4.79-35.19), while patients most valued time spent with the physician (20.26, 7.10-57.82).*

How does this improve population health?
*Patients and companions may have different experiences in the ED, highlighting the need for a differentiated approach to improve their experiences.*

## METHODS

### Study Design

We conducted a cross-sectional, telephone-based survey to compare whether adult patients and their companions presenting to the ED at a tertiary-care center in Beirut, Lebanon, perceived a different experience and level of satisfaction with ED services. We collected data between September 2022–September 2023. Confidentiality was guaranteed by removing all participant identifiers from the database after data collection. The study protocol was reviewed and approved by the institutional review board.

### Study Setting

Our institution is a 384-bed tertiary-care teaching hospital in Lebanon, with one of the largest EDs in the country accounting for more than 48,000 ED visits annually. The ED is staffed by a mix of emergency medicine (EM)-trained physicians and non-emergency physicians with extensive EM experience. The ED is divided into three clinical sections: high acuity, low acuity, and pediatrics. Trained nurses conducting patient assessment use the Emergency Severity Index (ESI) to categorize patients, ranging from level 1 (most critical) to level 5 (least critical).[13] As part of the medical center's routine patient-experience monitoring process, the Patient Affairs Office (PAO) completes phone surveys on randomly selected patients discharged from the ED within two days of discharge using an internally developed survey.

### Study Population and Study Protocol

The eligibility criteria for this study included patients aged 18 years and older who presented to the ED with either intermediate- or low-acuity complaints (ESI 3, 4, and 5) and

spent a minimum of two hours in the ED. Family members were considered eligible to participate in the study if they had spent a minimum of one hour with the patient during their ED visit. The study used a stratified random sample design, with weekdays and weekends serving as the strata. By conducting data collection at various times and days of the week, the random component of this sampling was accomplished. Participants were approached and briefed about the study, emphasizing the voluntary nature of participation. If both the patient and their companion agreed to participate, they were asked to sign an informed written consent. This list was then shared with the PAO, which conducted the survey to avoid overlap with patients contacted as part of the the routine surveying process. Patients were contacted within two working days following their ED presentation and companions within five working days. Following best practices in improving survey response rates, a maximum of three phone calls were attempted within one week of the initial call.[14] No incentives were provided for survey completion. If either companion or patient did not respond to our calls, both were excluded from the study.

Initially 219 patients and companions consented and agreed to participate in the study. Among patients 111 replied, of whom 11 were subsequently excluded because their companions failed to respond. The response rate was calculated by dividing the number of completed surveys (100) by the number of participants initially consented (219).

### Measurement

The patient satisfaction survey was developed in 2013 by ED leadership and the PAO, based on existing ED surveys published in the literature, as well as quality initiative priorities in the ED.[9,15,16] This survey has since been used by the PAO at our institution to assess ED patient satisfaction, as part of their routine quality assurance process.[15] The questionnaire included 30 questions and six areas of focus, including demographics, general admission, nursing and medical teams, discharge process, and overall satisfaction. The same survey was also applied to the patients' companions for consistency. We assessed overall satisfaction, which was the primary study outcome, using a multilevel response scale. For analysis purposes, satisfaction responses were dichotomized into two groups: low satisfaction, which included responses such as "Very Poor," "Poor," "Fair," and "Good" responses, and high satisfaction, which included only "Very Good" responses.

### Data Analysis

We used SPSS v28 (SPSS Statistics, IBM Corp, Armonk, NY) to clean, manage, and analyze the data. Descriptive statistics were carried out and results were reported as numbers and percentages for categorical variables, whereas we reported the mean and standard deviation for continuous variables. We calculated the association between different demographic characteristics and ED-specific information with overall satisfaction (survey question: Q20 – "Overall satisfaction with your visit to ED"), using the chi-square test for categorical variables, or the Student *t*-test for continuous variables. Results are reported as odds ratio and 95% confidence intervals. *P*-value < .05 indicated statistical significance.

## RESULTS

A total of 100 patients and 100 companions completed the survey of 219 who initially consented in each group, resulting in a 45.7% response rate. Sociodemographic characteristics between patients and companions are summarized in Table 1. Most responders were females in both groups, median age 42.59 (SD 18.09 years) for patients and 45.12 (SD 13.99 years) for companions, and most of those in both groups had an undergraduate degree; however, the results were not statistically significant. A statistically significant difference was observed for age distribution between patients and companions (*P* = .001), with companions generally being older than patients. As for marital status, there was a significant difference, with 48.0% of patients being married compared to 78.0% of companions (*P* <.001).

**Table 1.** Differences in sociodemographic characteristics between patients and their companions in a cross-sectional study assessing emergency department satisfaction.

| Variables | Patients (N = 100) | Companions (N = 100) | P-value |
|---|---|---|---|
| Sex (male) | 39 (39.0%) | 48 (48.0%) | .20 |
| Age (mean, SD) | 42.59 (18.09) | 45.12 (13.99) | .27 |
| [18-30] | 36 (36.0%) | 18 (18.0%) | .001 |
| [30-45] | 26 (26.0%) | 36 (36.0%) | |
| [45-65] | 21 (21.0%) | 38 (38.0%) | |
| Marital Status | | | |
| Married | 48 (48.0%) | 78 (78.0%) | < .001 |
| Educational level | | | |
| Up to high school | 24 (24.0%) | 19 (19.0%) | 55 |
| Undergraduate | 58 (58.0%) | 58 (58.0%) | |
| Graduate/ postgraduate | 18 (18.0%) | 23 (23.0%) | |
| Living location Rural | 11 (11.0%) | 17 (17.0%) | .22 |

Tables 2 and 3 present the associations between the sociodemographic characteristics and the overall satisfaction with ED visit reported by companions and patients, respectively. Most of the companions and patients rated their overall satisfaction with their ED visit as high.

Companions who reported high satisfaction were more likely to be 30-35 years of age (40.7 vs 29.3%, *P* = .67) and accompany patients who had previously visited the ED (81.4 vs

**Table 2.** Associations between sociodemographic characteristics and high overall satisfaction among companions (N = 100) in a cross-sectional study assessing emergency department satisfaction.

| Variables | Low satisfaction (n = 41, 41.0%) | High satisfaction (n = 59, 59.0%) | P-value | OR (95% CI) |
|---|---|---|---|---|
| Sex | | | | |
| Male | 22 (53.7%) | 26 (44.1%) | .35 | 0.68 (0.31, 1.52) |
| Age (mean, SD) | 45.41 (14.24) | 44.92 (13.93) | .73 | 1.00 (0.97, 1.03) |
| [18-30] | 8 (19.5%) | 10 (17.0%) | | Reference |
| [30-45] | 12 (29.3%) | 24 (40.7%) | .67 | 1.60 (0.50, 5.10) |
| [45-65] | 18 (43.9%) | 20 (33.9%) | | 0.89 (0.29, 2.74) |
| >65 | 3 (7.3%) | 5 (8.5%) | | 1.33 (0.24, 7.35) |
| Marital Status | | | | |
| Married | 32 (78.1%) | 46 (78.0%) | .99 | 1.00 (0.38, 2.60) |
| Educational level | | | | |
| Up to high school | 6 (14.6%) | 13 (22.0%) | | Reference |
| Undergraduate | 26 (63.4%) | 32 (54.2%) | .58 | 0.57 (0.19, 1.70) |
| Graduate/ postgraduate | 9 (22.0%) | 14 (23.7%) | | 0.72 (0.20, 2.58) |
| Living location | | | | |
| Rural | 8 (19.5%) | 9 (15.3%) | .58 | 0.74 (0.26, 2.12) |
| Guarantor type | | | | |
| Self-pay | 5 (12.2%) | 7 (11.9%) | 1.00 | 0.97 (0.29, 3.30) |
| ED | | | | |
| Low Acuity | 21 (51.2%) | 22 (37.3%) | .17 | 0.57 (0.25, 1.27) |
| Patient's first visit to ED | | | | |
| No | 28 (68.3%) | 48 (81.4%) | .13 | 2.03 (0.80, 5.13) |
| On shift* | | | | |
| Off shift | 29 (70.7%) | 43 (72.9%) | .81 | 1.11 (0.46, 2.69) |

*"On shift" refers to weekdays and mornings, whereas "Off shift" includes evenings, nights, and weekends.
*OR,* odds ratio.

68.3%, *P* = .13). These results were not statistically significant.

A statistically significant difference was observed in levels of satisfaction when it came to educational level, with 66.7% of those with undergraduate education reporting high satisfaction (*P* = .01), while only 9.5% of patients with graduate or postgraduate education reported high satisfaction (*P* = .01). Patients who reported high satisfaction were more likely to live in rural areas (14.3 vs 5.4%, *P* = .21), be self-payers (15.9 vs 5.4%, *P* = .20), and have previously visited the ED (81.0 vs 67.6%, *P* = .13); however, these were not statistically significant.

Figure 1 illustrates the associations (from strongest to weakest) between different elements of the companion's experience in the ED and high overall satisfaction. All variables were statistically significant, including the discharge process. The top three factors associated with high overall satisfaction among companions were respect for confidentiality and privacy (OR 12.98, 95% CI, 4.79-35.19); LOS before being seen by triage nurse (9.77, 3.6-25.89); and overall ED LOS (9.56, 3.75- 24.37).

Figure 2 illustrates the associations (from strongest to weakest) between different elements of the patient's experience in the ED and high overall satisfaction. All variables were statistically significant except for the discharge process. The top three factors associated with high overall satisfaction among patients were the following: amount of time the physician spent with the patient (OR 20.26, 95% CI, 7.10-57.82); overall ED LOS (19.71, 5.44-71.39), and LOS before being seen by the emergency physician team (13.26, 4.84-36.35).

## DISCUSSION

Our study compared an ED patient's experience with that of their companion regarding their overall satisfaction with ED services. A group of adult patients and their companions participated in our survey, with the majority rating their overall experience as high. Patients were generally younger than companions, and a majority of both groups had

**Table 3.** Associations between sociodemographic characteristics and high overall satisfaction among patients (N = 100), in a cross-sectional study assessing emergency department (ED) satisfaction.

| Variables | Low (n = 37, 37.0%) | High (n = 63, 63.0%) | P-value | OR (95% CI) |
|---|---|---|---|---|
| Sex | | | | |
| Male | 14 (37.8%) | 25 (39.7%) | .86 | 1.08 (0.47, 2.49) |
| Age (mean, SD) | 37.73 (14.74) | 45.44 ± 19.35 | .10 | 1.03 (1.00, 1.05) |
| [18-30] | 14 (37.8%) | 22 (34.9%) | | Reference |
| [30-45] | 13 (35.1%) | 13 (20.6%) | .19 | 0.64 (0.23, 1.76) |
| [45-65] | 7 (18.9%) | 14 (22.2%) | | 1.27 (0.41, 3.93) |
| >65 | 3 (8.1%) | 14 (22.2%) | | 2.97 (0.72, 12.23) |
| Marital Status | | | | |
| Married | 17 (46.0%) | 31 (49.2%) | .75 | 1.14 (0.51, 2.57) |
| Educational level | | | | |
| Up to high school | 9 (24.3%) | 15 (23.8%) | | Reference |
| Undergraduate | 16 (43.2%) | 42 (66.7%) | .01 | 1.57 (0.58, 4.31) |
| Graduate/ postgraduate | 12 (32.4%) | 6 (9.5%) | | 0.30 (0.08, 1.08) |
| Living location | | | | |
| Rural | 2 (5.4%) | 9 (14.3%) | .21 | 2.92 (0.59, 14.30) |
| Guarantor type | | | | |
| Self-pay | 2 (5.4%) | 10 (15.9%) | .20 | 3.30 (0.68, 15.98) |
| ED | | | | |
| Low Acuity | 16 (43.2%) | 27 (42.9%) | .97 | 0.98 (0.43, 2.23) |
| Patient's first visit to ED | | | | |
| No | 25 (67.6%) | 51 (81.0%) | .13 | 2.04 (0.80, 5.18) |
| On shift* | | | | |
| Off shift | 27 (73.0%) | 45 (71.4%) | P .87 | 0.93 (0.37, 2.30) |

*"On shift" refers to weekdays and mornings, whereas "Off shift" includes evenings, nights, and weekends.
*OR,* odds ratio.

completed an undergraduate education. Patients reporting high overall satisfaction were more likely to live in rural areas, self-pay, and have visited the ED before. Companions with lower satisfaction were more likely to have presented with a patient triaged to the low-acuity section, who had not visited the ED previously. Both patients and companions considered the overall LOS in the ED as a significant factor contributing to their overall satisfaction. For patients, the top factors associated with high overall satisfaction were the amount of time the physician spent with them and their LOS before being seen by the emergency physician team. In contrast, the patients' companions prioritized respect for confidentiality and privacy, and the LOS before seeing a triage nurse. Perceptions of discharge process uniquely influenced companion satisfaction but not patient satisfaction.

Our study was methodologically designed to understand the differences in variables associated with satisfaction for patients and companions during their ED visit, an area that has been underexplored in the literature. One prior study comparing pediatric patient satisfaction with that of their accompanying parent during the same visit found that—with the exception of pain resolution which was associated with pediatric patient satisfaction solely—factors associated with satisfaction were similar for both patients and their parents.[9] The only other study to our knowledge that compared factors influencing adult patient experience of ED visits with those influencing the companion's experience relied on analysis of secondary data from patient satisfaction surveys of ED visits administered to the patient (or to their companion only when the patient was unable to complete the survey for medical reasons).[10] That approach, however, did not allow for direct comparison of satisfaction within the same ED visit. In contrast, our study is the first to examine adult patients and their companions' experience of the same encounter, thereby providing a more accurate and methodologically robust assessment of their shared experience and potential differences in factors associated with their respective perceptions.

Our findings align with the literature, validating the impact

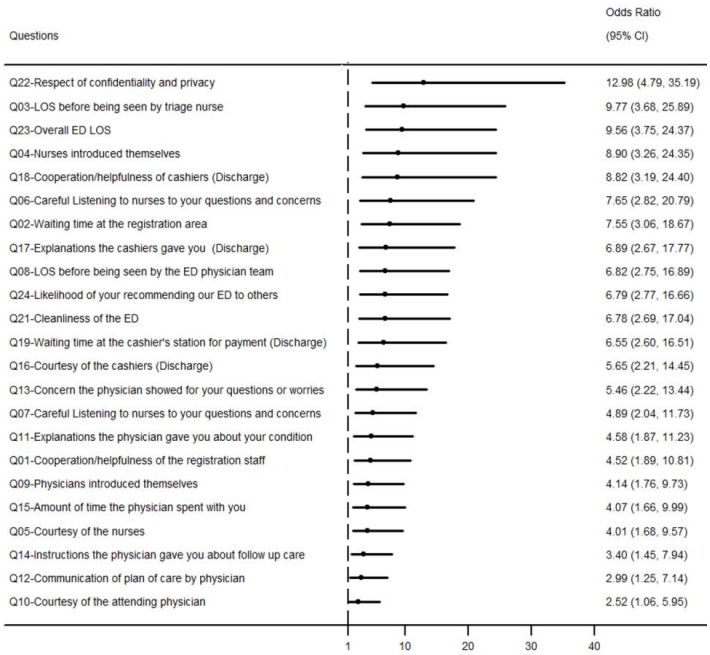


**Figure 1.** Association between elements of companion satisfaction and high overall satisfaction in a cross-sectional study assessing emergency department satisfaction.
*ED,* emergency department; *LOS,* length of stay; *OR,* odds ratio

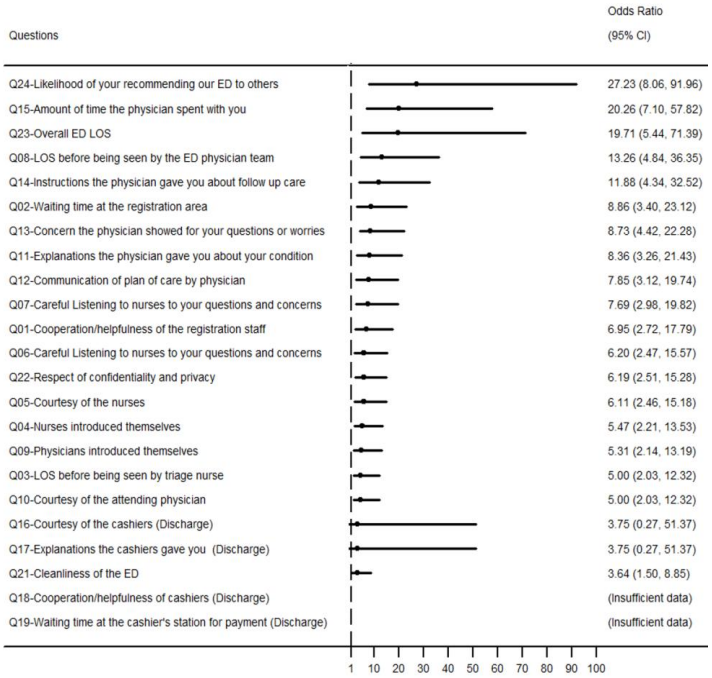


**Figure 2.** Association between different elements of patient satisfaction and high overall satisfaction in a cross-sectional study assessing emergency department satisfaction.
*ED,* emergency department; *LOS,* length of stay; *OR,* odds ratio.

of several key determinants on overall patient experience. While undergraduate education was associated with higher satisfaction among patients in our study, those with graduate or postgraduate education reported lower levels of satisfaction. This may reflect higher expectations among more highly educated individuals. Shorter ED LOS has been consistently associated with higher satisfaction levels across multiple studies, and our findings reinforced this association.[18-20]

In addition to the overall ED LOS, variables related to the treating physician, such as the amount of time the patient spent with the physician and the LOS before being seen by the physician team, were found to be significantly associated with patient satisfaction. Indeed, variables associated with the physician team have been consistently highlighted in the literature, indicating their importance in patients' experience of services. Aspects such as overall satisfaction with the doctors[7], doctors meeting expectations[7], quality of patient-provider interaction[9], satisfaction with the medical care[21] and treatment[22], as well as the amount of time the physician spent with the patient[21], have all been found to be associated with patient satisfaction across the literature. In addition, nursing team variables have been linked to patient satisfaction in a few studies.[21-23] While nursing- related variables were associated with patient satisfaction in our study, they did not emerge as significant factors associated with satisfaction. Furthermore, while several studies have highlighted the association of good pain control with patient satisfaction in their ED visit, this was not assessed in our study.[9,17]

For companions, the ED LOS also emerged as a significant factor associated with their satisfaction, consistent with Salehi et al and Natesan et al who reported that one of the most important determinants of a companion's experiences in the ED was the length of wait times.[10,21] However, our results revealed that the top drivers of companion satisfaction were respect for confidentiality and privacy, as well as the LOS before seeing a triage nurse. While privacy has been reported as a factor associated with ED patient satisfaction in other studies,[24,25] this has not been previously reported as a factor associated with companion satisfaction in the existing literature. Although the LOS before triage was not strongly associated with patient satisfaction in our study, it emerged as one of the main drivers of companion satisfaction. Indeed, a study investigating factors associated with parental satisfaction revealed that their satisfaction was significantly associated with shorter waiting room times.[9] Finally, the discharge process emerged as a unique factor associated with companion satisfaction and not patient satisfaction. One possible explanation is that companions often handle the discharge process on behalf of the patient and, thus, experience a process from which patients are generally shielded.

Our study underscores the important differences in the experiences of both the patient and their companion when evaluating and improving ED services. Our findings provide insights for policymakers and healthcare administrators when developing targeted interventions aimed at improving patient-centered care delivery and addressing the unique needs and

expectations of both patients and companions within the ED setting. Enhancing workflows related to triage times, patient privacy and confidentiality, and the discharge process are key areas that warrant focused efforts to improve companions' satisfaction. This is particularly relevant in a cultural context where companions are deeply involved in patient care, especially given reports in the literature demonstrating the positive impact of a companion in compliance to patient plans and outcomes.

## LIMITATIONS

This study has some limitations. First, the relatively small sample size constrained the statistical power of our analyses and contributed to the wide confidence intervals observed in some of the results. Second, the single-center design and limited response rate may restrict the generalizability of our results. Third, the cross-sectional design of this study did not enable causality to be established. In addition, the data was gathered through self-reporting by patients and companions, which may have introduced recall bias. Finally, we acknowledge the potential for selection bias due to non-response. Demographic data on non-responders was not collected for analysis.

## CONCLUSION

This study suggests that patients and their companions may have different perceptions of their ED stay, with patients valuing time spent with the treating physician of utmost importance, while companion satisfaction was tied to respect for privacy and confidentiality. Efforts aimed at enhancing patient experience in the ED should consider processes related to companion experience, especially in cultural contexts where family plays an integral role in patient care.

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# Identifying Social Need Trends Among Emergency Department Super-Users: A Latent Class Analysis

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**Introduction:** Frequent emergency department (ED) users, particularly those with high rates of use, often experience complex social determinants of health (SDOH) that contribute to their repeated visits and may lead to adverse health outcomes. Our objective in this study was to characterize the needs most commonly affecting this population, which may support the creation of tailored interventions with a higher chance of success.

**Methods:** This was a retrospective analysis of patients evaluated by an ED social medicine team in a large urban academic ED from May 2021–December 2023. Patients were identified either via frequent ED use (patients with the 10 highest number of visits each month) or referred by ED staff. We assigned 11 categories of medical, mental health, and social needs through chart review and team documentation. The primary outcome was the identification of distinct need-based subgroups among patients with high ED use, using latent class analysis of documented social, mental health, and medical needs.

**Results:** Of the 181 patients, representing approximately 0.4% of the ED patient population, 149 (82.3%) were frequent ED users, with a median of 14 ED visits annually (IQR 8-21), while the rest were referred by ED staff (median 2 visits (1-4.25). The majority were non-Hispanic Black (159, 87.8%) and publicly insured (163, 90.0%). The most common needs were related to housing instability (116, 64.1%) and limited access to outpatient care (112, 61.9%). Latent class analysis revealed four distinct subgroups, all of which included limited access to outpatient care: 1) primarily limited access to outpatient care (40, 22.1%); 2) housing instability and other basic needs (27, 14.9%); 3) housing instability, psychotic disorders, other basic needs, and inability to live independently (23, 12.7%); and 4) housing instability, substance use, and psychotic disorders (91, 50.3%).

**Conclusion:** This analysis identified four distinct need-based subgroups of frequent ED users, suggesting the need for tailored, multifaceted interventions. Housing instability, psychiatric illness, substance use, and outpatient care access were prevalent across groups, underscoring the importance of including resources for these basic needs in any programs developed for this population. Findings support prioritizing coordinated care models, particularly those that incorporate housing, behavioral health, substance use resources, and navigation support, for this vulnerable population. [West J Emerg Med. 2026;27(5)1180–1188.]

## INTRODUCTION

Social determinants of health (SDOH) have been shown to negatively impact the health outcomes of individuals.[1,2] Defined by the World Health Organization as the "non-medical factors [such as income, education, employment status, housing, and access to proper care] that influence

health outcomes,"[3] it is estimated that more than half of the U.S. population is affected by at least one adverse SDOH.[4,5] For example, around 26.4 million American households are uninsured,[6,7] which prevents them from being able to seek the routine care they need, resulting in worse health outcomes,[8,9] higher rates of chronic diseases,[5,10-12] and increased reliance on the emergency department (ED) for care.[13]

Emergency departments play a unique role in the healthcare system because, in addition to treating emergent conditions, they serve as a public health safety net, an entry point into the medical system, and sometimes the sole source of medical care and social services for individuals with limited access to care. Frequent ED users, commonly defined as individuals who present to the ED more than four to six times in a given year,[14] have been found to have a disproportionate burden of SDOH.[14,15] It is estimated that frequent ED users account for 3.816% of all ED users but 14–47% of all ED visits.[11] Prior studies have found that frequent ED users are more often publicly insured, have a disproportionate burden of chronic diseases and unmet primary care needs, perceive their own health status as poor, and have a higher likelihood of substance abuse, unemployment, mental health issues, and unstable housing.[11,16]

While a growing body of literature has examined frequent ED users, the population is somewhat ambiguously defined and generally includes individuals with visit rates more than four per year.[11,13,17,18] However, given the definition's inconsistency as well as the population's unique characteristics, the subset of this population with the highest reliance on the ED for care tends to be underexamined.[19] These "super-utilizers"[18] are sometimes defined as those who visit the ED > 18 times in a year. However, while there are likely important differences between individuals who visit the ED four times a year and those who visit three or four times that number, a standard definition of the minimum visit rate for this group has not been established. A few studies have suggested that the individuals with the highest number of ED visits are more likely to be uninsured, have lower acuity visits,20,21 and tend to visit the ED in place of other healthcare sources.[18] Despite their disproportionate number of ED visits, little is known about these super-users, how different their needs may be from patients with a lower ED use rate, and what types of interventions would be most beneficial for them.

In 2021, a large urban academic hospital ED on the South Side of Chicago, an area of high economic hardship, implemented an ED social medicine team as a quality improvement (QI) initiative, modeled after a similar program in San Francisco.[22] The team included social workers, care coordinators, patient navigators, behavioral health specialists, pharmacists, and an emergency physician. Team members met monthly to discuss patient cases and coordinate interventions. This multidisciplinary team model allowed for more comprehensive interventions for individuals with greater needs, as identified by high visit rates or clinician assessment, and the monthly meetings provided an opportunity for in-depth review of charts and group discussion of all potentially relevant resources. This project aims to review this cohort of individuals, most of whom would be considered not just frequent ED users, but super-users, with ED visit rates well above four per year, to understand the drivers of their ED use, with the ultimate goal of developing more efficient and effective interventions to better meet the specific needs of the most frequent ED users.

*Population Health Research Capsule*

What do we already know about this issue?
*Frequent emergency department (ED) users report substantial social and medical needs, but the highest users are poorly characterized and lack targeted interventions.*

What was the research question?
*What distinct need-based subgroups exist among frequent ED users?*

What was the major finding of the study?
*Latent class analysis identified four subgroups; housing instability (64%) and limited access to outpatient care (62%) were the most common needs.*

How does this improve population health?
*Identifying major needs and subgroups enables development of targeted, coordinated interventions to reduce ED use among the highest users.*

## METHODS

We conducted a retrospective review of all individuals followed by the social medicine team from its inception in May 2021 through December 2023. Patients were identified for team intervention either through frequent ED visits (among the top 10 most frequent ED users in the calendar month prior to the team meeting) or referral from ED staff. We performed case selection criteria, variable definition, abstraction forms, missing-data management planning, abstractor training, performance monitoring, and medical record identification in line with recommended medical record review criteria.[23] We recorded interventions by the ED social medicine team for clinical care in a REDCap secure database,[24,25] which was

supplemented with manual chart review. Demographic information, reasons for individual ED visits, and SDOH were extracted for each patient.

For each individual, it was noted whether they had been referred to the team by ED staff or identified via the monthly frequent ED users report. And for each of them we recorded the number of ED visits at the primary project site during the 12 months after that individual's initial evaluation by the ED social medicine team. Although some visits to other EDs are visible in the electronic health record (EHR), many local EDs do not use the same EHR system and, thus, visits outside the primary site ED could not be reliably tracked. Because of this uncertainty, only visits at the primary site were included. Of note, patients with ED visits solely due to unavoidable medical conditions and those visiting primarily for sickle cell pain crises were not eligible for the ED social medicine team intervention, because these visits were considered medically unavoidable and not related to SDOH.

**Categorization of Patient Needs**

We created 11 categories of patient needs (Table 1) based on our clinical experience, frequently occurring themes in the database, and review of the literature. Categories were assigned to each individual based on group discussion by the ED social medicine team, as documented in the database, as well as review of the medical chart by two independent reviewers. Individuals were assigned to a category if it was noted during at least one ED visit, and individuals could be assigned to multiple categories.

**Statistical Analysis**

We characterized individuals in the social medicine team's database descriptively based on their sociodemographic information and their reported needs. We used medians and interquartile ranges (IQR) for continuous variables (such as visit rates) and frequencies and percentages to describe the population for categorical variables. We used a chi-square test of independence to determine statistical significance between groups.

Latent class analysis was used to determine groupings of needs in the patient population. We used poLCA v. 1.6.0.1,[26] a latent class analysis package built for R (R Foundation for Statistical Computing, Vienna, Austria),[27] and the model was run with 2–10 clusters. The optimal number of clusters was determined by the lowest value of the Akaike information criterion.[28-30] The model was validated by observing lower off-diagonal values and higher diagonal values in the posterior probability matrix.[29] We ran the poLCA model 1,000 times with five different random starting positions to account for cluster assignment variation among study subjects. Cluster assignment was determined by the frequency of cluster assignment. Model fit and validity were assessed using Akaike information criterion and Bayesian information criterion for class selection, maximum likelihood estimation with multiple random starting values to ensure convergence and avoid local maxima, and posterior class membership probabilities to evaluate classification certainty. All data analysis was performed using R software v4.0.3.

This project was formally determined to be QI, not human

**Table 1**. Major categories of social, medical and mental health needs of emergency department frequent users as determined through literature review, common themes in the data, and author experience.

| Need category | Definition |
|---|---|
| Social needs | |
| Housing instability | Currently homeless or at risk of homelessness |
| Other basic needs | Limited access to other basic needs (eg, food, a cellphone, insurance) |
| Financial instability | Difficulty paying bills or reports financial strain |
| Access to outpatient care | Difficulty making or attending routine appointments |
| Interpersonal violence | Physical or sexual abuse from an intimate partner or other individual |
| Mental health needs | |
| Anxiety/depression | Depression or anxiety as one of the primary motivators for at least one ED visit |
| Psychotic disorders | Schizophrenia or other psychotic disorders contributing to or with symptoms present during at least one ED visit |
| Substance use disorder | Abuse of or dependence on alcohol, marijuana or illicit substances; or ED visits primarily seeking narcotics |
| Medical needs | |
| Serious medical conditions | ED visit primarily due to a serious medical condition unable to be managed outpatient |
| Access to hemodialysis | ED visit due to lack of access to regular hemodialysis |
| Unable to live independently | Requires additional assistance at home (eg, home health care) or placement (e.g., skilled nursing facility) |

*ED*, emergency department.

subjects research; therefore, it was not overseen by the institutional review board, per institutional policy.

## RESULTS

The ED social medicine team evaluated 181 patients from May 2021–December 2023. Of these, 149 (82.3%) were frequent ED users, identified via the monthly ED use report, and 32 (17.7%) were referred by ED staff. Frequent ED users had a median of 14 visits (IQR 8-21) to the primary project ED in the initial 12 months after evaluation by the social medicine team. Many of these individuals had visits to other EDs during this period as well, but these could not be reliably quantified from the EHR and were not included. Among individuals referred by staff, the median was two visits (IQR 1, 4.25) to the primary project ED, with a maximum of 16. Overall, 51 (28.2%) of the population had more than 18 visits in 12 months.

Among all patients, the median age was 55 (IQR 36-65), and 58% were male (Table 2). Most of the patients identified by the ED social medicine team were non-Hispanic Black (87.8%), reflecting the racial demographics of the local ED population, and used public insurance (92.8%), with 6.1% uninsured. The distribution of demographics was similar between the two groups, except that frequent ED users notably had a higher percentage of males than females (61.7% vs 40.6%) compared to referred patients. At the end of the evaluation period, 13 (7.18%) individuals were confirmed deceased, 11 of whom were frequent ED users.

Table 3 shows the frequency of each recorded need in the population. The two most common needs observed in the population were housing instability (116, 64.1%) and limited access to outpatient care (112, 61.9%). Overall, 64 (35.4%) had a history of substance use disorder, 76 (42%) had difficulty meeting basic needs, and 64 (35.4%) had a history of

**Table 2**. Demographics of patients evaluated by the emergency department (ED) social medicine team from May 2021 to December 2023 by source, referred by ED staff vs frequent ED users.

| Variable | Total, N (%) | Referred, n(%) | Frequent emergency department users, n(%) |
|---|---|---|---|
| Total | 181 (100) | 32 (17.7) | 149 (82.3) |
| Gender | | | |
| Male | 105 (58.0) | 13 (40.6) | 92 (61.7) |
| Female | 72 (39.8) | 18 (56.3) | 54 (36.2) |
| Transgender Female | 1 (0.6) | 0 (0) | 1 (0.7) |
| Transgender Male | 0 (0) | 0 (0) | 0 (0) |
| Other | 3 (1.7) | 1 (3.1) | 2 (1.3) |
| Age | | | |
| 18-39 | 59 (32.6) | 11 (34.4) | 48 (32.2) |
| 40-59 | 55 (30.4) | 5 (15.6) | 50 (33.6) |
| 60-79 | 58 (32.0) | 13 (40.6) | 45 (30.2) |
| ≥ 80 | 9 (5.0) | 3 (9.4) | 6 (4.0) |
| Race/Ethnicity | | | |
| Hispanic Black | 2 (1.1) | 0 (0) | 2 (1.3) |
| Hispanic White | 2 (1.1) | 1 (3.1) | 1 (0.7) |
| Non-Hispanic Black | 159 (87.8) | 29 (90.6) | 130 (87.2) |
| Non-Hispanic White | 8 (4.4) | 1 (3.1) | 7 (4.7) |
| Hispanic/Latino | 2 (1.1) | 0 (0) | 2 (1.3) |
| Other/Unknown | 8 (4.4) | 1 (3.1) | 7 (4.7) |
| Deceased during project | 13 (7.2) | 2 (6.3) | 11 (7.4) |
| Insurance coverage | | | |
| Medicare | 23 (12.7) | 4 (12.5) | 19 (12.8) |
| Medicaid | 111 (61.3) | 16 (50) | 95 (63.8) |
| Medicare + Medicaid | 29 (16) | 6 (18.8) | 23 (15.4) |
| Private | 5 (2.8) | 2 (6.3) | 3 (2.0) |
| Other | 2 (1.1) | 0 (0) | 2 (1.3) |
| Uninsured | 11 (6.1) | 4 (12.5) | 7 (4.7) |

**Table 3.** Reported medical and social needs of individuals evaluated by the emergency department (ED) social medicine team from May 2021–December 2023 by source, referred by ED staff vs frequent ED users.

| Needs | Total N (%) | Referred n(%) | Frequent emergency department users n (%) | *P* - value |
|---|---|---|---|---|
| | 181 (100) | 32 (17.7) | 149 (82.3) | |
| Social Needs | | | | |
| Housing instability | 116 (64.1) | 20 (62.5) | 96 (64.4) | .84 |
| Other basic needs | 76 (42.0) | 11 (34.4) | 65 (43.6) | .34 |
| Financial instability | 38 (21.0) | 11 (34.4) | 27 (18.1) | .04* |
| Access to outpatient care | 112 (61.9) | 20 (62.5) | 92 (61.7) | .94 |
| Interpersonal violence | 14 (7.7) | 4 (12.5) | 10(6.7) | .27 |
| Mental Health Needs | | | | |
| Anxiety/Depression | 40 (22.1) | 5 (15.6) | 35 (23.5) | .33 |
| Psychotic disorders | 64 (35.4) | 7 (21.9) | 57 (38.3) | .08 |
| Substance use disorder | 64 (35.4) | 8 (25.0) | 56 (37.6) | .18 |
| Medical Needs | | | | |
| Serious medical conditions | 38 (21.0) | 6 (18.8) | 32 (21.5) | .73 |
| Access to hemodialysis | 13 (7.2) | 1 (3.1) | 12 (8.1) | .33 |
| Unable to live independently | 57 (31.5) | 14 (43.8) | 43 (28.9) | .10 |

a psychotic disorder.

Some differences were observed between frequent ED users and the individuals referred to the ED social medicine team, although most of these were not statistically significant. Frequent ED users were more frequently noted to have substance use disorder (37.6% vs 25.1%), psychiatric illness (psychotic disorder 38.3% versus 21.9%, anxiety/depression 23.5% versus 15.6%), and other basic needs such as lack of a cellphones or reliable transportation (43.6% versus 34.4%), while referred patients more frequently were unable to live independently (28.9% versus 43.8%).

We performed latent class analysis for the entire ED social medicine team population and identified four distinct subgroups characterized by the predominant needs of each group (Table 4), all of which included limited access to outpatient care: 1) primarily needed assistance accessing outpatient care; 2) housing instability and other basic needs; 3) housing instability, other basic needs, inability to live independently, and psychotic disorders; and 4) housing instability, substance use, and psychotic disorders. Subgroup 4 was the largest group, with 50.3% in this subgroup. Access to outpatient hemodialysis was noted in subgroup 1 (23%) and subgroup 4 (4%). Housing instability was highly prevalent across all subgroups, ranging from 40% in subgroup 1 to 96% in subgroup 2. The median number of visits in 12 months after involvement of the ED social medicine team was similar between the subgroups (14, 12, 12, 10, respectively), with a relatively high IQR (6-19.3, 6.5-20, 2.5-19.5, 6-19) in all subgroups, reflecting the presence of very high users in each subgroup. Frequent ED users in subgroup 4 had a median visit number of 12.5 (IQR 13 : [8,21]). Referred individuals comprised a larger proportion of subgroups 1 and 3 (22.5% and 26.1%, respectively) compared to subgroups 2 and 4 (7.41% and 16.5%, respectively).

## DISCUSSION

To date, the literature has not focused on frequent ED users with extremely high ED visit rates. In this sample, frequent ED users had a median 12-month ED visit rate well above the threshold of four visits per year that is commonly used to define frequent ED use, and more than a quarter had over 18 visits per year. In one study of Medicaid data, the medical needs and SDOH of very high-use ED patients correlated significantly with those noted in the largest subgroup in this project, suggesting these may be common needs that will be key to address in future interventions. The combination of substance abuse, housing needs, and mental illness, which were major drivers identified in the largest subgroup in this study, has been shown to increase the likelihood of ED use in other studies as well.[31-34] "Housing first" programs may decrease hospital and ED use, even without integrated substance use interventions,[35,36] but they could be even more effective when using a holistic approach that includes substance use and mental health resources.[37] These interventions can be implemented directly from the ED visit,[38] which may be a critical opportunity for engagement in

**Table 4.** Reported social, mental health, and medical needs of individuals evaluated by the emergency department social medicine team from May 2021–December 2023 by subgroup, classified using latent class analysis.

| | Total N (%) | Subgroup 1 n (%) | Subgroup 2 n (%) | Subgroup 3 n (%) | Subgroup 4 n (%) |
|---|---|---|---|---|---|
| Total | 181 (100%) | 40 (22.1%) | 27 (14.9%) | 23 (12.7%) | 91 (50.3%) |
| Referred | 32 (17.7%) | 9 (22.5%) | 2 (7.4%) | 6 (26.1%) | 15 (16.5%) |
| Frequent users | 149 (82.3%) | 31 (77.5%) | 25 (92.6%) | 17 (23.9%) | 76 (83.5%) |
| Social needs | | | | | |
| Housing instability | 116 (64.1%) | 16 (40%) | 26 (96.3%) | 15 (65.2%) | 59 (64.8%) |
| Other basic needs | 76 (42.0%) | 11 (27.5%) | 16 (59.3%) | 23 (100%) | 26 (28.6%) |
| Financial instability | 38 (21%) | 8 (20%) | 5 (18.5%) | 10 (43.5%) | 15 (16.5%) |
| Access to outpatient care | 112 (61.9%) | 20 (50%) | 14 (51.9%) | 22 (95.7%) | 56 (61.5%) |
| Interpersonal violence | 14 (7.7%) | 1 (2.5%) | 4 (14.8%) | 4 (17.4%) | 5 (5.5%) |
| Mental health needs | | | | | |
| Anxiety/depression | 40 (22.1%) | 8 (20%) | 8 (29.6%) | 4 (17.4%) | 20 (22%) |
| Psychotic disorders | 64 (35.4%) | 7 (17.5%) | 6 (22.2%) | 12 (52.2%) | 39 (42.9%) |
| Substance use disorder | 64 (35.4%) | 15 (37.5%) | 4 (14.8%) | 0 (0%) | 45 (49.5%) |
| Medical needs | | | | | |
| Serious medical conditions | 38 (21%) | 7 (17.5%) | 5 (18.5%) | 0 (0%) | 26 (28.6%) |
| Access to hemodialysis | 13 (7.2%) | 9 (22.5%) | 0 (0%) | 0 (0%) | 4 (4.4%) |
| Unable to live independently | 57 (31.5%) | 14 (35%) | 8 (29.6%) | 16 (69.6%) | 19 (20.9%) |

a housing-first model.

Interestingly, the group of individuals defined by unstable housing, substance use, and mental health needs, which constituted the largest subgroup, had a lower median ED visit rate than frequent ED users overall. While we were unable to examine resource use outside the primary site ED, members of this group were frequently documented to visit multiple EDs around the city, spend prolonged periods incarcerated, or occasionally be admitted to psychiatric hospitals. This may account for sporadic heavy use of the primary site ED, followed by periods of absence, creating the illusion of lower ED use when, in fact, this group's overall use of the ED and system resource may have been much higher—an important area to consider in future research.

As has been reported in previous studies,[11,14,39-41] most individuals in this QI project used either Medicaid or Medicare. Evidence suggests that Medicaid users experience disproportionate difficulty accessing care, including being less likely to have a usual source of care, facing long wait times and low appointment availability, and transportation issues,[42-44] which is associated with higher ED use.[44,45] While some studies have suggested that individuals with the highest ED use may not represent a burden on ED costs or crowding due to their relatively low prevalence and low-acuity visits,[20] in this QI project some individuals were visiting the ED almost daily for a period of weeks to months. Further study is needed to understand the impact of this type of heavy ED use, in particular given low Medicaid reimbursement rates and bed use by uninsured and underinsured patients.

This analysis identified four major subgroups, or clinical phenotypes, of individuals who were evaluated by the ED social medicine team. While some characteristics, such as housing instability, psychiatric illness, and access to outpatient care, were present in all subgroups, differences between the subgroups suggest that tailored interventions could be developed to target the specific needs of each subgroup more efficiently. For instance, subgroup 4, the largest subgroup, experienced the confluence of mental health, housing instability, and substance use, suggesting that more resources should be put toward comprehensive interventions that target all these needs simultaneously, such as housing programs incorporating substance use treatment and mental health support on site. While these needs have been identified among patients with repeated hospitalizations,[46] this study is novel in its focus specifically on the highest users of ED care, as well as the amount of data available regarding distinct SDOH. Existing literature generally focuses on those with more than four or five annual ED visits,[47,48] which may not be representative of the needs of this very specific subset of individuals. Given the prevalence of housing instability, psychiatric illness, and access to outpatient care in all subgroups, all interventions for a similar population should consider including housing, mental health support, and community health workers or care navigators to assist

individuals in accessing the care they need. Some existing interventions have already shown promise in improving outcomes for this group of individuals, but increased support for these programs is needed from health departments and other government agencies that could provide funding or infrastructure that individual EDs cannot develop or sustain alone. Implementation research examining service delivery strategies in a variety of hospital settings and providing evidence of feasibility and efficacy is urgently needed.

## LIMITATIONS

This was a single-center QI initiative and, as such, results may not be generalizable to other locations. However, the findings are consistent with existing literature, and they are likely applicable to other urban EDs serving socioeconomically depressed populations. Additionally, because the establishment of an ED social medicine team was a QI initiative, team structure, record keeping, and interventions evolved over time. Identification of social needs is somewhat subjective, and this review relied on needs being recorded in a database or in the medical record, which may not always have been consistently done.

Individuals may not have disclosed certain SDOH to their medical team, and if not relevant to their ED visit, these needs may not have been recorded in the chart. Some individuals had more comprehensive social work evaluations, while others were unable or unwilling to participate in these evaluations, which may have affected the team's ability to accurately identify their SDOH. Individuals identified to have only medical needs driving their ED visits, including sickle cell pain crises, were excluded, but it is possible that they, too, had unidentified SDOH. Lastly, because members of the ED social medicine team were not reliably able to access information about ED visits or medical admissions at other hospitals, psychiatric admissions, or incarceration, use of system resources could not be completely evaluated. However, the patterns observed in this QI project are likely similar to those of ED super-users elsewhere, and the findings about ED use at a single site are relevant to other EDs caring for similar populations.

## CONCLUSION

Frequent users of the emergency department contribute to crowding and economic consequences; at the same time, they have worse health outcomes than other ED visitors. Needs identified in this analysis—most notably housing instability, psychiatric illness, substance use, and difficulty accessing outpatient care—could be used to develop targeted, comprehensive interventions that might have a higher likelihood of success than the current piecemeal system employed in most hospitals. As social safety nets face increasing challenges, placing additional strain on EDs and social service workers, it will be critical to advocate for additional, evidence-based resources that effectively address the most pressing needs of this vulnerable group.

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# Impact of Live Preferential Music on Pain in the Emergency Care Setting: A Randomized Controlled Trial

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**Introduction**: Pain is the most prevalent complaint for the more than 155 million patients accessing emergency care in the United States. Appropriate and timely management of pain is a measure of quality emergency care. However, the opioid crisis has created a need for multimodal and alternative approaches to successful pain management. Models for integrating such approaches in emergency departments (ED) are understudied. Therefore, we chose to investigate the impact of live preferential music (LPM) in the management of acute musculoskeletal pain.

**Methods**: This prospective, randomized, double-blind intervention study was designed with block randomization clustered by day of the week to live preferred music versus usual care. To ensure blinding, patients were deceived that the study focus was on pain assessment without disclosure that there was an intervention. A total of 2,262 patients were screened, and 272 patients (94 interventions, 128 usual care controls, and 50 declined-music intervention) were recruited from two free-standing EDs. All subjects received analgesics per prescription, had vital signs measured, and completed baseline and follow-up Pain Intensity Number Scale (0-10) scores via PAIN*Report*It. We calculated morphine equivalents for pain medications in the ED.

**Results**: The mean age of the 222 patients in the per-protocol analytic sample was 48.3 years (95% confidence interval, 45.9-50.7); 64% were female, 29% Black; and their triage acuity was 4% emergent Emergency Severity Index (ESI) 2, 52% urgent ESI 3, and 44% less urgent ESI 4. There were absolute reductions in current pain intensity from baseline in both the control (–1.21) and intervention (–1.34) groups (difference –0.14, 95% CI, –0.48 to 0.76). However, the difference was not significant in posttest pain intensity when controlling for baseline pain intensity ($P = .29$). Qualitative analysis reflected patient-reported reduction in the perception of pain as a common theme. Vital signs and morphine equivalents were similar between groups.

**Conclusion:** This study demonstrated that live preferential music interventions are feasible to study rigorously in the ED. Patients were enrolled using deception and were not informed of the study's focus on music or their potential exposure to music. However, they were told initially that they would be part of a pain assessment study. Although significant between-group differences were not observed, the general theme of patient-reported reduction in the perception of pain suggests that a more highly powered study might detect significant effects in pain reduction with LPM. Variation in clinician care strategies and evolving federal guidelines for pain management may have influenced study processes and outcomes. [West J Emerg Med. 2026;27(5)1189–1198.]

## INTRODUCTION

For the more than 155 million patients accessing emergency care in America every year, pain is the most prevalent complaint.[1] Although failure to recognize and treat pain in an appropriate and timely manner is a marker for poor emergency care, rise of the opioid crisis underscores the need for multimodal and alternative approaches to successful pain management. Models for integrating such approaches in emergency departments (ED) are understudied. This study investigated the effects of live preferential music (LPM) in an emergency and trauma care setting on acute musculoskeletal pain intensity and medication administration.

Emergency departments are high-stress environments that are one of the significant drivers of high costs in healthcare. Due to the relatively high pace, crowding, and resource-intensive environment, compared to other clinical settings, the ED has traditionally proven to be a challenging setting for the delivery of interventions including music. Although music therapy has been shown to reduce pain and anxiety in emergency settings,[2] LPM—patient-selected songs performed vocally with instrumental accompaniment—has been studied primarily outside acute care,[3,4] and remains largely unexplored in emergency and trauma settings.

This study was grounded in neuroscience evidence that music activates the brain's reward system, including dopamine release, and that both familiar stimuli and the act of choice are neurologically reinforcing.[5] Furthermore, the trial was supported by experience of two prior unpublished protocol development studies at the University of Florida (UF) and UF Health. The first study focused on the development of strategies for introducing LPM in ED settings, and the second unblinded study focused on the feasibility and impacts of this intervention in a primary hospital-based ED where most patients were exposed to two to four songs. In this third study, we aimed primarily to determine whether LPM could reduce pain intensity and secondary reduction in pain medications administered for patients presenting to the ED with musculoskeletal pain. We also examined the physiological effects of LPM on patients' vital signs, blood pressure, heart rate, respiratory rate, and oxygen saturation. Finally, we examined the fidelity of implementing a LPM protocol for obtaining specific preference-based musical requests from patients in the ED.

*Population Health Research Capsule*

What do we already know about this issue?
*Pain is the top emergency department (ED) complaint; opioid limits heighten interest in nonpharmacologic options, but ED music models remain understudied.*

What was the research question?
*Does live preferential music reduce acute musculoskeletal pain in ED patients compared with usual care?*

What was the major finding of the study?
*Post-music pain scores declined over time but were not different from usual care: Pain score decline: –1.21/10 control vs –1.34/10 music; difference –0.14 (95% CI, –0.48 to 0.76),* P = *.67.*

How does this improve population health?
*These findings support feasible, acceptable nonopioid ED pain strategies that may improve patient-centered care and warrant larger trials.*

## METHODS

### Study Design

This prospective experimental trial, conducted with a convergent mixed-methods design, included a randomized, controlled, double-blinded design with one experimental and one control arm to assess the effects of a new LPM protocol (ClinicalTrials.gov NCTT03327077). The University of Florida's Institutional Review Board (IRB201700938) approved the study.

A block randomization clustered by day of the week to LPM or usual care was used to determine the days of music intervention over the duration of the study. Within blocks of four, six, and eight days, randomly ordered, the days were assigned to music intervention or no music intervention (usual care). Patients were enrolled using deception and were not informed of the study's focus on music, or their potential exposure to music; however, they were told initially that they would be part of a pain assessment study. After the study was completed, we mailed letters to participating patients disclosing the deception.

### Sample Size

Trained research associates (RA) recruited patients from those seeking care in two free-standing EDs. Inclusion criteria included English-speaking patients 18 years of age and older with a chief complaint of musculoskeletal pain, grade two reading level or greater, and the capacity to participate physically and cognitively. Patients who could not consent and prisoners were excluded. Based on study duration and clinical feasibility for detection of a 25% reduction in pain with 80% power, a total of 242 subjects (121 per group) was required.

### Procedures

The study took place with trained musicians and RAs in 5-hour shifts from 12 PM - 5 PM on randomized weekdays.

Only the study statistician and the assistant director of the Arts in Medicine program, who was responsible for supervision of the musicians, knew the days assigned to each condition. The RA and musicians were made aware of the music day assignment on the date of randomization. On all study days, patients were screened for participation and enrolled in the study via written informed consent by a RA in the ED. The RA then administered the prequestionnaire and on music days notified the musician of the patients who consented. The musician subsequently consulted with the charge nurse and/or attending physician(s) to identify patients for whom music would be appropriate. If the clinician agreed, the musician entered the patient's room and offered music to the patient within a 15-minute window of completion of the premeasure.

If the patient was interested, the musician discussed music preference with the patient using the LPM protocol (Supplemental Materials) and offered to perform appropriate preference-based music. For all enrolled patients, the RA returned to the patient room 30 minutes after the completion of the premeasure to obtain the postmeasure. This period allowed a standard time frame for both groups with wait time for the control group and sufficient time for the music intervention.

**Usual Care**

Patients consenting on days randomized to usual care received prescribed analgesics. They completed the study procedures (ie, pre- and post-measures and vital signs).

**Music Intervention**

Patients consenting on days randomized to the music intervention received usual care (prescribed analgesics) and study procedures (ie, pre- and post-measures and vital signs) and after the RA exited the room, the musician entered and offered to perform for the patient; the patient did not know that music was part of the study. The RA was not informed whether the patient accepted the music; all patients enrolled on days randomized to the music intervention completed all study measures.

Per the protocol, each conversation between the musician and patient, following introductions, started with the question "What would you like to hear?" and subsequently went from broader levels of preference (genre) to specific (song), based on whether the patient had an initial music preference or not. The protocol had six distinct pathways to preference. Musicians used the protocol as a framework, rather than a script, and always deferred to the patient's comfort with answering questions.

Musicians were guitarist-vocalists with broad musical repertoires that allowed them to respond to a range of requests across musical genres. The patient's door remained closed during the interaction to limit the drift of sound to other areas. Per the normal practice of artists in the hospital's Arts in Medicine program, patients were provided the option to decline or discontinue the interaction at any time.

To assess the intervention processes, the musicians documented their interactions with patients on a Research Electronic Data Capture (REDCap) form after each performance. The form documented the location, time and length of the interaction, the number, and roles of the people in the room, the patients' sex, the music played (genres, artists, songs), and how preference was (or was not) established in relation to the LPM protocol. Protocol fidelity was examined through analysis of the pathways taken to obtain preference. These pathways were mapped using an online Qualtrics LLC survey that documented the musician's questions and patient's answers regarding musical preference. The objective was to garner preference using the fewest questions possible. The musicians also entered a narrative description of the interaction.

**Outcomes and Measurement**

The primary outcome of this study was the assessment of pain reduction using PAINR*eport*It[6] collected via Apple iPad or Microsoft Surface devices. PAINR*eport*It is a validated computerized extension of Melzack's (1970) McGill Pain Questionnaire (MPQ).[7] Its Pain Intensity Number Scale (PINS)[8] allows subjects to indicate the intensity of pain at present, as well as their least and worst pain during the prior 24 hours (baseline) or since the last measure (postintervention). The PINS provides ratio-level data as a measure of pain intensity[9] with its scale of 0 ("no pain") to 10 ("pain as bad as it could be." Concurrent (r =.80-.89)[8] and construct validity have been reported.[10,11] The PINS with its standardized instructions can be completed by patients in less than one minute.[8]

Secondary effects of LPM included morphine equivalents and physiological measures. Variables were collected and cross-referenced using the subject's medical record number and the date of visit. Bedside collection of the patient medical record number, music selection, and date/time of the intervention were recorded at the time of the musician visit. Variables collected from the medical record included patient age, sex, mailing address, blood pressure, heart rate, oxygen saturation, and respiratory rate before and after the music intervention. All data were entered into the university's secure REDCap database.

**Statistical Analysis**

We exported pain data from the PAIN*Report*It structured query language (SQL) database into Microsoft Excel and imported into Statistical Package for the Social Sciences (SPSS25) for statistical analysis. All clinical data were extracted from the REDCap to SPSS. Live preferential music protocol data were analyzed using SAS Institute Inc. Descriptive statistics (means, frequencies, and percentages) and inferential tests (the independent *t* test, chi-square test, and Fisher exact test) were used to examine the relationships between the outcome variable and the covariates. All *P* values were from two-sided tests, and results were deemed

statistically significant at $P < .05$.

We chose a per-protocol analysis approach over an intention-to-treat approach because patients were unaware that the intervention was music-based, having been told the study's sole purpose was pain assessment. The primary study outcome was the between-group difference in post-pain intensity scores after the group condition (wait period or music intervention), controlling for the baseline pain intensity score. The model for this was as follows: postintervention pain score = constant + ($a$ × baseline pain score) + ($b$ × group), where $a$ and $b$ are regression coefficients and group is a binary dummy variable (with the control coded as 0 and treatment coded as 1). The main coefficient of interest was $b$, which was the estimated difference between the treatment and control group. An analysis of covariance (ANCOVA) adjusted each subject's follow-up score for their own baseline score but was unaffected by baseline differences and regression to the mean. Statistical significance a priori was set as $P < .05$.

Qualitative data garnered from the musicians' narrative reports following each music interaction and decline were analyzed thematically by a team of investigators and RAs. A codebook was developed to define and document themes. The resulting themes were used to explain and triangulate with the quantitative findings. Assessment of the fidelity of the LPM protocol was undertaken through quantitative analysis of the pathways the musicians took to obtain musical preference from patients.

## RESULTS

### Sample Characteristics

A total of 2,262 patients were screened for the study, and 272 patients were consented to participate at two free-standing EDs. Of those who consented, 94 received the music intervention and 128 received usual care in the control group. An additional 50 patients were consented on intervention days and completed measures but declined the music intervention and were subsequently excluded from the main analysis, which included 222 total patients (Figure).

Table 1 outlines patient characteristics as well as differences in characteristics between the control and intervention group. The mean age of the sample was 48 (95% CI, 46-51); age ranged from 18 to 95 years. Most patients were female (64%) and White (71%), and 37% were privately insured. The triage acuity distribution was 4% emergent ESI 2, 52% urgent ESI 3, and 44% less urgent ESI 4. The mean body mass index was 31.3 kg/m$^2$ and mean length of stay was 4.4 hours (95% CI, 3.78-5.03). As shown in Table 1, the control and intervention groups did not differ significantly on any of the measured personal or clinical characteristics ($P > .05$).

### Outcomes

Table 2 shows the mean pain intensity score of all three pain measurements by groups and changes in pain intensity scores within group. The *pain now* had the highest reduction of pain intensity for the control (−1.21) and the intervention (−1.34) groups among the three pain measurements.

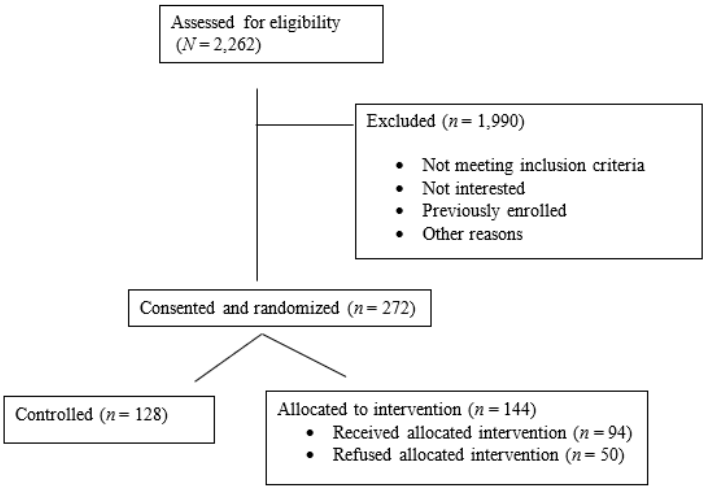


**Figure.** Consolidated Standards of Reporting Trials diagram showing the flow of participants through a randomized control trial of the effect of live preferential music on pain in the emergency care setting.

Table 3 shows the results of the ANCOVA model, in which we adjusted for the baseline pain score effect on the postintervention pain score. Results show that although there were absolute reductions in pain intensity for patients who were randomized to control or intervention groups, the differences in the pain intensity were not statistically significantly different between-groups ($P > .29$). Absolute reductions in pain scores were more clinically significant in patients with moderate initial pain intensity scores as opposed to higher or lower pain intensity scores. We conducted a similar analysis—adjusting for patient's sex, age groups (younger than 50 versus older than 50 years), race, and payer status—and found no significant predictor except baseline pain score.

There were no differences in vital signs (Table 4) or pain medication administration between groups as determined by morphine equivalent administration (Table 1).

### Qualitative Findings

The qualitative data garnered from musician's narrative reports resulted in seven themes (Table 5). It was notable in the qualitative analysis that all the themes were positive in nature, generally and overtly reflecting appreciation and satisfaction with the music intervention. A common theme was patient-reported reduction in the perception of pain, suggesting that a more highly powered study may detect more significant effects on pain.

### Live Preferential Music Protocol Fidelity

Among the 94 participants in the music intervention

**Table 1.** Patient characteristics participating in a randomized control trial of live preferential music on pain in the emergency care setting.

| Characteristics | Intervention (*n* = 94) | Control (*n* = 128) | Total (*n* = 222) |
|---|---|---|---|
| Age in years, mean (95% CI) | 48.54 (44.63, 52.44) | 48.12 (45.10, 51.15) | 48.30 (45.92, 50.68) |
| Body mass index, mean (95% CI) | 32.14 (30.20, 34.08) | 30.64 (29.15, 32.13) | 31.28 (30.10, 32.47) |
| Length of stay in hours, mean (95% CI) | 4.46 (3.25, 5.67) | 4.18 (3.35, 5.02) | 4.4 (3.78, 5.03) |
| Morphine equivalents (mg), mean (95% CI) | 29.49 (15.45, 43.44) | 24.64 (16.55, 32.73) | 26.69 (19.22, 34.16) |
| Sex, *n* (%) | | | |
| Male | 35 (37.23) | 45 (35.16) | 80 (36.04) |
| Female | 59 (62.77) | 83 (64.84) | 142 (63.96) |
| Race, *n* (%) | | | |
| White | 61 (68.54) | 90 (72.00) | 151 (70.56) |
| Black | 28 (31.46) | 35 (28.00) | 63 (29.44) |
| Payer status, *n* (%) | | | |
| Private/commercial | 29 (32.22) | 51 (41.13) | 80 (37.38) |
| Medicare | 23 (25.56) | 21 (16.94) | 44 (20.56) |
| Medicaid | 24 (26.67) | 32 (25.81) | 56 (26.17) |
| Self-pay | 14 (15.56) | 20 (16.13) | 34 (15.89) |
| Triage acuity, *n* (%) | | | |
| Urgent | 53 (56.38) | 63 (49.22) | 116 (52.25) |
| Less urgent | 39 (41.49) | 58 (45.31) | 97 (43.69) |
| Immediate | 0 | 1 (0.78) | 1 (0.45) |
| Emergent | 2 (2.13) | 6 (4.69) | 8 (3.60) |

Note: Other race (n = 9) are not shown here. All characteristics were non-significant at $P < .05$ level.
*CI*, confidence interval.

group, six were missing data and nine noted "other" as a means of achieving preference. These 15 records were removed from analysis, leaving 79 LPM data points. Initial preference was documented for 49 patients (62%), whereas 30 (38%) did not express an initial preference. When patients had an initial music preference, P3 (genre–artist–song) was the most common pathway to preference (77.5%). When patients did not have an initial music preference, NP3 (tempo–genre–artist–song) was the most common pathway (70%). Across both initial and no initial preference groups, the most prevalent ending point in the dialogue for determining musical preference was genre (44.3%) followed by tempo (22.8%). Compared to earlier study phases, which were only able to obtain clear preference from 49% of patients, the protocol was determined to be an effective and efficient means for determining preference, as it resulted in preference being obtained and documented for 100% of patients at the level of genre, tempo, artist, or song.

The music interactions lasted 8–9 minutes, including conversation and performance. Among patients who enrolled in the intervention group, most were only exposed to one song (53%) or two songs (36%).

**Financial Cost Estimates**

For our program, we invested in an initial 12-month start-up period to develop and refine practice and protocols. The contracted musicians were paid $30 per hour. Following an initial start-up investment of $23,700, the program was maintained at a cost of $87,000 per year, including hourly pay for the musicians (with 30 total contact hours per week), a part-time coordinator, two RAs and a statistician, and additional in-kind support for supervision by leaders of the hospital art program and research effort by the study co-investigators. The total annual cost for the study, including in-kind support, was $143,700 per year with $63,000 for music program costs and $80,700 in research costs.

**Challenges**

There were notable challenges in the initial execution of the study. Enrollment was initiated during the respiratory viral season with unexpectedly high patient volumes. Consequently, access to acoustically isolated areas to facilitate the music intervention was limited. In addition, masking posed challenges in communication between the musician and patient. Therefore, the music protocol was temporarily

**Table 2.** Comparison of pain measurements in a randomized control trial of the effect of live preferential music on pain in the emergency care setting.

| | Control (*n* = 128) Mean (SD) | Intervention (*n* = 94) Mean (SD) | Difference between means, (95% CI) | *P* value |
|---|---|---|---|---|
| Pain Now | | | | |
| Baseline | 6.84 (2.48) | 6.28 (2.57) | –0.56 (–0.11, 1.24) | .10 |
| Follow-up | 5.63 (2.59) | 4.97 (2.69) | –0.65 (–0.05, 1.36) | .07 |
| Change score | –1.21 | –1.34 | –0.14 (–0.48, 0.76) | .67 |
| Pain Worst | | | | |
| Baseline | 8.56 (1.74) | 8.35 (1.91) | –0.21 (–0.27, 0.70) | .40 |
| Follow-up | 7.55 (2.37) | 7.18 (2.54) | –0.37 (–0.28, 1.03) | .27 |
| Change, pain intensity scores | –1.01 | –1.17 | –0.16 (–0.71, 0.38) | .56 |
| Pain Least | | | | |
| Baseline | 4.90( 3.14) | 4.64 (3.02) | –0.26 (–0.57, 1.09) | .54 |
| Follow-up | 4.54 (2.83) | 4.35 (2.85) | –0.19 (–0.57, 0.95) | .62 |
| Change, pain intensity scores | –0.36 | –0.29 | 0.07 (–0.63, 0.73) | .85 |

*SD*, standard deviation.

suspended at a large academic ED and relocated to two satellite or free-standing EDs, which were less prone to crowding during the proposed period of the intervention. Despite this effort, the study team encountered protracted enrollment opportunities, secondary to the lower acuity and shorter length of stay of the free-standing population.

## DISCUSSION

We examined the effects of live music for patients seeking ED care for musculoskeletal (MSK) pain, a common reason patients seek emergency care. We demonstrated that LPM intervention can be rigorously studied in an ED environment, was well-received by the patients, but did not show a statistically significant benefit on MSK pain outcomes or other secondary outcomes. Reasons for the not statistically significant findings are not clear from the data we collected but could include the smaller sample than planned for adequate power, relatively short intervention sessions, and variation in emergency clinician care strategies with the institution of new state and federal pain management guidelines.

Improving quality of care for MSK pain is an important priority for patients, clinicians, and policymakers. Musculoskeletal pain conditions (eg, low back pain, osteoarthritis, cervical and thoracic spine pain) share similarities in mechanisms, prognosis, and clinical trajectory, which has led to overarching clinical practice guidelines for assessment and management.[12] Recommendations include patient-centered care with effective communication, shared decision-making, screening for serious pathology, physical examination, and assessment of psychosocial status. Given the current opioid public health crisis, nonpharmacologic therapies, including those that promote relaxation, such as live music, are becoming important in reducing the dependency on opioid prescription therapy and could be an important adjuvant to other pain reduction strategies. Reduction of pain by 1 to 2 points on a 0 to 10 pain intensity scale or a 30% reduction is typically considered clinically important,[13] and patients greatly appreciated the relief, especially if severe pain (7 to 10/10) is reduced to moderate (4 to 6/10) or mild (1 to 3/10) pain.[14] In our study, we observed a reduction of more than 1 point in both groups treated with prescription medications in both groups and combined with LPM in the experimental group.

Over the past two decades, partnerships between musicians, music therapists, and clinical researchers have yielded unprecedented development of clinical interventions supported by rigorous scientific studies.[2,15] Hundreds of studies have confirmed the effect of music on reducing pain, anxiety, and other clinical measures such as vital signs.[16]

**Table 3.** Analysis of covariance model predicting follow-up pain score in a randomized control trial of live preferential music on pain in the emergency care setting.

| | *t* value | *P* value | Beta coefficient |
|---|---|---|---|
| Baseline pain score | 10.899 | .001 | 0.62 |
| Group (Intervention vs control) | –1.056 | <.29 | –0.306 |

**Table 4.** Vital signs by group and time in a randomized control trial of the effect of live preferential music on pain in the emergency care setting.

| Vital signs | Control Mean (SD) *n* = 128 | Intervention Mean (SD) *n* = 94 |
|---|---|---|
| Systolic blood pressure | | |
| Baseline | 129.8 (20.13) | 133.71 (24.39) |
| Follow-up | 128.98 (19.5) | 133.71 (22.05) |
| Diastolic blood pressure | | |
| Baseline | 75.0157 (80.13) | 77.86 (13.08) |
| Follow-up | 74.0694 (78.98) | 79.46 (11.8) |
| Heart rate | | |
| Baseline | 74.21 (13.05) | 73.36 (12.07) |
| Follow-up | 75.94 (13.09) | 75.16 (12.4) |
| Oxygen saturation | | |
| Baseline | 97.98 (1.91) | 97.76 (1.9) |
| Follow-up | 96.16 (10.7) | 97.77 (2.13) |
| Respiratory rate | | |
| Baseline | 16.01 (4.5) | 15.5 (1.94) |
| Follow-up | 17.31 (10.59) | 15.48 (1.83) |

All differences were non-significant at $P < .05$ level.
*SD*, standard deviation.

There is clearly documented evidence of the physiologic impact of music including effects on parasympathetic activity, stress hormone levels, and immunity, suggesting its efficacy in decreasing stress-induced autonomic and neuroendocrine arousal and the facilitation of the relaxation response. In the medical environment, music can be a safe and low-cost, nonpharmacologic intervention to reduce anxiety and enhance relaxation in intensive care patients as well as to reduce pain perception, anxiety, and stress levels in the ED setting.[17]

In various patient populations and procedures, music positively affects pain control, pain tolerance, and pain perception,[18-24] as well as the need for anesthesia and sedation.[25,26] The 2008 analysis by Nilsson[27] of 42 studies found that approximately half of the studies reported significant positive effects of music on pain and anxiety. The 2016 meta-analysis by Lee[28] of 97 studies found that music interventions had statistically significant effects in decreasing pain, emotional distress from pain, opioid intake, nonopioid intake, systolic blood pressure, diastolic blood pressure, and respiration rate. Also, studies of music in emergency care have presented positive outcomes related to anxiety and stress,[29,30] pain management,[30-32] reduction of noise stress,[29] and significant pain and anxiety reduction during burn dressing changes.[33,34] Most interventions used recorded music, and some engaged technology such as iPods[35] in contrast to our use of LPM.

In our study, participants were blind to the study goals, and our findings add to the few unblinded investigations that have been conducted with small samples on the use of live music as an intervention for pain and anxiety.[2] For example, Ferrer[36] documented positive effects of live music on fear, fatigue, diastolic blood pressure, and relaxation levels among patients receiving chemotherapy. Holmes et al[37] suggest that live music has advantages over recorded music, a conclusion cited as well in the review by Aldridge[38] of music therapy. Live music has been shown to be beneficial for neonatal, pediatric, burn, postoperative, and palliative care populations.[33,39] A recent study[40] of live patient-preferred music resulted in greater anxiety reduction than recorded music. More such research is needed in emergency and acute care environments.

Preferential music is also becoming the standard in music interventions as studies show that choice, preference, and familiarity with music can enhance its effectiveness as an intervention and can contribute to reductions in pain and anxiety.[41-45] Several terms are used for such interventions, including patient-preferred music, customized music, and patient-directed music.[46,47] More recent studies have begun to look specifically at LPM as an intervention, using terms such as patient-preferred live music, live preferred music, and LPM. These studies have found significant improvements in the reduced perception of pain and anxiety, in particular.[42,48] The review by Ramaswami and Silverman[5] offered a neuroscience-based rationale for patient-preferred live music as a receptive music therapy intervention for adult medical patients. They suggest that there is ample neuroscientific evidence regarding the brain's response to music, mostly pertaining to the reward system and dopamine release. They also offer evidence that both exposure to familiar stimuli and the act of making a choice may be neurologically reinforcing. A recent review[44] found preferred live music was applicable for affective states, pain, nausea, and physiological measures for adult cancer and transplant patients.

Our findings are interesting and suggest that patients with moderate-intensity pain may be more likely to show quantifiable benefit from a LPM intervention. The absolute reductions in pain scores were more clinically relevant in patients with moderate initial pain intensity scores as opposed to higher or lower pain intensity scores. This finding was not likely due to differences in pain medication between groups because the morphine equivalent doses did not differ. Also, we noted that the most common reason patients provided for declining music and being excluded from the analysis was that they were in too much pain for music. These findings suggest there may be a specific range of pain in which music may be most appropriate and acceptable to patients in the ED setting. Additional research is needed to define the pain intensity levels most amenable to preferential live music intervention.

A notable finding of this study was that the LPM protocol was a useful means for obtaining a patient's musical

**Table 5.** Seven themes derived from musician's narrative reports in a randomized control trial of the effect of live preferential music on pain in the emergency care setting.

| Theme | Exemplar Comments |
|---|---|
| Theme 1:<br>Patients had positive responses to the music interaction. | "Patient said, 'I can't wait to come back to the emergency room!'"<br>"Patient was very pleasant and appreciative of the music visit. She smiled and thanked me."<br>"Delighted afterward. Sat back and relaxed during the song, put her phone down to listen." |
| Theme 2:<br>Patients expressed gratitude for the interaction. | "She ended by saying, 'that was a blessing,' and I told her I was glad to be able to share that with her. She asked my name and I left with good wishes."<br>"Exceptionally thankful for the music and said it shifted her day." |
| Theme 3:<br>Patients reported reduction in pain. | "Patient said 'That took the pain away.'"<br>"Patient was really relaxed by the music. Said it helped her pain."<br>"He said his pain level was at a 1 when the nurse asked him. Said the music helped."<br>"Patient was in pain, but said the music helped." |
| Theme 4:<br>Patients participated actively in the interaction (ie, singing along, dancing). | "Praised Jesus the whole time. Sang along with each song. Looked tired but was interactive and said that God sent me."<br>"Sang and danced along. Seemed like it really distracted her." |
| Theme 5:<br>Initial hesitation followed by positive response to the interaction | "[Patient] was hesitant at first. Warmed up to me throughout the visit. Ended up smiling."<br>"Patient was hesitant, but daughter welcomed me in. I offered choices for tempo and genre and the patient smiled as I sang." |
| Theme 6:<br>The interaction provided meaningful social engagement for the patient. | "Talked a lot, about musicians they knew and other random things."<br>"Patient really wanted to talk about music afterwards." |
| Theme 7:<br>Patients shared the experience with others. | "[Phoned] his girlfriend to come in to listen. He invited his neighbors to listen also."<br>"Patient closed his eyes and sang along to all of the songs, looking over at his guest with approval." |

preference and represented a significant improvement from our prior approach. Additional testing and qualitative data collection at other sites could enhance the specificity and reliability of the instrument. In addition, the term "preference," and the level of preference (ie, genre, artist, song) needed to qualify as a true preference need further definition in relation to hospital bedside music. Although this study marks significant advancement in defining the term LPM, further work is needed.

Live preferential music interventions in the ED have significant potential to alter the environment of care and impact patients' perception of pain. There is ample qualitative evidence of beneficial impact. The strategies that we have developed to provide these alternative and unorthodox interventions in the ED is imminently scalable and easily disseminated. A larger, more narrowly focused multisite study with like organizations with a similar infrastructure and sophistication of arts in medicine programs may be required to demonstrate quantitative outcomes in reducing costs and supporting benefit in patient care in the acute setting. During our study, we did not experience negative impacts on the presence of LPM in these settings, and the music program costs for the two ED settings was reasonable: $63,000 per year. Future efficacy studies should also evaluate the cost-effectiveness of LPM in ED settings.

## LIMITATIONS

The study enrollment began at a period of extraordinarily high census during the flu season. Due to unexpectedly high patient volumes, the study was suspended for several reasons. Patients initially meeting enrollment criteria were triaged to locations that did not meet the required criteria for isolating the music to the individual patient. In addition, all personnel, including the musicians, were required to wear masks, making the intervention even more challenging and significantly changing the nature of the interaction. As a result, the music protocol was relocated to two satellite EDs where further challenges to enrollment occurred, specifically because fewer patients met the inclusion criteria for MSK pain. In addition, the greater efficiency, shorter length of stay, and lower acuity of the satellite facilities resulted in fewer opportunities for enrollment. Further, patient length of stay may have also impacted the length of time and exposure of patients to the intervention (most were only exposed to one song (53%) or two songs (36%), which, in turn, could be an important factor impacting outcomes. The reasons 50 patients declined the LPM intervention are unknown, but their decisions resulted in a smaller sample size than projected by the power analysis.

## CONCLUSION

Among ED patients who also received analgesic

medication for acute MSK pain, we found a not statistically significant effect of more than 1 point reduction in pain intensity in both the control and live preferential music. Patients were enrolled using deception and were not informed of the study's focus on music or their potential exposure to music. However, they were told initially that they would be part of a pain assessment study. In this context, we demonstrated that LPM interventions can be rigorously studied in some ED environments and were well-received by the patients who accepted the intervention. Future, adequately powered multisite studies are needed to demonstrate any potential quantitative benefit of LPM on patient outcomes in the ED setting.

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# Effectiveness of a Nurse-Led Ambulatory Care Clinic in Reducing Emergency Department Visits and Hospitalizations

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**Introduction:** Gaps in care integration and coordination contribute to emergency department (ED) crowding and preventable hospitalizations, necessitating innovative solutions to improve care transitions and reduce acute care use. This study evaluates whether attendance at a nurse-led ambulatory intermediate care clinic (AICC) reduces three-month ED visits and hospitalizations compared to missed AICC appointments.

**Methods:** This retrospective cohort study at a single academic center analyzed AICC appointments from the first three years of clinic operations using multivariable logistic regression models, controlling for demographic, socioeconomic, and clinical factors. Our primary outcome measure was an ED visit within three months of the AICC appointment; our secondary outcome measure was hospitalization within three months. Robustness was assessed using Poisson, negative binomial, and zero-inflated models.

**Results:** Among 2,698 appointments analyzed (mean age 51.5 years; 49.7% female), patients who attended their AICC appointment had a lower absolute ED visit rate compared with those who missed it (250/2,389 [10.5%] vs 47/309 [15.2%]; risk difference, 4.75%; 95% CI, 0.56-8.93%; $P$ = .03). Missing an AICC appointment was significantly associated with greater odds of an ED visit (OR, 1.54; 95% CI, 1.07-2.21; $P$ = .02). Hospitalization rates were 47.3% versus 53.4% ($P$ = .04), although missing an AICC appointment was not significantly associated with increased hospitalizations (OR, 1.28; 95% CI, 1.00-1.64; $P$ = .05). Findings were consistent across robustness analyses.

**Conclusion:** The ambulatory intermediate care clinic model was associated with fewer ED visits but not reduced hospitalizations, suggesting that intermediate care can improve timely access and address acute care needs but may be insufficient to influence more complex drivers of inpatient admissions. Future research should explore strategies to enhance coordination and optimize the role of intermediate care within broader health system workflows. [West J Emerg Med. 2026;27(5)1199–1207.]

## INTRODUCTION

Emergency departments (ED) and hospitals are increasingly confronting the challenge of crowding.[1-3] This issue extends beyond the boundaries of individual facilities, emerging as a systemic problem that is influenced by and affects the coordination and capacity of the broader landscape of healthcare delivery.[4] In this context, ambulatory care settings often encounter patients whose health concerns exceed the capacity of these clinics, necessitating referrals to EDs or hospitals.[5,6] As a result, primary care clinics have become a notable source of referrals, unintentionally contributing to the crowding in both EDs and hospitals.[7] This trend underscores the complex interplay between various levels of healthcare provision (eg, nonacute versus acute) and the need for integrated solutions to address systemic crowding.

In response to this challenge, the concept of intermediate care has been proposed as a viable solution.[8-11] Intermediate care, first introduced in healthcare systems in the United Kingdom,[8,12] aims to provide a level of care that sits between the intensity of the ED or hospital and the basic care offered in outpatient settings.[13] A large academic health system has pioneered a nurse-led ambulatory intermediate care clinic (AICC) with the objective of mitigating ED congestion and reducing avoidable hospital admissions. The nurse-led AICC is designed to cater to patients requiring more than primary care but less than acute hospital or ED care, focusing on balancing efficiency and quality of care. The AICC operates same-day referrals from outpatient clinics and has demonstrated measurable success during its first three years of operation, including a consistent increase in the volume of referrals and the ability to manage presenting patients without requiring same-day transfer to the ED.[14]

The AICC manages patients requiring services such as intravenous fluid administration, diagnostic workup for acute symptom exacerbation, medication adjustments, and monitoring for conditions such as chest pain, shortness of breath, or uncontrolled hypertension that exceed primary care capacity but do not yet warrant ED-level intervention. Conceptually, by addressing access barriers—such as affordability (lower copays than ED visits), availability and accommodation (avoiding long waits in overcrowded EDs), and accessibility (co-location with referring clinics)[15]—the AICC aims to address unmet health needs before they escalate to conditions requiring ED visits or hospitalizations.

However, the effectiveness of such intermediate care remains an area of exploration. Traditional evaluations of intermediate care often focus narrowly on within-clinic metrics, such as number of referrals, appointment attendance rates, and outcomes specific to those who received care.[9,16] While these approaches provide valuable initial insights into the clinic's role in care delivery, they fail to capture the broader value of intermediate care clinics within the larger healthcare network.[17] This limitation restricts the understanding of their systemic roles and contributions. Moreover, such evaluations performed at the clinic level, rather than the patient level, often overlook diverse patient characteristics—such as demographic factors, socioeconomic status, and clinical conditions—which critically influence a patient's access to care and use patterns.

This study fills these gaps through an in-depth, patient-level evaluation of the AICC, focusing on reducing ED visits and hospitalizations. We hypothesized that patients who received care in the AICC would have a lower likelihood of experiencing both an ED visit and an inpatient hospital stay compared with those who did not receive care in the clinic.

*Population Health Research Capsule*

What do we already know about this issue?
*Intermediate ambulatory care clinics may reduce emergency department (ED) crowding, but nurse-led models and their impact on ED visits is limited.*

What was the research question?
*Does attending a nurse-led intermediate care clinic reduce three-month ED visits and hospitalizations?*

What was the major finding of the study?
*Missing an ambulatory intermediate care clinic appointment: 54% greater odds of ED visit (OR, 1.54; 95% CI, 1.07-2.21; P = .02)*

How does this improve population health?
*Nurse-led intermediate ambulatory care clinics can reduce ED use by providing timely access to care that bridges primary care and emergency services.*

## METHODS

### Study Setting

This study took place in the nurse-led AICC within a large, multiclinic outpatient center in a key urban area in the United States. The outpatient center offers a wide range of outpatient services, from primary care to specialties like cardiovascular, neurology, oncology, and diabetes management. Additionally, a nearby complementary clinic extends the capacity for outpatient care. Combined, these two clinics treat over 2,000 patients per day. The AICC, implemented in May 2020, functions as a same-day referral clinic where clinicians from both outpatient facilities can call to discuss concerns regarding their patients and receive feedback on patient acceptance.[14] The AICC operates

Monday–Friday, 8 AM to 8 PM and provides same-day referrals for patients requiring a higher level of acuity, treating patients and discharging them home with follow-up care in the outpatient setting or transferring them to the ED as clinically indicated. Led by two registered nurse practitioners, the AICC is staffed by four registered nurses, a pharmacist, and a patient encounter specialist. It also has access to laboratory, imaging, and other services to assess and treat the patients. In collaboration with the referring physician, the AICC determines whether the patient can be safely discharged home or requires transfer to the ED.

### Data

Data were extracted from the electronic health record system by the institutional research and informatics service center using a structured approach consistent with recommended practices for retrospective medical record-based research.[18] Data collected included appointment characteristics and patient demographics and clinical information. Appointment characteristics, deidentified to protect patient privacy, encompassed both the scheduling and actual appointment dates and times. Our dataset also covers pertinent comorbidities and the appointment status (arrived, no show, canceled, or rescheduled). We combined the "cancelled" and "no show" categories into one category, ie, "missed," for a clear binary representation, forming a binary category ("arrived" versus "missed"), especially considering the relatively low frequency of no-shows (0.6%).

Demographic and socioeconomic details provided are the patient's city, state, Zip code, age, sex, ethnicity, race, marital status, preferred language, and primary insurance provider. These pieces of information are vital for analyzing patients' healthcare access and use, as well as for identifying areas where there may be disparities in care delivery.[19,20] The independent variable was appointment status; demographic, socioeconomic, and clinical variables were incorporated as covariates. To test the hypotheses, we used two dependent variables: (1) ED visits within three months following each patient's AICC appointment and (2) hospitalizations within the same timeframe. Because missing values were expected to be minimal, the degree of missingness was evaluated and summarized in the results narrative instead of being examined in detail.

This study was approved by the Institutional Review Board at the University of Alabama at Birmingham (Protocol #300010408).

### Patient Selection

Patients were excluded if their appointments occurred in the last three months of the dataset, because three-month post-appointment outcomes could not be observed. Patients were also excluded if they had a same-day ED visit or hospitalization on the date of a missed AICC appointment, as these visits likely represented direct clinical escalation rather than a failure to attend. The final analytic sample selection is detailed in Figure 1.

### Study Design and Methodologies

This retrospective cohort study employed a multivariable patient-level regression analysis to evaluate the effectiveness of the AICC in reducing ED visits and hospitalizations within three months of a patient's AICC appointment.

### Primary Analysis

We used multivariable logistic regression as the primary analytical approach to evaluate the association between AICC appointment status (arrived versus missed) and the primary outcome of a three-month ED visit. A parallel logistic regression model assessed the secondary outcome of three-month hospitalization. All models adjusted for demographic, socioeconomic, and clinical characteristics to address potential confounding.

### Secondary Analyses for Robustness

To account for potential overdispersion and zero-inflation in the dependent variable, Poisson, negative binomial (NB), zero-inflated Poisson (ZIP), and zero-inflated negative binomial (ZINB) regression models were employed. These additional analyses provided complementary perspectives and tested the consistency of associations observed in primary analyses.

## RESULTS

### Patient Selection and Sample Characteristics

Our original dataset included 3,137 AICC appointments over the first three years of operations (May 21, 2020, to June 12, 2023). After applying exclusion criteria described above, our final analytic sample consisted of 2,698 appointments (Figure). Missing data were observed for sex in one patient (< 0.1%); all other variables had complete data.

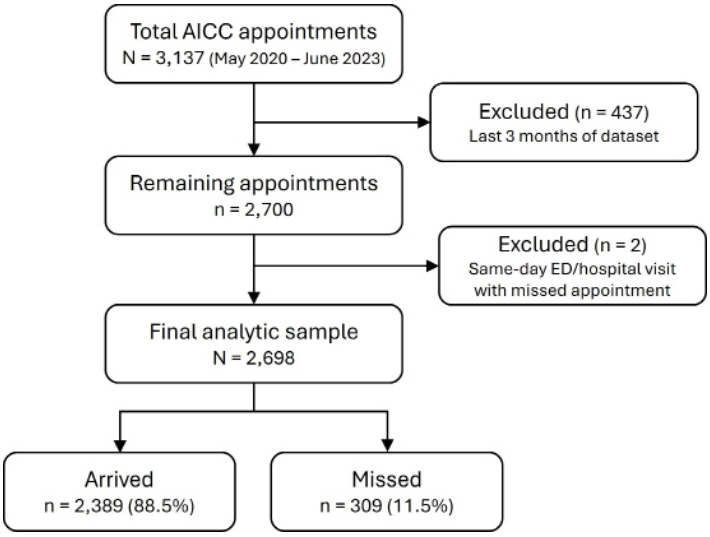


**Figure.** Patient selection flow diagram for this study. *AICC*, ambulatory intermediate care clinic; *ED*, emergency department.

The mean age was 51.5 years (24.0), and the sample was evenly split by sex (49.7% female). Most patients were White (58.2%) or Black (38.0%). Of the 2,698 appointments, 2,389 (88.5%) arrived and 309 (11.5%) were missed (cancelled or no-show). Among patients who attended their AICC appointment, none had an ED visit or hospitalization on the same day, indicating that all patients were managed without requiring same-day escalation to acute care.

**ED Visits**

Table 1 presents the bivariate descriptive analysis results for three-month ED visits. Patients who missed their AICC appointment had a higher ED visit rate compared with those who arrived (47/309 [15.2%] vs 250/2,389 [10.5%]; risk difference, 4.75%; 95% CI, 0.56-8.93%; $\chi^2 = 5.82$; $P = .02$). Significant bivariate differences were also observed for age, race, sex, marital status, and diagnoses of asthma, anxiety, and depression (Table 1).

**Hospitalizations**

Table 2 presents the bivariate descriptive analysis results for three-month hospitalizations. Patients who missed their AICC appointments had a higher hospitalization rate compared to those who arrived (165/309 [53.4%] vs 1,131/2,389 [47.3%]; risk difference, 6.06%; 95% CI, 0.14-11.97%; $\chi^2 = 3.78$; $P = .05$). Patients with a hospitalization

**Table 1.** Univariate descriptive characteristics and bivariate comparisons for three-month emergency department visits among patients referred to the ambulatory intermediate care clinic in a study evaluating the impact of appointment attendance.

| | All | No three-month ED visit | Yes three-month ED visit | *P* value |
|---|---|---|---|---|
| AICC Factor | | | | |
| AICC appointment status | | | | *P* = .02 |
| Arrived | 2,389 (88.5) | 2,139 (89.1) | 250 (84.2) | |
| Missed (cancelled / no show) | 309 (11.5) | 262 (10.9) | 47 (15.8) | |
| Demographics and Social Determinants of Health | | | | |
| Age, M (SD) | 51.5 (24.0) | 51.8 (23.9) | 48.8 (24.4) | *P* < .001 |
| Race/ethnicity, *n* (% of total) | | | | *P* < .001 |
| White | 1,570 (58.2) | 1,434 (59.7) | 136 (45.8) | |
| Black | 1,025 (38.0) | 873 (36.4) | 152 (51.2) | |
| Asian | 40 (1.5) | 34 (1.4) | 6 (2.0) | |
| Hispanic or Latino | 29 (1.1) | 26 (1.1) | 3 (1.0) | |
| Other | 34 (1.3) | 34 (1.4) | 0 (0) | |
| Sex, *n* (% of total) | | | | *P* < .001 |
| Female | 1,340 (49.7) | 1,156 (48.2) | 184 (62.0) | |
| Male | 1,357 (50.3) | 1,244 (51.8) | 113 (38.0) | |
| Marital status, *n* (% of total) | | | | *P* = .02 |
| Married/life partner | 1,345 (49.9) | 1,223 (51.0) | 122 (41.1) | |
| Single | 774 (28.7) | 668 (27.8) | 106 (35.7) | |
| Divorced/separated | 291 (10.8) | 255 (10.6) | 36 (12.1) | |
| Widowed | 222 (8.2) | 195 (8.1) | 27 (9.1) | |
| Unknown | 66 (2.4) | 60 (2.5) | 6 (2.0) | |
| Preferred language, *n* (% of total) | | | | *P* = .92 |
| English | 2,609 (96.7) | 2,320 (96.6) | 289 (97.3) | |
| Spanish | 14 (0.5) | 12 (0.5) | 2 (0.7) | |
| Other/unknown | 75 (2.8) | 69 (2.9) | 6 (2.0) | |
| Payor type, *n* (% of total) | | | | *P* = .50 |
| Commercial | 1,111 (41.2) | 989 (41.2) | 122 (41.1) | |
| Medicare | 703 (26.1) | 632 (26.3) | 71 (23.9) | |
| Medicaid | 773 (28.6) | 685 (28.5) | 88 (29.6) | |
| Uninsured | 93 (3.4) | 81 (3.4) | 12 (4.0) | |
| Unknown | 18 (0.7) | 14 (0.6) | 4 (1.4) | |

**Table 1.** Continued

| | All | No three-month ED visit | Yes three-month ED visit | *P* value |
|---|---|---|---|---|
| Comorbidities | | | | |
| Diabetes | 1,151 (42.7) | 1,030 (42.9) | 121 (40.7) | *P* = .52 |
| Myocardial infarction | 411 (15.2) | 358 (14.9) | 53 (17.8) | *P* = .21 |
| Coronary artery disease | 891 (33.0) | 803 (33.4) | 88 (29.6) | *P* = .21 |
| Chronic kidney disease | 1,324 (49.1) | 1,191 (49.6) | 133 (44.8) | *P* = .13 |
| Hypertension | 1,658 (61.5) | 1,475 (61.4) | 183 (61.6) | *P* = 1.00 |
| COPD | 397 (14.7) | 345 (14.4) | 52 (17.5) | *P* = .18 |
| Venous thromboembolism pulmonary embolism | 549 (20.3) | 488 (20.3) | 61 (20.5) | *P* = .99 |
| Asthma | 297 (11.0) | 252 (10.5) | 45 (15.2) | *P* = .02 |
| Anxiety | 887 (32.9) | 738 (30.7) | 149 (50.2) | *P* < .001 |
| Autoimmune disorder | 319 (11.8) | 278 (11.6) | 41 (13.8) | *P* = .31 |
| Depression | 768 (28.5) | 636 (26.5) | 132 (44.4) | *P* < .001 |
| Dyslipidemia | 1,365 (50.6) | 1,219 (50.8) | 146 (49.2) | *P* = .64 |
| Heart failure | 875 (32.4) | 765 (31.9) | 110 (37.0) | *P* = .08 |

*AICC,* ambulatory intermediate care clinic; COPD, chronic obstructive pulmonary disease; *ED,* emergency department; *M,* mean; *SD,* standard deviation.

were younger, had a higher proportion with Medicaid, and had a higher prevalence of multiple comorbidities (Table 2).

### Multivariable Regression Results

Table 3 presents the multivariable logistic regression results for ED visits and hospitalizations within three months of the AICC appointment.

### Emergency Department Visits

Missing an AICC appointment was significantly associated with 54% greater odds of an ED visit (OR, 1.54; 95% CI, 1.07-2.21; *P* = .02). Other significant predictors included prior ED visits (OR, 1.90; *P* < .001; prior hospitalizations (OR, 1.18; *P* = .03); Black race (OR, 1.74; *P* < .001); anxiety (OR, 1.57; *P* < .01); depression (OR, 1.76; *P* < .001); and cirrhosis (OR, 0.62; *P* = .02).

### Hospitalizations

Missing an AICC appointment was associated with 28% greater odds of hospitalization, but this was not statistically significant at the 95% confidence level (OR, 1.28; 95% CI, 1.00-1.64; *P* = .05). Significant predictors included prior ED visits (OR, 1.17; *P* = .04); prior hospitalizations (OR, 1.31; *P* < .001); younger age (OR, 0.99; *P* < .001); Medicare insurance compared with commercial insurance (OR, 1.30; *P* < .01); dialysis (OR, 0.58; *P* < .01); and heart failure (OR, 1.36; *P* < .01).

### Secondary Analyses

Results from secondary robustness analyses (Poisson, negative binomial, ZIP, and ZINB models) were consistent with the primary logistic regression results (Supplement Tables S1 and S2).

## DISCUSSION

This study evaluated the impact of a nurse-led AICC on reducing ED visits and hospitalizations within three months of an AICC appointment. By leveraging a multivariable analytical approach, this research assessed whether attending an AICC appointment influences healthcare use patterns and explored the clinic's role within the broader healthcare system.

The findings strongly supported the first hypothesis, which proposed that patients adhering to AICC referrals would have fewer ED visits within three months of an AICC appointment. Patients who attended their AICC appointment were significantly less likely to visit the ED within three months compared to those who missed their appointment. This result highlights the critical importance of timely access to intermediate care in addressing acute healthcare needs and preventing escalation of conditions that often lead to emergency visits. These findings align with prior research emphasizing the role of enhanced access in reducing ED congestion and improving care outcomes.

In contrast, the second hypothesis, which suggested that AICC adherence would be associated with reduced hospitalizations, was not supported by the data. Although the point estimate directionally indicated a protective effect, this association was not statistically significant, and the robustness checks yielded similar findings. This lack of association may reflect the complexity of hospitalization decisions, which are influenced by factors beyond outpatient care access, particularly disease severity and comorbidities. Additionally, the weaker

**Table 2.** Bivariate comparisons for three-month hospitalizations among patients referred to the ambulatory intermediate care clinic in a study evaluating the impact of clinic appointment attendance.

| | No three-month hospitalization | Yes three-month hospitalization | *P* value |
|---|---|---|---|
| AICC Factor | | | |
| AICC appointment status | | | *P* = .05 |
| Arrived | 1,258 (52.7) | 144 (46.6) | |
| Missed (cancelled / no show) | 1,131 (47.3) | 165 (53.4) | |
| Demographics and Social Determinants of Health | | | |
| Age, M (SD) | 53.8 (21.0) | 49.0 (26.7) | *P* < .001 |
| Race/ethnicity, *n* (% of total) | | | *P* = .05 |
| White | 793 (56.6) | 777 (60.0) | |
| Black | 541 (38.6) | 484 (37.3) | |
| Asian | 25 (1.8) | 15 (1.2) | |
| Hispanic or Latino | 21 (1.5) | 8 (0.6) | |
| Other | 22 (1.5) | 12 (0.9) | |
| Sex, *n* (% of total) | | | *P* = .12 |
| Female | 718 (51.2) | 623 (48.1) | |
| Male | 684 (48.8) | 673 (51.9) | |
| Marital status, *n* (% of total) | | | *P* = .12 |
| Married/life partner | 690 (49.2) | 655 (50.6) | |
| Single | 425 (30.3) | 349 (26.9) | |
| Divorced/separated | 151 (10.8) | 140 (10.8) | |
| Widowed | 100 (7.1) | 122 (9.4) | |
| Unknown | 36 (2.6) | 30 (2.3) | |
| Preferred language, *n* (% of total) | | | *P* = .19 |
| English | 1,353 (96.5) | 1,256 (96.9) | |
| Spanish | 11 (0.8) | 3 (0.2) | |
| Other/unknown | 38 (2.7) | 37 (2.9) | |
| Payor type, *n* (% of total) | | | *P* =.01 |
| Commercial | 598 (42.6) | 513 (39.6) | |
| Medicare | 366 (26.1) | 337 (26.0) | |
| Medicaid | 374 (26.7) | 399 (30.8) | |
| Uninsured | 49 (3.5) | 44 (3.4) | |
| Unknown | 15 (1.1) | 3 (0.2) | |
| Comorbidities | | | |
| Diabetes | 561 (40.0) | 590 (45.5) | *P* < .01 |
| Myocardial infarction | 179 (12.8) | 232 (17.9) | *P* < .001 |
| Coronary artery disease | 414 (29.5) | 477 (36.8) | *P* < .001 |
| Chronic kidney disease | 668 (47.6) | 656 (50.6) | *P* = .13 |
| Hypertension | 828 (59.1) | 830 (64.0) | *P* < .01 |
| COPD | 176 (12.6) | 221 (17.1) | *P* < .01 |
| Venous thromboembolism pulmonary embolism | 224 (16.0) | 325 (25.1) | *P* < .001 |
| Asthma | 154 (11.0) | 143 (11.0) | *P* = 1.00 |
| Anxiety | 433 (30.9) | 454 (35.0) | *P* = .02 |
| Autoimmune disorder | 162 (11.6) | 157 (12.1) | *P* = .70 |
| Depression | 382 (27.2) | 386 (29.8) | *P* = .16 |
| Dyslipidemia | 661 (47.1) | 704 (54.3) | *P* < .001 |
| Heart failure | 376 (26.8) | 499 (38.5) | *P* < .001 |

*AICC,* ambulatory intermediate care clinic; COPD, chronic obstructive pulmonary disease; *M,* mean; *SD,* standard deviation.

effect for hospitalization compared to ED visits might suggest that intermediate care has a more direct impact on avoiding acute exacerbations requiring ED-level intervention than on preventing inpatient admissions. Notably, no patients who attended their AICC appointment had an ED visit or hospitalization on the same day, suggesting that the AICC successfully managed all presenting patients without requiring same-day escalation to acute care. While our data do not capture whether patients were explicitly advised to return to the ED at a later date, the absence of same-day transfers supports the effectiveness of the AICC's intermediate care model.

These results contribute to the theoretical understanding of access to care and systems theory. By addressing critical dimensions of access to care, such as availability, affordability, and accommodation, the AICC enhances patients' ability to engage with the healthcare system at an intermediate level. This study demonstrated that the AICC mitigates barriers to care by offering same-day appointments, co-locating services, and employing multidisciplinary teams, which collectively improve patients' healthcare experiences. These structural and operational enhancements reduce logistical barriers, such as scheduling difficulties and accessibility challenges, enabling patients to engage with the healthcare system more effectively.[21,22] From a systems perspective, the AICC demonstrates how intermediate care clinics can act as vital nodes within the broader healthcare network, linking primary care and EDs to optimize resource allocation and patient flow. By absorbing nonurgent but high-risk cases that would otherwise escalate to ED visits, the AICC alleviates pressure on acute care services and enhances the overall efficiency of the system. However, the observed lack of a significant effect on hospitalizations highlights the complex interplay between systemic factors and individual patient trajectories,[23-25] suggesting that hospitalization decisions are more influenced by clinical severity and comorbidities than by outpatient care availability. These findings underscore the need for integrated strategies that bridge gaps in both access and coordination, ensuring that intermediate care models like the AICC can address the diverse needs of patients while reducing systemic inefficiencies.

Black patients demonstrated higher odds of ED use even after controlling for demographic, socioeconomic, and clinical factors. While the AICC was associated with reduced ED visits overall, this finding suggests that the AICC model may not equally mitigate ED utilization across all racial groups. The AICC's design, including same-day referral pathways, co-location with outpatient clinics, and lower copays relative to ED visits, may not sufficiently address the specific access barriers experienced by Black patients that contribute to higher ED use. Future research should explore how intermediate care models like the AICC can be tailored to more effectively reduce ED use among populations disproportionately affected by access barriers.

Patients with anxiety or depression also exhibited significantly higher odds of ED use, suggesting that the AICC model may benefit from incorporating mental health screening or integrated behavioral health services to better address the needs of these patients.[26,27] Conversely, hospitalizations were more strongly associated with clinical factors, such as heart failure, pointing to the differentiated pathways driving ED versus inpatient service use. These patterns suggest that while the AICC can effectively address acute care needs that lead to ED visits, reducing hospitalizations may require complementary strategies targeting chronic disease management and care coordination.

Because the AICC model operates within existing outpatient infrastructure, it requires no additional facility construction. Based on the program's internal operational report, the initial equipment and setup costs were approximately $100,000. Annual operating costs during early implementation totaled approximately $600,000, primarily attributable to staffing. For the fully developed future-state model, annual staffing costs are estimated at approximately $750,000 per year. The AICC was not always financially viable on a standalone basis, particularly during its early implementation period when referral volumes were limited by both the natural ramp-up of a new clinical program and the impact of the COVID-19 pandemic on outpatient operations. However, the financial assessment extends beyond direct AICC revenue. The AICC provides system-level benefits, including decompressing the ED, reducing avoidable admissions for low-acuity patients, and creating capacity for higher acuity patients, which positively impacts revenue across the organization. Since the study period ended, the AICC has continued to grow, currently averaging approximately 15 patients per day, further demonstrating the viability of the model. A formal cost-effectiveness analysis, including estimated savings from averted ED visits and hospitalizations, is an important area for future study.

## LIMITATIONS

This study has limitations. As a single-site study, the generalizability of these findings to other healthcare systems may be limited, particularly in regions with different patient populations, resource availability, or healthcare structures. Nevertheless, the single-site design allowed for a controlled evaluation with a clear emphasis on intermediate care, providing insights that can guide the adaptation of intermediate care models to similar settings. Additionally, while the study focused on short-term outcomes (three-month ED visits and hospitalizations), this time frame may not fully capture the long-term effects of AICC adherence on healthcare use or patient outcomes. However, three-month outcomes are widely accepted metrics to indicate the quality of care and align with operational priorities.[28,29]

Lastly, this study primarily relied on administrative data, which, while comprehensive, may not capture nuanced patient experiences or reasons for nonadherence to AICC referrals. Future studies incorporating qualitative methods or patient-

**Table 3.** Multivariable logistic regression results for three-month emergency department visits and hospitalizations in a study assessing the association between ambulatory intermediate care clinic appointment attendance and subsequent healthcare use.

| Variable | Three-month ED visit OR (95% CI) | Three-month hospitalization OR (95% CI) |
|---|---|---|
| Past three-month ED visit frequency | 1.90*** (1.60, 2.26) | 1.17* (1.01, 1.35) |
| Past three-month hospitalization frequency | 1.18* (1.02, 1.36) | 1.31*** (1.18, 1.44) |
| AICC appointment status | | |
| Arrived | Reference | Reference |
| Missed (canceled or no show) | 1.54* (1.07, 2.21) | 1.28† (1.00, 1.64) |
| Age in years | 1.00 (0.99, 1.00) | 0.99*** (0.99, 0.99) |
| Race | | |
| White | Reference | Reference |
| Black | 1.74*** (1.30, 2.34) | 0.97 (0.80, 1.19) |
| Asian | 1.70 (0.67, 4.34) | 0.62 (0.31, 1.24) |
| Hispanic or Latino | 1.46 (0.41, 5.21) | 0.56 (0.24, 1.30) |
| Marital status | | |
| Married/life partner | Reference | Reference |
| Divorced/separated | 1.11 (0.73, 1.69) | 0.97 (0.80, 1.19) |
| Single | 1.02 (0.74, 1.41) | 0.62 (0.31, 1.24) |
| Widowed | 1.07 (0.64, 1.73) | 0.56 (0.24, 1.30) |
| Primary insurer | | |
| Commercial | Reference | Reference |
| Medicaid | 1.03 (0.75, 1.41) | 1.30** (1.07, 1.58) |
| Medicare | 1.09 (0.78, 1.53) | 1.17 (0.95, 1.43) |
| Uninsured | 1.13 (0.56, 2.27) | 1.02 (0.65, 1.61) |
| Medical history | | |
| Diabetes mellitus | 0.96 (0.73, 1.28) | 1.15 (0.97, 1.37) |
| Chronic kidney disease | 0.82 (0.57, 1.16) | 1.10 (0.90, 1.34) |
| Hypertension | 0.99 (0.71, 1.38) | 0.99 (0.81, 1.21) |
| Anxiety | 1.57** (1.16, 2.12) | 0.99 (0.81, 1.21) |
| Cirrhosis | 0.62* (0.41, 0.93) | 1.11 (0.89, 1.39) |
| Depression | 1.76*** (1.29, 2.40) | 0.94 (0.77, 1.16) |
| Any dialysis | 0.61† (0.35, 1.06) | 0.58** (0.41, 0.81) |
| Heart failure | 1.39† (0.97, 2.00) | 1.36** (1.09, 1.71) |

All results reported to 2 decimal places.
*AICC,* ambulatory intermediate care clinic; *OR,* odds ratio.

reported outcomes could complement these findings by providing a deeper understanding of barriers to AICC use and its broader impact on care coordination.

## CONCLUSION

This study underscores the value of nurse-led intermediate care clinics like an ambulatory intermediate clinic in reducing ED use. However, the findings also suggest that their impact on hospitalization rates may be limited, emphasizing the need for complementary strategies to address inpatient admissions. As healthcare systems strive to address systemic inefficiencies, expanding and refining intermediate care models like the AICC could provide scalable solutions to balance care quality and efficiency. Future research should explore the long-term outcomes of nurse-led intermediate care clinics and their integration within broader healthcare networks, focusing on their potential to reduce disparities and enhance patient-centered care delivery.

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# Impact of Physician Patient Load on Imaging Use in the Emergency Department

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**Introduction:** Emergency department (ED) crowding may alter physician decision-making, yet little is known about how real-time physician workload affects diagnostic imaging use. We examined the association between physician patient load and the proportion of patients who received diagnostic imaging, including computed tomography (CT), CT with intravenous (IV) contrast, CT without contrast, plain radiography, magnetic resonance imaging (MRI), and ultrasound (US).

**Methods:** We conducted a retrospective cohort study of all ED visits at an academic tertiary care center (January 2019–December 2024). Physician workload was defined as the sequential patient assignment order per physician per day (range 1–17). Our primary outcome measures were binary indicators of whether each imaging modality was ordered during the ED visit: CT (any); CT with IV contrast; CT without IV contrast; radiograph, MRI; and US. Multivariable logistic regression with physician-clustered robust standard errors estimated adjusted odds ratios (aOR) for each imaging modality, controlling for age, sex, triage acuity, chief complaint, and temporal factors. We also performed mixed-effects logistic regression with physician random intercepts and a within-between (Mundlak) decomposition. Absolute risk differences (ARD) were computed for the 17th versus the first patient.

**Results:** Among 287,925 encounters across approximately 41,132 physician shifts managed by 77 physicians, higher workload was associated with decreased odds of imaging for most modalities. Computed tomography with IV contrast showed the strongest effect (aOR 0.990, 95% CI, 0.986–0.994; within-physician aOR 0.991; ARD −2.2 percentage points [pp], from 21.8% to 19.6%). Results were as follows: any CT, aOR 0.994 (0.991–0.997); ARD −1.9 pp (from 38.7% to 36.8%); radiograph, aOR 0.994 (0.990–0.998, $P < .001$); ARD −1.6 pp (from 44.2% to 42.6%); US, aOR 0.994 (0.990–0.998, $P < .001$); ARD −0.7 pp (from 9.9% to 9.2%); and MRI was nonsignificant in the pooled model (aOR 0.993, $P = .09$) but significant in the mixed-effects model ($P < .001$). Noncontrast CT was unaffected (aOR 1.000, $P = .87$). Intraclass correlation coefficients ranged from 0.020–0.047, indicating 2–5% of imaging variance was attributable to physician-level differences.

**Conclusion:** Higher physician workload was associated with modestly reduced imaging use, particularly for resource-intensive modalities. Noncontrast CT was unaffected. Within-physician analyses were consistent with the interpretation that these effects reflect real-time behavioral adaptation rather than physician practice style alone. These findings highlight a trade-off between throughput and diagnostic testing that warrants further study of its impact on clinical outcomes. [West J Emerg Med. 2026;27(5)1208–1216.]

## INTRODUCTION

Diagnostic imaging use in the emergency department (ED) has increased markedly over recent decades, raising concerns about overuse, radiation exposure, and throughput delays.[1,2] Advanced imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) provide critical diagnostic information but are resource-intensive, expose patients to radiation or contrast agents, and frequently prolong ED length of stay.[3] Prior studies have documented wide variation in imaging ordering rates among emergency physicians, with higher use not necessarily associated with better patient outcomes.[4]

Emergency department crowding and physician workload have become ubiquitous challenges in emergency medicine. As patient volume and acuity rise, emergency physicians may alter their clinical behavior in response to time pressures. One hypothesis is that during busy periods, physicians might increase imaging as a diagnostic shortcut, ordering tests "just to be safe" to compensate for reduced time at the bedside. Conversely, overwhelmed physicians might avoid or defer certain imaging to expedite care, effectively rationing time-consuming diagnostics.[5,6] Understanding which pattern predominates is important for patient safety: If workload pressure leads to omission of necessary imaging, critical diagnoses may be delayed; if it reduces low-value testing, it may represent adaptive efficiency.

Despite considerable interest in ED crowding and resource use, there is limited direct evidence on the relationship between physician-specific workload and imaging use. Prior research has examined system-level crowding effects on length of stay, prescribing, and admission rates, and several large studies, predominantly conducted by radiology investigators using department-wide volume metrics, have reported that imaging orders rise with ED crowding or higher EP volume.[10–12] By contrast, few studies have examined how a physician's active patient load, in real time, influences their tendency to order diagnostic imaging on a per-encounter basis.[7] We aimed to address this gap by examining a large sample of ED visits over a six-year period, leveraging detailed operational data to link each patient with their treating physician's contemporaneous workload.

We hypothesized that increasing physician workload would be associated with reduced diagnostic imaging use overall, with the largest reductions occurring for resource-intensive modalities (CT with intravenous [IV] contrast, ultrasound [US], and MRI) and minimal change for time-critical modalities used for cannot-miss diagnoses (noncontrast CT for stroke or trauma, and plain radiography. We examined the association between physician patient load and the proportion of patients who received CT, CT with IV contrast, CT without contrast, radiograph, MRI, and US. Understanding these dynamics may help clinicians and administrators recognize potential decision-making shifts under workload pressure and guide strategies to optimize imaging use without compromising patient care.

*Population Health Research Capsule*

What do we already know about this issue?
*Emergency department (ED) imaging use varies widely, but real-time effects of physician workload on imaging decisions have not been well characterized.*

What was the research question?
*Does higher real-time physician workload change imaging use in the ED?*

What was the major finding of the study?
*The adjusted odds ratio (aOR) for computed tomography with contrast was statistically lower for the physician's 17th vs. 1st patient of the shift (aOR 0.99 per +1 patient [95% CI, 0.986-0.994]; absolute risk reduction -2.2 percentage points).*

How does this improve population health?
*Recognizing that crowding subtly reduces ED imaging may inform staffing and protocols that protect diagnostic care during high-load shifts.*

## METHODS

### Study Design and Setting

We performed a retrospective cohort study of all patient visits to an academic tertiary care ED (approximately 45,000–60,000 annual visits) over a six-year period from January 1, 2019, through December 31, 2024. The study site is in an urban metropolitan area; the institution does not hold a formal trauma center designation and hosts an emergency medicine residency program accredited by the Accreditation Council for Graduate Medical Education. Board-certified or board-eligible emergency physicians directly evaluate each patient and are responsible for all imaging orders; while residents and advanced practice clinicians may enter orders within the electronic health record (EHR), all imaging orders are placed under direct attending supervision and are attributed to the attending physician of record. Fewer than 10% of all cases during the study period were co-managed with a resident or advanced practice clinician. Patients are automatically assigned upon arrival to emergency physicians on a rotational basis, in practice removing physician discretion on when and which patients to accept. The study was reviewed and approved by the institutional review board with a waiver of informed

consent due to its retrospective nature and minimal risk.

Our retrospective data collection methods adhered to recommendations for medical record review studies in emergency medicine as described by Worster et al.[8] Specifically, we used standardized EHR data extraction with predefined variable definitions, minimizing abstractor subjectivity.

**Study Population and Data Sources**

We extracted all ED patient encounters in the specified date range from the EHR. For each visit, we obtained patient demographics (age, sex), triage acuity (Emergency Severity Index [ESI] 1–5), chief complaint, arrival timestamp, the identity of the attending emergency physician, and indicators of imaging orders placed during the ED visit.

For each encounter, we determined the "physician assignment order," defined as the sequential position of the encounter within the attending physician's set of patients seen that calendar day. This served as a proxy for the physician's real-time workload position within their shift; it captures how deep into a workload sequence the physician is when a given patient arrives but does not directly measure acuity-weighted simultaneous patient load (eg, the number of concurrently active patients) or nonclinical workload (eg, interruptions, calls, documentation backlog). Within each physician-day group, encounters were ordered chronologically. One modification accounted for overnight shifts: patients arriving at or after 10:30 PM were attributed to the next calendar day's workload sequence.

Encounters with assignment order greater than 17 were excluded ($n$ = 723, 0.2% of all visits). This ceiling reflects an institutional operational artifact rather than a clinical threshold: the automated rotational assignment system caps assignments at 17 per attending physician per shift, after which the system rolls to the next available physician or triggers a shift-handoff prompt. The excluded encounters therefore represent rare overflow situations driven by system handoff timing rather than by physicians being asked to see additional patients beyond their cap. An additional 4,695 (1.6%) encounters lacking a linked attending physician identifier were also excluded. The final cohort comprised 287,925 visits managed by 77 attending physicians.

**Variables and Definitions**

The primary independent variable was physician assignment order (1–17), treated as a continuous predictor reflecting the incremental effect of being one position later in the physician's queue. Outcomes were binary indicators of whether each imaging modality was ordered during the ED visit: CT (any); CT with IV contrast; CT without IV contrast; radiograph; MRI; and US (including both point-of-care and formal radiology US). These were not mutually exclusive; a single visit could involve multiple modalities. Covariates included patient age (continuous), sex (male, female, other/unknown), ESI level (categorical, with ESI 3 as reference), chief complaint (top 10 presenting complaints, plus "other" as reference), arrival hour (0–23, continuous), a binary night shift indicator (arrival time ≥ 10:30 PM), and a weekend indicator.

**Statistical Analysis**

We first performed descriptive analyses to characterize the cohort and the unadjusted relationship between physician assignment order and imaging use. We tabulated imaging frequency by modality and examined imaging rates stratified by workload groupings, using chi-square tests for trend. Our primary analysis used pooled multivariable logistic regression with Huber-White robust standard errors clustered by physician. Six separate models were fit, one for each imaging modality, producing an adjusted odds ratio (aOR) for the effect of a one-patient increase in assignment order on imaging odds, controlling for the covariates listed above.

We additionally employed two approaches to characterize physician-level heterogeneity. First, mixed-effects logistic regression (generalized linear mixed model [GLMM]) with a random intercept for each physician, fit using variational Bayes approximation (BinomialBayesMixedGLM in Python statsmodels). This partitions variance into within-physician and between-physician components and yields the intraclass correlation coefficient ($ICC = \sigma^2_u / [\sigma^2_u + \pi^2/3]$), representing the proportion of total variance in imaging decisions attributable to the physician. Second, a within-between decomposition (Mundlak model) splitting the workload variable into a within-physician component (encounter-level deviation from that physician's mean assignment order) and a between-physician component (the physician's overall mean). This method cleanly separates within-physician behavioral adaptation under varying workload from between-physician practice style differences. A Hausman-type test assessed whether within and between coefficients differed significantly.

Absolute risk differences (ARD) were computed by comparing marginal predicted probabilities at assignment order 1 versus 17. Model diagnostics included variance inflation factors (all < 2.0) and c-statistics (area under the receiver operating characteristic curve; range 0.654–0.766). All hypothesis tests were two-tailed with $\alpha = .05$. Analyses were conducted using Python, version 3.13, with pandas, statsmodels, and scikit-learn.

## RESULTS

**Characteristics of Study Subjects**

From 2019 through 2024, there were 293,343 patient visits to the study ED. After excluding 723 encounters beyond the 17th assignment order and 4,695 (1.6%) encounters lacking a linked attending physician identifier, 287,925 ED visits remained in the study cohort, managed by 77 unique attending emergency physicians across approximately 41,132 physician shifts over the six-year period.

The median patient age was 61 years (interquartile range

[IQR] 42–74; mean (standard deviation), 57.8 (20.7) years. A substantial proportion (44.0%) were elderly (≥ 65 years), and 2.1% were pediatric (< 18 years). Sex distribution was 53.3% female and 46.7% male. By triage acuity, ESI 3 was most common (59.2%), followed by ESI 2 (26.7%), ESI 4 (12.7%), ESI 1 (0.7%), and ESI 5 (0.6%). The median assignment order was 7; approximately 40% of encounters were order 1–5, 30% were ≥ 10, and 5% were ≥ 15. At the physician level, the median number of encounters per physician was 2,436 (range 1–12,752).

**Imaging Use**

In unadjusted analyses, CT and US showed mild downward trends with increasing workload (chi-square trend $P < .01$), whereas radiograph and MRI rates were relatively flat across the workload spectrum ($P > .10$). Figure 1 illustrates the unadjusted imaging rates by assignment order grouping. Supplementary Figure S1 provides a complementary view of the same data plotted at the level of exact assignment order (1–17) with 95% confidence bands, allowing the per-patient dose-response to be examined directly.

**Adjusted Association Between Workload and Imaging**

Table 1 and Figure 2 present the results of the multivariable analyses. After controlling for patient age, sex, triage acuity, chief complaint, and temporal factors, higher physician workload was significantly associated with reduced odds of ordering most imaging modalities. Adjusted odds ratios for all model covariates are reported in Supplementary Table S1. Briefly, higher triage acuity was the strongest single predictor of CT and MRI use (ESI 1 had several-fold higher odds than ESI 3), whereas ultrasound was ordered less often at the highest acuity; older age increased the odds of CT and plain radiography but not ultrasound; chest pain, abdominal pain, and fall-related chief complaints drove the largest complaint-specific imaging effects; and arrival hour and night-shift indicators contributed small, mostly nonsignificant effects. The workload effect estimates reported below are adjusted for all these covariates.

Computed tomography with IV contrast showed the strongest effect: aOR 0.990 per additional patient (95% CI, 0.986–0.994, $P < .001$), meaning approximately a 1.0% decrease in odds per patient. The within-physician effect from the Mundlak decomposition was 0.991, suggesting this reflects behavior change within individual physicians rather than solely between-physician differences. The between-physician effect was notably larger (aOR 0.933), indicating that physicians who habitually see more patients also tend to order fewer contrast CTs overall. The GLMM yielded the highest ICC among all modalities (0.047). Cumulatively, the 17th patient had 14.1% lower odds of contrast CT than the first patient (ARD −2.2 percentage points [pp], predicted rate 21.8% versus 19.6%).

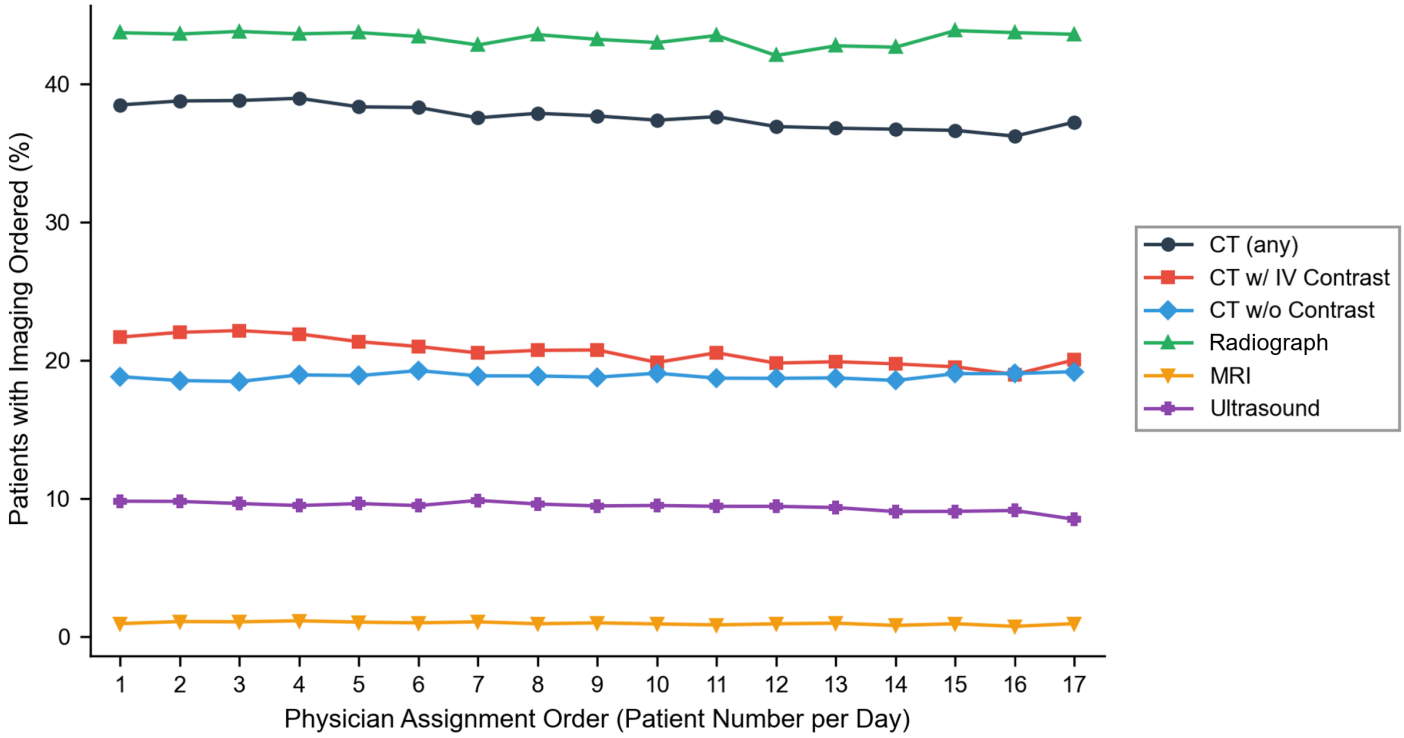


**Figure 1.** Unadjusted imaging use by order of physician patient assignment, in a study of 287,925 emergency department encounters examining the association between physician workload and diagnostic imaging ordering (January 2019–December 2024). *CT*, computed tomography; *IV*, intravenous; *MRI*, magnetic resonance imaging.

**Table 1.** Adjusted odds of imaging use per one-patient increase in physician daily workload, in a study of 287,925 emergency department encounters at an academic tertiary care center (January 2019–December 2024).

| Imaging Modality | Pooled aOR (95% CI) | Pooled *P* value | Within-Physician aOR | Between-Physician aOR | ICC | ARD (pp) |
|---|---|---|---|---|---|---|
| CT (any) | 0.994 (0.991–0.997) | < .001 | 0.994 | 0.940 | 0.044 | −1.9 |
| CT with IV contrast | 0.990 (0.986–0.994) | < .001 | 0.991 | 0.933 | 0.047 | −2.2 |
| CT without contrast | 1.000 (0.997–1.004) | .87 | 1.000 | 0.960 | 0.022 | 0.0 |
| Plain radiography | 0.994 (0.990–0.998) | .003 | 0.994 | 0.966 | 0.027 | −1.6 |
| MRI | 0.993 (0.984–1.001) | .087 | 0.992* | 0.955 | 0.034 | −0.1 |
| US | 0.994 (0.990–0.998) | .006 | 0.994 | 0.931 | 0.020 | −0.7 |

*Significant in generalized linear mixed model (*P* < .001) but not pooled model.
*aOR*, adjusted odds ratio; *ARD*, absolute risk difference (pp = percentage points, 17th vs first patient); *CT*, computed tomography; *ICC*, intraclass correlation coefficient; *MRI*, magnetic resonance imaging; *US*, ultrasound.

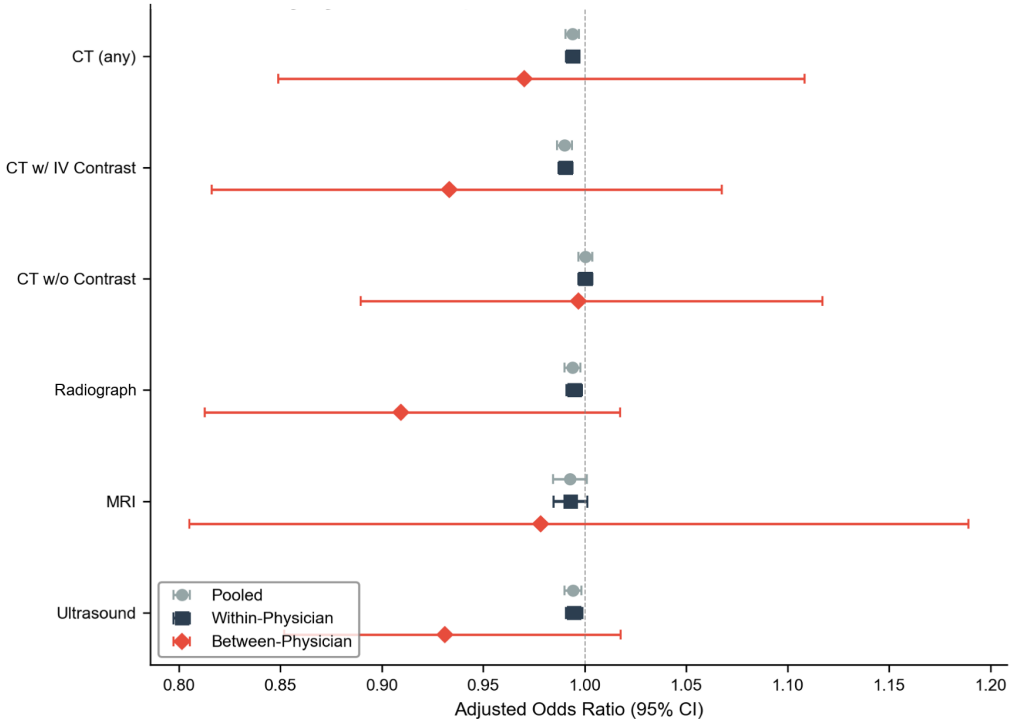


**Figure 2.** Pooled vs within-physician vs between-physician effects on imaging use per unit increase in workload, in a study of 287,925 emergency department encounters evaluating physician workload and imaging use.
*CT*, computed tomography; *IV*, intravenous; *MRI*, magnetic resonance imaging.

Any CT imaging showed a similar pattern: aOR 0.994 (95% CI, 0.991–0.997, *P* < .001), within-physician aOR 0.994, ICC 0.044, and ARD −1.9 pp (38.7% to 36.8%). Plain radiograph use decreased modestly with each additional patient: aOR 0.994 (95% CI, 0.990–0.998, *P* < .001), with a cumulative ARD of −1.6 pp. Ultrasound showed a comparable effect: aOR 0.994 (95% CI, 0.990–0.998, *P* < .001), ARD −0.7 pp, with the largest between-physician effect (aOR 0.931), suggesting that high-throughput physicians use US substantially less than low-throughput physicians overall.

Magnetic resonance imaging was nonsignificant in the pooled model (aOR 0.993, 95% CI, 0.984–1.001, *P* = .09) but the GLMM, which properly accounts for physician clustering, detected a significant association (aOR 0.992, *P* < .001; ICC 0.034). The ARD was negligible (−0.1 pp) given the very low base rate (1.0%). This is intuitive since MRI is particularly time-intensive; when busy, physicians may defer MRI to inpatient settings.

Notably, noncontrast CT was the only modality unaffected by workload (aOR 1.000, 95% CI, 0.997–1.004, $P = .87$). This implies that CT commonly ordered for critical diagnoses, such as noncontrast head CT for stroke or trauma, remained steady regardless of physician load. The difference between contrast and noncontrast CT behavior suggests physicians may consciously or unconsciously differentiate: avoiding the more time-consuming CTs (requiring IV access, lab checks, contrast administration) when busy, while still obtaining necessary noncontrast studies.

### Within-Between Decomposition and Mixed-Effects Models

The Mundlak model confirmed that within-physician effects were consistent with pooled estimates for all modalities, supporting the inference that individual physicians change their imaging behavior as workload increases within a shift. Between-physician effects were consistently larger in magnitude (eg, aOR 0.933 versus 0.991 for CT with IV contrast), but Hausman tests were nonsignificant for all modalities (all $P > .05$), meaning we cannot definitively conclude the two mechanisms differ in magnitude. The GLMM random intercept standard deviations ranged from 0.256 (US) to 0.402 (CT with IV contrast), and ICCs ranged from 0.020 to 0.047, indicating that 2–5% of imaging variance is attributable to physician-level differences (Figures 3 and 4).

## DISCUSSION

### Summary of Findings

In this six-year retrospective study of nearly 288,000 ED visits, increasing physician patient load was associated with modest but statistically significant decreases in the proportion of patients receiving imaging, particularly for resource-intensive modalities. CT with IV contrast showed the strongest workload effect (ARD −2.2 pp over a full shift), followed by any CT (−1.9 pp), radiograph (−1.6 pp), and US (−0.7 pp). Noncontrast CT, often ordered for critical diagnoses such as stroke or trauma, was unaffected, suggesting physicians preserve essential imaging even under high workload. While the per-patient effect was small, the cumulative impact over a typical shift was clinically meaningful.

### Interpretation

The modality-specific pattern supports an adaptive rather than indiscriminate response to workload pressure. Computed tomography with contrast and US require additional steps—IV

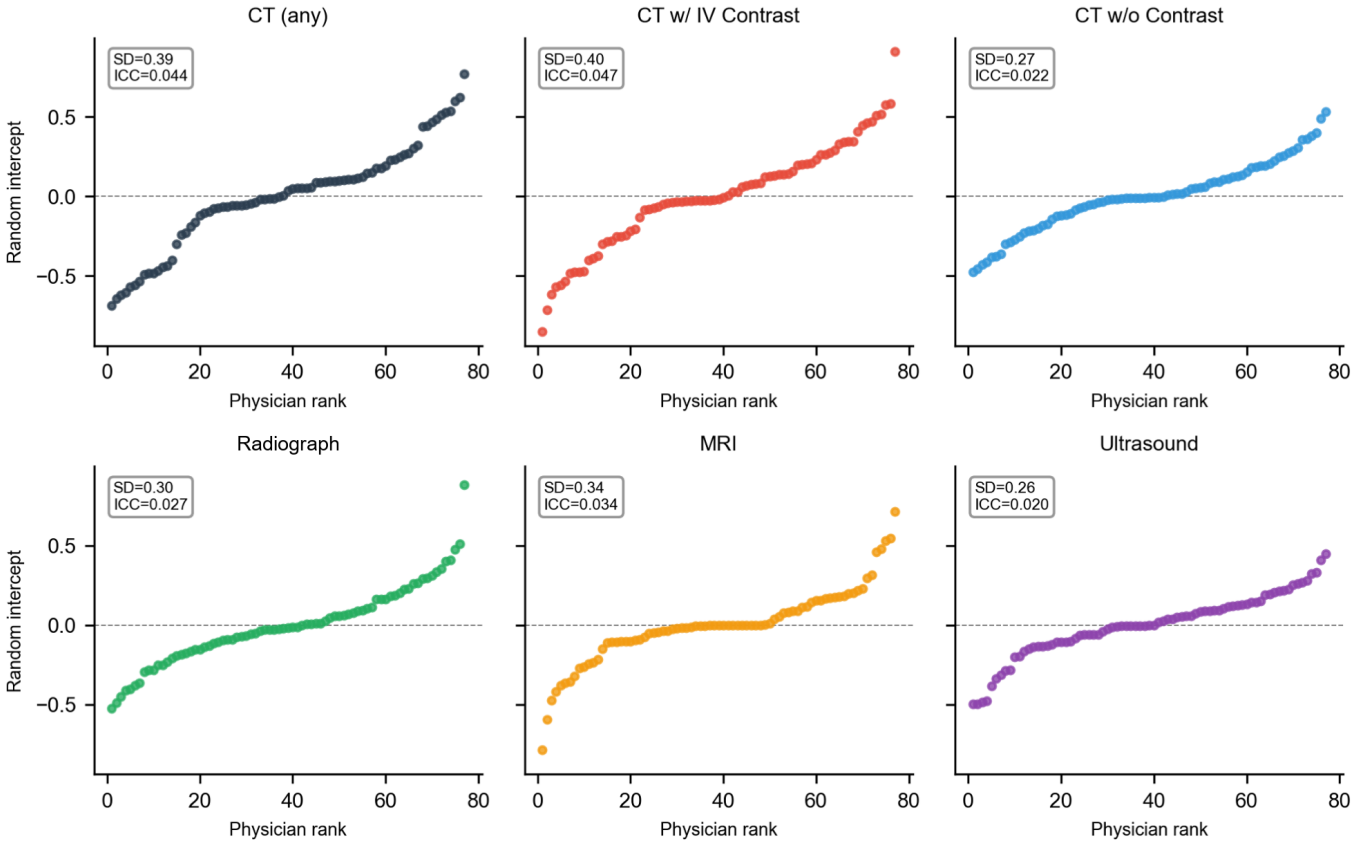


**Figure 3.** Physician random intercepts by imaging modality, in a study of 287,925 emergency department encounters across 77 physicians examining workload effects on imaging ordering.
*CT*, computed tomography; *IV*, intravenous; *MRI*, magnetic resonance imaging.

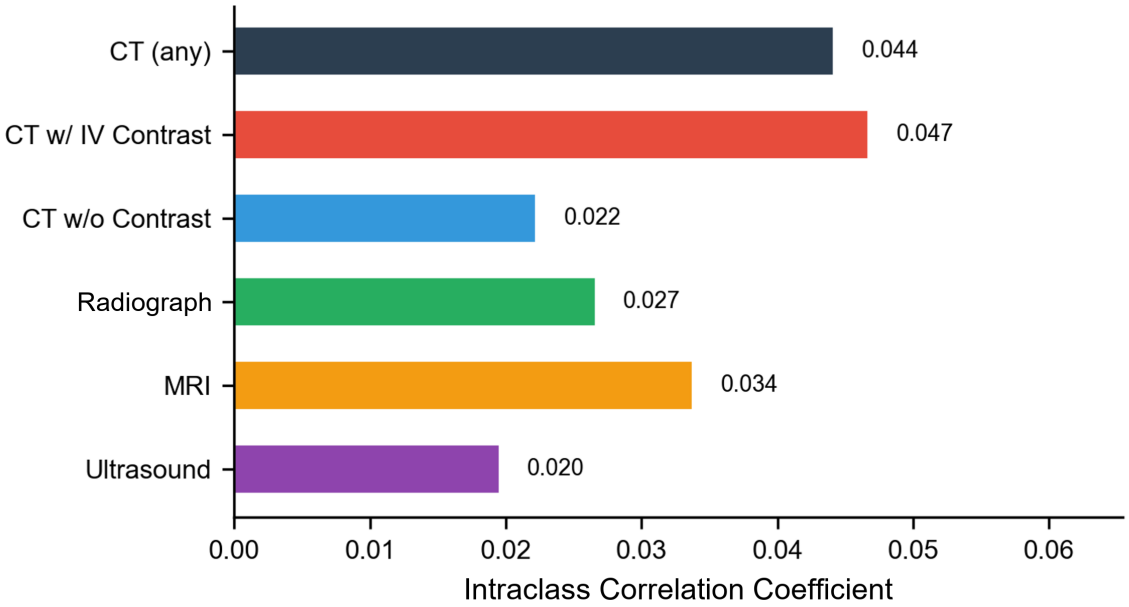


**Figure 4.** Physician-level intraclass correlation coefficient for each imaging modality, in a study of 287,925 emergency department encounters evaluating between-physician variance in imaging use.
CT, computed tomography; IV, intravenous; MRI, magnetic resonance imaging.

access, creatinine checks, contrast administration time, or technician availability—that may be deferred when time is limited. For example, a physician managing multiple acute patients may choose to observe, arrange outpatient imaging, or admit a patient rather than order an immediate CT abdomen with contrast. Noncontrast CT and radiography are faster to obtain and often protocolized for acute presentations, explaining their relative stability.

The selective nature of this pattern is reassuring from a patient safety perspective: many noncontrast CTs are performed for critical, cannot-miss diagnoses (head CT for trauma or stroke, cervical spine CT for trauma). The fact that physicians did not decrease ordering of noncontrast CTs under high load suggests continued adherence to imaging for high-risk situations even when busy. Physicians appear to be cutting "optional" or less urgent imaging first while preserving necessary emergent imaging.

The within-between decomposition confirmed that these effects operate within individual physicians as workload varies within a shift, though between-physician practice style differences also contribute. Between-physician effects were consistently larger in magnitude (eg, aOR 0.933 vs 0.991 for CT with contrast), suggesting that high-throughput physicians inherently order fewer imaging studies, but Hausman tests were nonsignificant. The ICCs of 0.020–0.047 indicate that 2–5% of imaging variance is attributable to physician-level heterogeneity, justifying mixed-effects modeling for this data structure.

These findings also touch on the efficiency-versus-thoroughness trade-off in emergency medicine. Under high workload, clinicians tend to satisfice, doing just enough to manage the problem, possibly at the expense of thoroughness, eg CT without contrast, which lowers length of stay.[9] Our data show that as workload increases, thoroughness (in terms of extensive imaging) diminishes slightly, presumably in favor of efficiency.

**Comparison to Previous Studies**

To our knowledge, this is among the first studies to directly link physician-specific real-time workload to imaging use in the ED. Prior investigations into ED crowding have largely focused on system-level outcomes rather than individual physician practice patterns. Our findings align with evidence that more experienced, higher-throughput physicians use slightly less CT imaging.[9] The efficiency-thoroughness trade-off, a well-recognized concept in human factors engineering, is consistent with our observation that diagnostic thoroughness (imaging) diminishes slightly as workload increases, presumably in favor of efficiency.

Notably, the direction of our finding runs opposite to most published work on emergency physician workload and imaging use. Prior studies, many conducted by radiology investigators using department-wide volume metrics, have generally reported that imaging orders increase when emergency physicians are busier or when the ED itself is more crowded.[10–12] The dominant explanation in that literature has been a substitution hypothesis: Under time pressure, physicians lean on imaging as a faster proxy for a comprehensive history and physical examination, "ordering tests to think."

Several important methodological differences likely account for our opposite finding. First, the prior literature largely measured department-level crowding (ED occupancy, boarding burden, total daily volume) rather than the physician-specific real-time patient load we use here, and department-level metrics can confound patient mix and ordering behavior in ways that bias toward more imaging. Second, much of that work was performed before contemporary throughput-focused operational pressures became routine in academic EDs; physician behavior under crowding has plausibly changed as length-of-stay metrics, value-based care incentives, and Choosing Wisely campaigns have matured. Third, our outcome is imaging use per individual patient encounter, normalized against case mix, rather than absolute imaging volume; volume-based metrics conflate higher patient throughput with higher imaging because both naturally rise together.

Read in this light, our results suggest that, at our institution, imaging is not functioning as a substitute for a careful history and physical examination when physicians are under workload pressure. If imaging were being used as a cognitive shortcut, we would expect to see the prior literature's pattern of increased ordering with higher workload, especially for the resource-intensive modalities that take time to perform. We see the opposite. The modalities that are most resource-intensive to obtain (CT with IV contrast, US) showed the largest workload-associated decreases, while the modalities that are typically protocolized and fast to obtain (noncontrast CT, plain radiography) showed the smallest or no decreases. This pattern is more consistent with physicians selectively deferring optional or slower-to-resource imaging when they have less time per patient, while preserving cannot-miss imaging for high-risk presentations. Practically, this implies that increasing emergency physician workload is not driving overuse of imaging in our setting; rather, it is associated with selective de-use that is concentrated in modalities where delay is least likely to cause immediate harm. Whether this selective de-use is clinically appropriate (omitting marginal-value imaging that does not change management) or clinically concerning (omitting imaging that would have altered care) cannot be determined from this study and is the most important question for future prospective work.

### Strengths

Key strengths include a large sample size (287,925 encounters), objective workload measurement via automated rotational patient assignment (which removes selection bias in patient allocation), six years of longitudinal data, three complementary analytic approaches (pooled logistic, GLMM, and Mundlak decomposition), and adjustment for chief complaint alongside standard confounders including triage acuity and temporal factors.

### Clinical Implications

Clinicians should be aware that workload pressure may subtly alter imaging thresholds. During peak volume periods, decision-support tools or imaging safety nets (eg, automated prompts for high-risk presentations) may help ensure necessary studies are not omitted. Conversely, the finding that imaging decreases under pressure, without evidence of harm, raises the possibility that some imaging ordered during low-workload periods may be of marginal value, aligning with broader efforts to reduce imaging overuse in emergency medicine.

From an operational standpoint, our results suggest that imaging demand per patient is not static but can drop during peak workload conditions. This could temporarily alleviate pressure on radiology but may also mean deferred studies increase demand on inpatient wards. Department leaders should note that providing safety nets during crowding is crucial to ensure quality of care is maintained under variable workload conditions.

### Sign-Out Culture and End-of-Shift Behavior

An additional factor that may contribute to reduced imaging later in a physician's shift is the culture surrounding clinical sign-outs. At our institution, as at many EDs, physicians at the end of their shifts transfer care of remaining patients to the incoming physician. If ordering a resource-intensive imaging study, such as CT with IV contrast, near the end of a shift means the ordering physician will not be present to interpret and act on the results, they may be less inclined to initiate such studies. This reluctance could stem from a desire to avoid burdening the incoming physician with pending results, or from concerns about continuity of care when the clinical context is lost during handoff. Conversely, at institutions where sign-out of pending studies is routine and well-integrated into workflow, this effect may be attenuated. Our study design did not allow us to distinguish between workload-driven behavioral adaptation and end-of-shift sign-out avoidance, as both factors increase with higher assignment order. Future studies incorporating shift-end timing data could help disentangle these mechanisms.

### Research Implications

Future research should link workload-related imaging changes to patient outcomes (eg, missed diagnoses, return ED visits, delayed treatment) and extend to multicenter settings to assess generalizability across institutions with differing patient assignment systems. Whether computerized decision support for imaging (eg, clinical decision rules built into order entry) reduces workload-related variation warrants investigation. Additionally, examining whether other clinical behaviors (lab test ordering, consultations) follow a similar workload pattern would broaden understanding of how crowding affects emergency care.

## LIMITATIONS

This was a single-center observational study at an academic tertiary care center, which may limit generalizability.

The rotational patient assignment system is not universal; institutions where physicians have discretion in self-assigning patients may show different patterns due to potential selection bias. Physician assignment order is an imperfect proxy for simultaneous patient load and does not capture other workload aspects such as patient acuity load or interruptions. As discussed in the section "Sign-Out Culture and End-of-Shift Behavior," because higher assignment order is correlated with proximity to end of shift, we cannot fully disentangle workload-driven behavioral adaptation from end-of-shift sign-out avoidance; both factors may contribute to the modality-specific patterns observed.

We lacked granular clinical data (eg, comorbidities, secondary chief complaints) that influence imaging decisions, particularly at a center with an elevated median age and a high percentage of immunocompromised patients. We included triage acuity and chief complaint to help mitigate this. The study period (January 2019–December 2024) overlapped substantially with the COVID-19 pandemic, which altered both ED volume and imaging mix at our institution; a prior analysis from our group documented sharp shifts in contrast-CT use driven by intermittent contrast shortages during this period. While our primary analysis adjusts for temporal factors and the consistent modality-specific pattern argues against pandemic-driven artifact as the dominant explanation, residual pandemic-era confounding cannot be excluded.

Imaging-resource availability also varies systematically by shift (radiology-technician staffing, MRI availability, consultant access), and we were unable to measure or adjust for these system-level factors directly. Because our outcome is imaging ordered rather than imaging clinically indicated, we have no direct measure of the appropriateness of each study, and we did not assess patient outcomes (return visits, missed diagnoses, mortality); whether reduced imaging under high workload represents safe efficiency or poses diagnostic risk therefore remains unknown and is the most important question for future prospective work. Point-of-care US performed without formal orders may be undercaptured, although this likely does not systematically differ by workload. We did not adjust for multiple comparisons across six outcomes; however, the consistent pattern (five of six modalities in the same direction) supports genuine associations rather than spurious findings.

## CONCLUSION

Higher physician workload was associated with modest reductions in imaging use, particularly for resource-intensive modalities such as CT with IV contrast and ultrasound. Noncontrast CT was unaffected, suggesting physicians preserve essential imaging even when busy. A within-between decomposition supported the interpretation that these effects reflect real-time behavioral adaptation within individual physicians. These findings highlight a trade-off between ED throughput and diagnostic testing that warrants further study regarding its impact on clinical outcomes.

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# Impact of Secure Electronic Health Record Chat on Physician Communication in the Emergency Department

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**Introduction:** Effective communication in the emergency department (ED) is essential for safe patient care. Electronic health record (EHR)-integrated secure messaging may improve communication workflows, but limited evidence exists comparing clinician satisfaction across modalities in the ED. This study evaluated physician satisfaction with an EHR-integrated secure messaging tool compared to existing communication methods for non-emergent communication.

**Methods:** We conducted an electronic pre-post survey study at an urban academic ED following implementation of an EHR-integrated secure messaging tool in October 2024. The primary outcome was overall communication satisfaction pre-post implementation. We also compared nursing communication satisfaction and repeat consult order proportions. Survey domains (ease of use, efficiency, timeliness, clarity, overall satisfaction) were graded using a four-point forced-choice Likert scale.

**Results:** Response rates were 35% (33/95) pre-implementation and 36% (34/95) post-implementation. Although face-to-face communication maintained superior clarity ratings, secure chat received significantly higher overall satisfaction than phone communication (median 3 [IQR 3–4] vs 2 [2–3], $P < .001$) and higher ratings than the existing consult workflow across all domains (all $P \leq .03$). Overall nursing communication satisfaction shifted toward higher scores post-implementation (median 3 [3–4] vs 3 [2–3], $P = .03$). Repeat consult order proportion decreased from 22% to 18% (risk difference, −3.5%; 95% CI, −4.5% to −2.5%; $P < .001$).

**Conclusion:** Electronic health record-integrated secure messaging demonstrated high user satisfaction among emergency physicians and may reduce repeat consultant communications. Secure chat provides a complementary communication channel in the ED setting. [West J Emerg Med. 2026;27(5)1217–1221.]

## INTRODUCTION

Effective communication and teamwork within the hospital setting are essential for high-quality patient care and preventing adverse events.[1] Communication in the emergency department (ED) presents challenges due to variable patient volumes, high acuity cases, multitasking requirements, frequent interruptions, and decisions based on limited information.[2–4] Traditional communication methods—face-to-face interaction, paging systems, and phone calls—each have limitations. Synchronous modes are associated with workflow interruptions,[5] and paging systems entail delayed and unreturned responses.[6] Face-to-face communication requires

physically locating individuals, which is challenging in large hospital environments. Electronic health record (EHR)-integrated chat provides asynchronous communication that may reduce interruptions while maintaining message timeliness.[7–10]

Only two studies have evaluated asynchronous messaging in the ED, but neither compared satisfaction across modalities. Luu et al evaluated EHR-integrated secure messaging and found it reduced nonurgent calls and workflow interruptions,[11] while Gulacti et al showed that WhatsApp, a third-party application, decreased ED length of stay and consultation time.[12] In this study based on a survey of 95 emergency physicians, we addressed this gap through a pre-post implementation design comparing EHR-integrated secure messaging to existing communication modalities across multiple satisfaction domains in a large academic ED. In October 2024, our ED implemented EHR-integrated secure messaging as a supplementary tool for non-emergent communication. The study's primary outcome was overall communication satisfaction. Secondary outcomes included domain-specific satisfaction scores, repeat consult order proportions, and interruption burden.

*Population Health Research Capsule*

What do we already know about this issue?
*Effective emergency department communication is essential for patient safety, but traditional methods like phone calls cause workflow interruptions and delays.*

What was the research question?
*Does electronic health record (EHR)-integrated secure chat improve physician satisfaction compared to existing communication methods?*

What was the major finding of the study?
*Secure chat had higher satisfaction than telephone communication (P < .001); the rate of repeat consults fell from 22% to 18% (P < .001).*

How does this improve population health?
*Secure messaging may reduce communication barriers and workflow interruptions, supporting safer and more efficient patient care delivery.*

## METHODS

### Study Setting and Sample

We performed this study in an academic ED comprising 47 adult attendings, 15 pediatric emergency attendings, and 33 emergency medicine residents ($N = 95$). The ED has 42 licensed beds and approximately 60,000 patient visits annually.

### Communication Workflows

Emergency physicians communicate with nursing staff via department-issued phones and face-to-face interaction. Specialty consultations are initiated through EHR orders, which trigger paging through a centralized communications center that connects to the emergency clinician via department-issued phones. Follow-up communication with consultants requires placing repeat consult orders through the same workflow.

### Secure Chat Tool

Secure Chat (Epic Systems Corporation, Verona, WI) is an EHR-integrated messaging platform available on desktop and mobile devices with read receipts and delivery confirmation. Prior to implementation, institutional messaging established that Secure Chat was designated for non-emergent communication needs. It supplemented existing communication methods.

### Survey Development

The survey domains (ease of use, efficiency, timeliness, clarity, and overall satisfaction) were informed by constructs from a system usability scale, the DeLone and McLean Information Systems Success Model,[13] and a technology acceptance model. We used a four-point forced-choice Likert scale (1 = very dissatisfied to 4 = very satisfied) to improve response polarity and reduce midpoint acquiescence bias.[14] The survey instrument was reviewed by a departmental quality improvement committee and refined based on recommendations from an institutional survey methodology expert, including revisions to scale anchors and unipolar versus bipolar scale structure.[15] Both surveys explicitly defined non-emergent communication as "messages that need to be communicated/asked in a timely manner but will not result in harm to the patient if not addressed immediately." The instrument was pilot tested with practicing emergency physicians prior to distribution. Identical items and definitions were used in both surveys. The complete survey instruments are available as Supplemental Appendix A.

### Measures

Two anonymous surveys were distributed electronically via a cloud-based survey platform (Qualtrics International Inc, Provo, UT) to all 95 emergency physicians, representing a census of the eligible population. The pre-implementation survey assessed satisfaction with phone, face-to-face, and consult-page workflow communication. Three months after implementation of the EHR-based messaging tool, a parallel survey assessed Secure Chat. Both surveys assessed interruption frequency (1 = never to 4 = always) and

disruptiveness (1 = not disruptive to 4 = extremely disruptive). We calculated response rates using the American Association for Public Opinion Research RR6 definition.[16]

We examined the proportion of repeat consult orders before implementation (July 1–September 30, 2024) and after implementation (November 1, 2024–February 28, 2025), excluding October for the uptake period. A repeat consult order was operationally defined as any subsequent order for the same consulting specialty within a single ED encounter, identified from an automated EHR report. This composite measure captures follow-up communications, non-responses requiring re-ordering, and duplicate entries.

### Statistical Analysis

Results are reported as median (interquartile range). We used Mann-Whitney U tests to compare satisfaction scores across communication modalities and to assess changes in satisfaction and interruption burden. We did not adjust for multiple comparisons; each comparison addressed a distinct, pre-specified research question rather than testing a universal null hypothesis, and correction methods such as Bonferroni increase Type II error risk in this context.[17] Individual *P* values are reported to allow reader interpretation. Chi-squared test of independence evaluated changes in repeat consult proportions. We performed analysis using Python 3.12.7 (Python Software Foundation, Wilmington, DE).

### Institutional Review Board

The institutional review board classified this project as quality improvement not requiring its oversight.

## RESULTS

### Survey Response and Secure Chat Utilization

Response rates were 35% (33/95) for the pre-survey and 36% (34/95) for the post-survey. During the study period (November 2024–February 2025), emergency physicians sent 7,482 Secure Chat messages and received 13,595, confirming active tool adoption.

### Communication Satisfaction

Table summarizes satisfaction comparisons across all communication modalities and domains. Compared to face-to-face communication with nursing, Secure Chat received higher ease-of-use ratings ($P = .04$), although face-to-face communication maintained higher clarity ratings ($P = .008$). No significant differences were found for efficiency,

**Table.** Comparisons of communication by modality and domain in a survey-based study of emergency physicians' satisfaction with a Secure Chat messaging tool integrated into the electronic health record.

| Domain | Comparator Median (IQR) | Secure Chat Median (IQR) | U Statistic | *P* Value |
|---|---|---|---|---|
| Nursing: Secure Chat vs Face-to-Face (n = 34 vs n = 32) | | | | |
| Ease of Use | 3 (2–4) | 4 (3–4) | 392.0 | .04* |
| Efficiency | 3 (2–4) | 3 (3–4) | 420.5 | .09 |
| Timeliness | 3 (3–4) | 3 (3–4) | 461.0 | .26 |
| Clarity | 4 (3–4) | 3 (3–4) | 729.5 | .008* |
| Overall | 3.5 (3–4) | 3 (3–4) | 630.0 | .23 |
| Nursing: Secure Chat vs Phone (n = 34 vs n = 32) | | | | |
| Ease of Use | 2 (2–3) | 4 (3–4) | 231.5 | < .001* |
| Efficiency | 2.5 (2–3) | 3 (3–4) | 308.0 | .002* |
| Timeliness | 3 (3–4) | 3 (3–4) | 529.0 | .84 |
| Clarity | 3 (3–4) | 3 (3–4) | 530.0 | .85 |
| Overall | 2 (2–3) | 3 (3–4) | 293.0 | < .001* |
| Consultants: Secure Chat vs Consult Workflow (n = 33 vs n = 29) | | | | |
| Ease of Use | 2 (2–3) | 4 (3–4) | 235.5 | < .001* |
| Efficiency | 2 (1–2) | 4 (3–4) | 168.5 | < .001* |
| Clarity | 3 (2–3) | 4 (3–4) | 335.5 | .03* |
| Overall | 2 (2–3) | 3 (3–4) | 224.0 | < .001* |

Scale: 1 = very dissatisfied, 2 = somewhat dissatisfied, 3 = somewhat satisfied, 4 = very satisfied.
Mann-Whitney U tests used for comparisons.
*Statistically significant ($P < .05$).
*IQR*, interquartile range.

timeliness, or overall satisfaction. Compared to phone communication with nursing, Secure Chat demonstrated significantly higher ratings for ease of use ($P < .001$), efficiency ($P = .002$), and overall satisfaction ($P < .001$). No significant differences were observed for clarity or timeliness.

For specialist consultant communication, Secure Chat showed significantly higher satisfaction than the existing consult workflow across all domains (all $P \leq .03$; Table).

Overall satisfaction with nursing communication showed a significant shift in response distribution toward higher satisfaction after secure chat implementation (median 3 [IQR 3–4] versus 3 [2–3], U = 384.0, $P = .03$), with more physicians reporting "very satisfied" (12/34 [35%] versus 6/32 [19%]) (Figure).

### Repeat Consult Orders

The proportion of repeat consult orders was lower post-implementation (18%) compared to pre-implementation (22%) ($\chi^2(1, N = 26{,}376) = 50.51$, $P < .001$).

### Interruption Burden

Secure Chat interruptions were rated as less frequent than phone (U = 656.0, $P = .03$) and face-to-face interruptions (U = 679.5, $P = .01$). Secure Chat was also rated less disruptive than phone calls (median 2 [IQR 1–2] vs 3 [2–3], U = 850.5, $P < .001$) and face-to-face communication (median 2 [1–2] vs 2 [2–3], U = 701.5, $P = .007$). No significant changes in phone or face-to-face interruption patterns were observed after implementation.

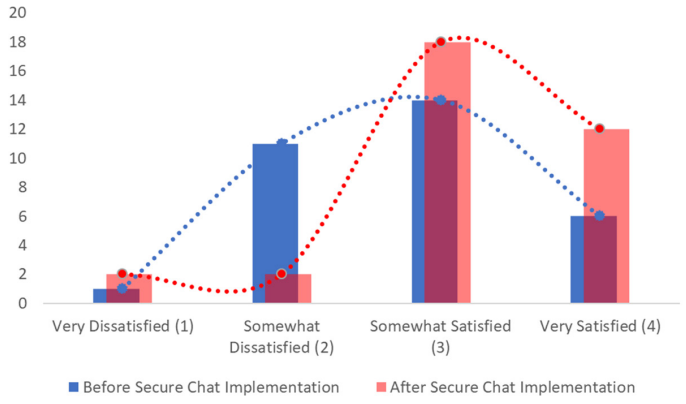


**Figure.** Overall satisfaction with nursing communication pre- vs post-Secure Chat implementation (all modalities combined) in a study of physician satisfaction with a secure messaging tool integrated into the electronic health record.
Y-axis represents the number of respondents (pre, $n = 32$; post, $n = 34$).
Scale: 1 = very dissatisfied, 2 = somewhat dissatisfied, 3 = somewhat satisfied, 4 = very satisfied.
Mann-Whitney U test was used for comparison.

## DISCUSSION

Secure Chat received higher nursing communication satisfaction ratings than face-to-face communication for ease of use, and it also received higher ratings than phone communication for ease of use, efficiency, and overall satisfaction. Secure Chat and phone received equivalent clarity ratings, although face-to-face communication remained superior for clarity, consistent with richer information exchange afforded by in-person interaction. For consultant communication, Secure Chat outperformed the existing consult page workflow across all satisfaction domains, likely reflecting friction inherent in the multi-step ordering process. Our findings align with prior research demonstrating high user satisfaction with secure messaging systems. Przybylo et al reported improved clinician satisfaction with a smartphone messaging system in a large hospital,[7] and Gulacti et al demonstrated reduced consultation time with WhatsApp compared to phone communication.[12] Consistent with the technology acceptance model, perceived ease of use showed the most consistent advantage for secure chat across all comparisons.

Secure Chat provides a complementary channel for non-emergent ED communications. Both surveys explicitly defined non-emergent communication, and institutional messaging prior to rollout established this boundary. The lower disruptiveness rating compared to phone and face-to-face communication suggests that asynchronous messaging may reduce workflow interruptions. The decrease in repeat consult orders suggests that Secure Chat may facilitate follow-up conversations that previously required re-ordering through the communications center.

## LIMITATIONS

Several limitations affect interpretation. The single-site design and three-month time frame limit generalizability and steady-state assessment. Response rates of 35–36%, while consistent with published ranges for electronic physician surveys,[16,18,19] introduce the possibility of nonresponse bias. As a census rather than probability sample, findings should be interpreted with caution.

While the survey instrument was developed through expert review and established frameworks, it lacks formal psychometric validation. The four-point forced-choice scale may not capture the full range of respondent attitudes.[14] The repeat consult metric is an indirect proxy that does not distinguish between orders placed due to nonresponse, duplicate entry, or clinical necessity, and the observed reduction cannot establish causation. We did not assess barriers to adoption, message-read rates, or the potential for missed asynchronous communications. Our study captured the perspectives of emergency physicians only; nursing staff, specialist consultants, and patient perspectives warrant future investigation. Future research should include multi-site designs, validated instruments, and longitudinal outcomes.

## CONCLUSION

Secure messaging integrated into the electronic health record showed high user satisfaction among emergency physicians for non-emergent communication and may reduce repeat consultant communications. While face-to-face communication remains superior for message clarity, Secure Chat provides a complementary communication channel in the ED setting.

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# Efficiency of Early Warning Scores in Adult Emergency Department and Inpatient Populations: Overview of Reviews

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**Introduction:** Early Warning Scores (EWS) are used to support decisions regarding triage and early intervention of patient deterioration in emergency departments (ED) and other clinical environments. We synthesized evidence from systematic reviews on the predictive performance and clinical impact of EWS and their modifications in adult in-hospital populations.

**Methods:** We conducted and reported an overview of reviews following the Joanna Briggs Institute (JBI) methodology, PRIOR statement, and our predefined protocol. A systematic search of MEDLINE (Ovid) and Epistemonikos was performed in May 2025. Two reviewers independently screened studies, extracted data, and critically appraised systematic reviews. We included systematic reviews of adult in-hospital populations evaluating EWS as either prognostic tools for deterioration or mortality, or as interventions implemented within track-and-trigger or rapid response systems. Primary study overlap was quantified using the corrected covered area (CCA). We synthesized evidence narratively and tabularly, emphasizing ED-related data.

**Results:** From 502 records identified, 21 systematic reviews comprising 343 primary studies were included. We identified ED-relevant evidence in 12 reviews. In ED populations, EWS demonstrated moderate-to-good discrimination for mortality and clinical deterioration (National EWS area under the receiver operating characteristic curve (AUROC) values: 0.88 for 24-hour mortality, 0.86 for 48-hour mortality). Across ED and mixed acute-care cohorts, Early Warning Scores also showed fair performance for predicting ICU admission and composite adverse outcomes (AUROC ~0.70–0.75). In sepsis-focused analyses relevant to ED populations, quick Sequential Organ Failure Assessment (qSOFA) demonstrated low sensitivity but high specificity for 28/30-day mortality (sensitivity 0.41, 95% CI, 0.24–0.62; specificity 0.88, 95% CI, 0.81–0.92). The SOFA score showed high sensitivity and moderate specificity for in-hospital mortality (sensitivity 0.89, 95% CI, 0.88–0.90; specificity 0.69, 95% CI, 0.68–0.69). Evidence on the clinical impact of EWS implementation in ED and other emergency settings was limited and heterogeneous.

**Conclusion:** In EDs, Early Warning Scores support early risk stratification and identification of patients at risk of deterioration, particularly for short-term mortality and escalation of care. Their impact on patient-important outcomes remains uncertain. Early Warning Scores should complement clinical judgment, triage systems, and structured escalation protocols. They should not be a standalone tool. Future research should prioritize standardized thresholds, transparent reporting, and rigorous comparative and implementation studies defining the role of EWS in emergency care. [West J Emerg Med. 2026;27(5)1222–1234.]

## INTRODUCTION

Emergency departments (ED) manage patients with diverse and initially undifferentiated clinical presentations. Because decisions regarding triage, escalation of care, and patient disposition are often made before complete diagnostic information is available, clinicians increasingly rely on structured approaches to risk stratification. When implemented within structured rapid response or track and trigger systems, Early Warning Scores (EWS) facilitate early recognition of patient deterioration, prompting care escalation and timely appropriate clinical intervention.[1] Early Warning Scores are based on routinely recorded physiological parameters, such as respiratory rate, heart rate, blood pressure, temperature, oxygen saturation, and level of consciousness.[2]

The evidence base evaluating Early Warning Scores encompasses a wide range of primary studies, including randomized and nonrandomized trials, as well as secondary research.[3–6] Given the heterogeneity of this literature, several scoping reviews have attempted to map the field and describe the range of available tools and study designs.[7–9] Existing primary and secondary studies address two closely related aspects of EWS use. One focuses on the predictive value of EWS and its ability to identify patients at risk of adverse outcomes, such as mortality or admission to the intensive care unit (ICU). Other studies evaluate the impact of EWS implementation on clinical outcomes and healthcare resource utilization, including mortality, length of hospital stay, and rates of serious adverse events.[10–13]

*Population Health Research Capsule*

What do we already know about this issue?
*Early Warning Scores (EWS) use vital signs to identify clinical deterioration, but evidence on their emergency department (ED) performance and outcome impact is heterogeneous.*

What was the research question?
*How do EWS perform and affect outcomes in adult ED and inpatient populations?*

What was the major finding of the study?
*National Early Warning Score (NEWS) predicted ED mortality with AUROC 0.88 at 24h and 0.86 at 48h; implementation effects were uncertain.*

How does this improve population health?
*EWS may support earlier ED risk stratification, but must be embedded in triage, reassessment, and escalation pathways.*

For the purposes of this overview of reviews, we distinguish between the EWS and the broader Early Warning System. The EWS refers to the numerical score derived from physiological observations. In contrast, an Early Warning System, often described as a track and trigger system (TTS), integrates the score with structured escalation protocols to ensure appropriate and timely clinical action. For example, within the National Early Warning Score (NEWS), a score of 5 or greater typically prompts an increased level of monitoring, while a score of 7 or greater triggers urgent clinical review or an emergency response.[14] Although our primary analyses address the predictive performance of EWS, their real-world effectiveness is inherently linked to systematic clinical implementation within structured escalation pathways.

From a clinical and research perspective, substantial variability exists in the types of scores used, their modifications, threshold values, and the outcomes assessed. This heterogeneity complicates implementation in routine practice and limits comparability across studies and healthcare systems.[15,16] As a result, despite the large volume of research, the overall strength and consistency of evidence supporting the effectiveness of EWS, particularly in improving patient outcomes, remain limited.[1]

Given this heterogeneity in study populations, score definitions, and reported outcomes, we conducted an overview of reviews to synthesize evidence from existing systematic reviews addressing EWS in adult in-hospital settings with special focus on EDs. This study design enables the summarization of the evidence from systematic reviews of different interventions for the same population and setting. This approach allows the exploration of research questions with a broader scope than those typically addressed in individual systematic reviews.[17,18]

The aim of this overview was to synthesize evidence from systematic reviews on the predictive performance and clinical impact of EWS and their modifications in adult ED and acute in-hospital populations, with particular attention to outcomes relevant to emergency care, including mortality, ICU or high-dependency unit (HDU) admission, cardiac arrest, serious adverse events, and length of stay.

## METHODS

This review was conducted in accordance with the Joanna Briggs Institute (JBI) methodology for umbrella reviews.[19] Reporting followed the Preferred Reporting Items for Overviews of Reviews (PRIOR) statement.[20] The study protocol was prospectively registered in the Open Science Framework (https://osf.io/gbevn/).

### Eligibility criteria

Eligibility criteria were defined using the PICOS framework

(Population, Intervention, Comparison, Outcomes, Study design).

- **Population**: We included systematic reviews of adult hospitalized patients. Reviews focusing on pediatric or obstetric populations were excluded.
- **Intervention/Comparison**: We included reviews evaluating any type of EWS and its modifications, as well as reviews comparing different track and trigger or rapid response systems. We excluded reviews focusing exclusively on paediatric or obstetric EWS.
- **Outcome**: We summarized evidence on the predictive performance and clinical impact of EWS. The primary outcome was mortality; secondary outcomes were length of hospital stay (LOS), ICU, or HDU admission (including unplanned admission), in-hospital cardiac arrest, and serious adverse events. We also extracted review-level recommendations regarding the use of specific EWS.
- **Settings**: We considered only reviews of hospital-based settings. Reviews collecting evidence on prehospital settings were excluded.
- **Study design**: We selected the systematic reviews published in peer-reviewed journals. Systematic reviews were defined as studies that reported a clearly formulated research question and conducted searches in at least two databases. Scoping reviews, primary research studies, and conference abstracts were excluded.

### Information Sources and Search Strategy

An information specialist conducted a comprehensive search in May 2023 to identify systematic reviews related to EWS, using the CADTH filter for systematic reviews.[21] An initial search was performed in MEDLINE (Ovid) using relevant keywords and index terms, followed by a refined search using all identified terms across MEDLINE (Ovid) and Epistemonikos. This database combination was chosen to optimize the retrieval of systematic reviews.[22] No restrictions were applied regarding language or geographic location. However, no relevant non-English studies were identified. Reference lists of included reviews were also screened. Full search strategies are provided in Appendix A.

Retrieved records were imported into the Zotero (AGPL) reference management software tool and deduplicated using the systematic review accelerator.[23] The search was updated in May 2025, with new records deduplicated against the original dataset using the same process.[24]

### Selection Process

Records were managed using Zotero (AGPL) and the PICO Portal. [25] Two reviewers (MP, JM) independently screened titles, abstracts, and full texts for eligibility. The screening process was piloted prior to formal screening. Disagreements were resolved by a third reviewer (AL).

### Data Collection Process

Data extraction was performed independently by two reviewers (AL, MP) using prepiloted Microsoft Excel forms. Extracted data included review title, year of publication, population characteristics, types of EWS and track and trigger systems, number and identity of included primary studies, methods of data analysis, reported heterogeneity, outcomes and conclusions, and review-level recommendations. Extraction tables are provided in Appendix B.

To quantify the overlap of primary studies across included reviews, citation matrices were constructed, and we calculated corrected covered areas (range, 0–100%). Overlap was classified as slight (0–5%), moderate (6–10%), high (11–15%), or very high (> 15%). Overlap was visualized using the GROOVE tool. When overlapping reviews reported discordant findings, priority was given to the most recent and methodologically robust review, with verification against primary studies where necessary.[26,27] Reviews were additionally categorized by population, intervention, and comparison (PICOS/PIRDs), and we identified no systematic reviews with identical populations, interventions, comparisons, and settings (or index and reference tests).

### Risk of Bias Assessment

Two reviewers (AL, TF) independently assessed the risk of bias in included studies based on the JBI critical appraisal tool for systematic reviews.[26] A third reviewer (MP) resolved conflicting decisions. The visualization was performed using Review Manager 5.4.[28] Risk of bias in individual primary studies was not reassessed, as this was beyond the scope of this overview of reviews.

### Synthesis Methods

Findings were synthesized narratively, with the characteristics and key results of the included reviews summarized in tables. We recorded reported measures of heterogeneity. This overview provides a structured synthesis of existing systematic reviews, without involving reanalysis or meta-analysis of primary study data.

## RESULTS

The search yielded 502 records. After removing duplicate records, 348 records were screened at the title/abstract and full-text levels. The flow of records through the different phases of this overview of reviews is shown in the PRISMA 2020 flow diagram (Figure).[29] The list of studies excluded based on the full-text screening is attached in Appendix C.

The overall corrected covered area was 2.03%, indicating slight overlap among the included reviews. Most pairs of reviews showed no or minimal overlap in primary studies, suggesting that the findings are unlikely to be substantially influenced by overlapping evidence. Overlap was visualized using the GROOVE tool (Appendix D).[27]

### Risk of Bias in Systematic Reviews

Risk of bias assessments for the included systematic

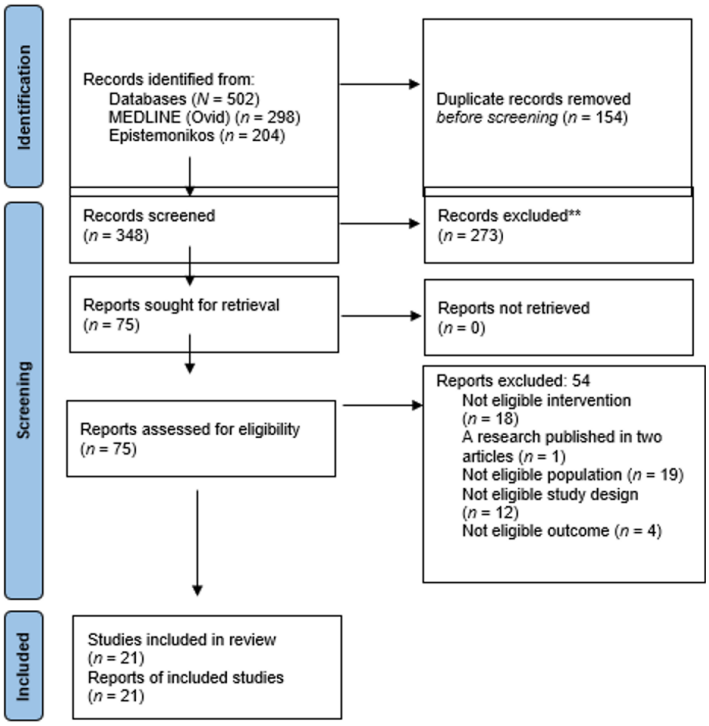


**Figure.** PRISMA 2020 flow diagram showing the identification, screening, and inclusion of systematic reviews in this review.[29] According to: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.
*PRISMA,* Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

**Table 1.** Risk of bias assessment of included systematic reviews using the Joanna Briggs Institute critical appraisal tool. Green (+) indicates a "Yes" response (low risk of bias), red (−) indicates a "No" response (high risk of bias), and yellow (?) indicates an "Unclear" response (unclear risk of bias).

reviews are presented in Table 1. Most reviews demonstrated high methodological quality, with 7–11 domains rated as low risk of bias using the JBI critical appraisal tool.

## Summary of Results

In total, 21 systematic reviews comprising 343 primary studies were included. The reviews evaluated the prognostic performance of EWS, the impact of their implementation as an intervention, or both. Key characteristics of the included reviews are summarized in Tables 2–4.

## Early Warning Scores in Emergency Department Settings

Among the 21 included systematic reviews, ED-specific or ED-relevant evidence was identified in 12 reviews. Three reviews focused specifically on adult ED populations: one systematic review of physiologically based early warning or track-and-trigger systems after triage in EDs; and one systematic review comparing qSOFA with hospital EWS in ED patients with suspected sepsis.[15,32,38] One additional review focused on the ED and acute medical unit and was therefore considered directly relevant to acute unscheduled care.[36] Eight additional reviews included ED cohorts as part of mixed-setting populations, including combinations of ED, general ward, ICU, acute inpatient, or outside-ICU settings. These reviews were considered ED-relevant but not ED-specific, and their findings were interpreted cautiously because ED-specific estimates could not always be separated from those reported in other inpatient settings.[18,30-31,33,35,37,39-40]

**Table 2.** Characteristics of included systematic reviews evaluating the predictive performance of Early Warning Scores (emergency department settings marked in bold).

| Author, year, reference | N (included primary studies) | N (number of patients) | Population | Settings | Assessed score | Outcomes |
|---|---|---|---|---|---|---|
| Adegbite (2021)[30] | 24 | 27,237 | Adult and adolescent patients (≥15 years old) with suspected infection or sepsis | **ED**, GW, ICU | EWS, MEWS, qSOFA, SIRS, UVA | Acute organ dysfunction, Mortality |
| Alhmoud (2021)[31] | 103 | 3,805,052 | Adult and adolescent patients (≥16 years old) | **ED**, ICU, MD, SD | EWS, HEWS, HOTEL, MEWS, NEWS, NEWS 2, SOS, TREWS, ViEWS, WORTHING | Cardiac arrest, ICU admission, Mortality |
| Arévalo-Buitrago (2021)[32] | 9 | 165,580 | Adult patients (≥18 years old) | **ED** | MEWS, NEWS, REMS, SEWS, TREWS, ViEWS | ICU admission, Hospital admission, Mortality |
| Hamilton (2018)[33] | 6 | 4,298 | Adult patients (≥18 years old) with sepsis | **ED**, MD | EWS, MEWS | Short-term mortality (in-hospital or 28–30-day mortality) |
| Lan (2024)[35] | 32 | 55,088 | Adult patients with sepsis | **ED**, ICU | MEWS, SIRS, SOFA | 28-day mortality, 30-day mortality, In-hospital mortality |
| Nannan Panday* (2017)[36] | 42 | 166,344 | Adult and adolescent patients (≥16 years old) | **ED**, ICU | APACHEII, CCI, CRB-65, CURB-65, CREWS, ESI, EWS, GAP, MEDS, MEES, MEWS, NEWS, PIRO, PSI, qSOFA, RAPS, REMS, RTS, SEWS, SCS, SIRS, PEDS, THERM, ViEWS, WPS | ICU admission, Mortality |
| Xia Qiu (2023)[37] | 57 | 227,726 | Adults (two articles did not specify the age range) | **ED**, GW, ICU | NEWS, qSOFA , SIRS, SOFA | 7-day mortality, 10-day mortality,14-day mortality, 28-day mortality, 30-day mortality, In-hospital mortality, ICU admission, Sepsis |

**Included Tools and Their Characteristics**

Across the included reviews, we identified more than 39 scoring tools, ranging from universal bedside Early Warning Scores (eg, NEWS/NEWS2 and MEWS variants) to sepsis screening tools (qSOFA, SOFA, Systemic Inflammatory Response Syndrome), condition-specific severity scores, triage scales, and other specialty tools.[15,31,37,40,41,46] Key examples and inputs are summarized in Table 5. Most tools rely on core physiological observations (respiratory rate, heart rate, oxygen saturation, level of consciousness, blood pressure, and temperature), although some models additionally include laboratory parameters and comorbidity measures.[15,31,36]

**Predictive Performance of Early Warning Scores**

This section summarizes the predictive performance of Early Warning Scores as reported in the included systematic reviews (Tables 2 and 4), focusing on area under the curve (AUROC/AUC), sensitivity, and specificity.

*Mortality*

Across ED and ward cohorts, Early Warning Scores generally show moderate-to-good discrimination for short-term mortality (AUC/AUROC commonly ~0.70–0.90). NEWS and MEWS typically demonstrate moderate discrimination in sepsis/infection cohorts, whereas qSOFA is generally more specific but less sensitive. In a sepsis-focused meta-analysis, pooled sensitivity/specificity were 0.89/0.69 for SOFA in predicting in-hospital mortality and 0.41/0.88 for qSOFA in predicting 28/30-day mortality.[37] Heterogeneity is noticeable across most studies, settings, and thresholds.[15,30–33,35–40]

**Table 2.** Continued

| Author, year, reference | N (included primary studies) | N (number of patients) | Population | Settings | Assessed score | Outcomes |
|---|---|---|---|---|---|---|
| Sabir (2022)[38] | 13 | 403 865 | Adult patients with suspected sepsis | ED | EWS, MEWS, NEWS, NEWS 2, qSOFA | ICU admission, Mortality |
| Wang (2022)[39] | 26 | 62,338 | Patients with suspected sepsis | ED, Acute inpatient department, Outside the ICU | NEWS, qSOFA, SIRS | 28-day mortality, 30-day mortality, In-hospital mortality |
| Zhang (2021)[40] | 21 | 107,008 | Adult patients (≥18 years old) with infection or sepsis | ED, GW, Outside the ICU | NEWS, NEWS 2 | In-hospital mortality, 30-day mortality, ICU admission |
| Zhang (2021)[41] | 18 | 6,922 | Adult patients with confirmed cases of SARS-CoV-2 infection | Mostly general ward, not always reported | NEWS, NEWS 2, qSOFA | In-hospital mortality, 30-day mortality, ICU admission |
| Long (2023)[34] | 29 | 1,039,992 | Adult patients (≥18 years old) hospitalized in the ICU for more than 24 h | ICU | EWS, MEWS, NEWS | ICU readmission after ICU discharge (follow-up 24 h to 30 days, depending on primary study) |

*This study is self-described as a "narrative review" in the title. However, its methodology fulfilled our inclusion criteria for systematic reviews, as it conducted comprehensive searches in multiple databases, applied explicit eligibility criteria, and presented a transparent selection process. Therefore, it was retained in our analysis.
*APACHE II,* Acute Physiology and Chronic Health Evaluation II; *AWTTS,* Aggregate Weighted Track and Trigger Systems; *BEWS,* Bispebjerg Early Warning Score; *CART,* Cardiac Arrest Risk Triage; *CCI,* Charlson Comorbidity Index; *CCO,* Critical Care Outreach; *CRB-65,* Confusion, Urea nitrogen, Respiratory rate, Blood pressure and age 65 years and over; *CREWS,* Chronic Respiratory Early Warning Score; *CURB-65,* Confusion, Urea nitrogen, Respiratory rate, Blood pressure and age 65 years and over; *ED,* Emergency Department; *ESI,* Emergency Severity Index; *EWS,* Early Warning Score; *GAP,* Glasgow, Age, Arterial pressure; *GW,* General Ward; *HEWS,* Hamilton Early Warning Score; *HOTEL,* Hypotension, low-Oxygen, low-Temperature, abnormal ECG, Loss of independence; *ICU,* Intensive Care Unit; *LOS,* Length of Stay; *MD,* Medical Department; *MEDS,* Mortality in the Emergency Department Sepsis score; *MEES,* Mainz Emergency Evaluation Score; *MEWS,* Modified Early Warning Score; *mREMS,* Modified Rapid Emergency Medicine Score; *N,* Number of included studies; *NEWS,* National Early Warning Score; *NEWS-L,* National Early Warning Score–Lactate; *PEDS,* Prince of Wales Emergency Department Score; *PIRO,* Predisposition, Infection, Response and Organ failure; *PSI,* Pneumonia Severity Index; *qSOFA,* quick Sequential Organ Failure Assessment; *RAPS,* Rapid Acute Physiology Score; *REMS,* Rapid Emergency Medicine Score; *RTS,* Revised Trauma Score; *SCS,* Simple Clinical Score; *SD,* Surgical Department; *SEWS,* Standardised Early Warning Score; *SIRS,* Systemic Inflammatory Response Syndrome; *SOFA,* Sequential Organ Failure Assessment; *SOS,* Search Out Severity; *TEWS,* Triage Early Warning Score; *TREWS,* Targeted real-time early warning score; *THERM,* The Resuscitation Management Score; *UVA,* Universal Vital Assessment; *ViEWS,* VitalPAC Early Warning Score; *ViEWS-L,* VitalPAC Early Warning Score–Lactate; *WPS,* Worthing Physiological Scoring System.

*Intensive Care Unit/High-Dependency Unit Admission*

Evidence for predicting ICU/HDU admission is mixed. In ED sepsis and mixed-acuity cohorts, NEWS and MEWS show fair discrimination for ICU admission, with sensitivity varying by threshold. On general wards, discrimination for unplanned ICU admission is often moderate, but the evidence is mostly from heterogeneous observational studies.[15,31,32,35,37–41]

*Cardiac Arrest*

For in-hospital cardiac arrest, reported discrimination is moderate to good and depends strongly on the chosen thresholds. In one systematic review, CART (AUROC ~0.84) outperformed MEWS (~0.78), and NEWS also showed good short-term performance.[46] One study noted that cardiac arrest was the least examined endpoint.[31]

*Serious Adverse Events*

In ED settings, combined endpoints of ICU admission or death were predicted with AUROCs around 0.70-0.75 for NEWS and 0.73–0.76 for MEWS models.[36,38] In infection cohorts outside

**Table 3.** Characteristics of included systematic reviews assessing the implementation of Early Warning Scores.

| Author, year, reference | N (included primary studies) | N (number of patients) | Population | Settings | Intervention | Comparison | Outcomes |
|---|---|---|---|---|---|---|---|
| Alam (2014)[42] | 7 | 486,237 | Adult and adolescent patients (≥ 16 years old) | GW, MD | MEWS | No MEWS + CCO present vs. no MEWS + no CCO | Documentation of physiological parameters, Cost-effectiveness, Cardiopulmonary arrest, HDU and ICU admission, ICU mortality, LOS, Mortality, SAE |
| Lee et al. (2018)[43] | 5 | 11,753 | Adult patients (≥18 years old) | GW with rapid response team | AWTTS, EWS, MEWS, NEWS | Not specified | Cardiac arrest, ICU admission, In-hospital mortality |
| McGaughey (2021)[1] | 11 | 666,131 | Adult patients at risk of clinical deterioration | Acute in-hospital settings | EWS, MEWS, NEWS, PAR and single parameter calling criteria as defined by RRS | Not specified | Admission to ICU, Cardiac arrest, Death, LOS, Readmission, Respiratory arrest, Unexpected death |
| McNeill (2013)[44] | 4 | 677,025 | Adult patients | In-hospital settings | EWS, MEWS | Not specified | Cardiac arrest rates, Hospital survival, In-hospital mortality, ICU mortality, Length of ICU stay, LOS, Unplanned ICU admissions |
| Stolze (2024)[45] | 8 | 118,860 | Surgical adult patients (≥18 years old) | MD, High-intensity monitoring area | EWS | Not specified | Cardiopulmonary arrest, Emergency surgery, In-hospital mortality, LOS, Unplanned ICU admission |

*AWTTS,* Aggregate Weighted Track and Trigger Systems; *CCO,* Critical care outreach; *HDU,* high dependency unit; *ICU,* intensive care unit; *MEWS,* Modified Early Warning Score; *MD,* medical department; *PAR,* Patient At Risk score; *NEWS,* National Early Warning Score; *RRS,* rapid response systems; *SAE,* serious adverse events.

the ICU, NEWS shows moderate discrimination for ICU admission (AUC ~0.71), with sensitivity ~0.71 and specificity ~0.55.[37,38,40] In COVID-19 cohorts, NEWS2 shows good discrimination for deterioration outcomes (AUC ~0.82) with pooled sensitivity ~0.82 at commonly used thresholds (e.g., ≥5). [41]

*Predictive Performance in the Emergency Department*

Emergency department-specific reviews support the relevance of EWS for risk stratification, particularly for early mortality, in-hospital mortality, hospital admission, and ICU admission. Emergency department-specific quantitative evidence came from the systematic review and meta-analysis, where NEWS showed good discrimination for 24-hour mortality (AUROC 0.88) and 48-hour mortality (AUROC 0.86), with lower but still acceptable discrimination for in-hospital mortality (AUROC 0.77). The NEWS also showed adequate predictive ability for hospital and ICU admission, although the findings were limited by heterogeneity in scores and thresholds.[32]

This ED-focused evidence was consistent with broader ED and acute-care review, which found that EWS and track-and-trigger systems used after ED triage can predict mortality and ICU admission, but that the evidence is mainly observational and heterogeneous.[15] In ED and acute medical unit populations, NEWS and MEWS generally showed favorable prognostic performance, although score performance varied by subgroup and clinical context.[36]

**Impact of Early Warning Scores Implementation on Clinical Outcomes**

This section synthesizes evidence on whether implementing EWS within track and trigger/ rapid response systems is associated with changes in clinical outcomes (Tables 3 and 4).

*Mortality*

Evidence on mortality reduction after EWS implementation is mixed. A meta-analysis reported reduced unexpected in-

**Table 4.** Characteristics of included systematic reviews – both systematic reviews evaluating predictive values and systematic reviews assessing the impact of Early Warning Scores (and its modification) intervention.

| Author, year, reference | N (included primary studies) | N (number of patients) | Population | Settings | Intervention, Comparison, intervention/control; Type of Test | Outcomes |
|---|---|---|---|---|---|---|
| Credland (2021)[18] | 5 | 74,000 | Adult patients | ED, GW, SD | EWS, NEWS | Cardiopulmonary arrest, HDU admission, Hospital admission, ICU admission, LOS, Mortality, Observation frequency, SAE |
| Wuytack (2017)[15] | 36 | 45,221 | Adult patients following initial triage | ED | BEWS, EWS, MEWS, MEWS plus, mREMS, NEWS, NEWS-L, TEWS, ViEWS, ViEWS-L | Death, Critical illness, Economic measures, Extent of use, ICU admission, LOS, Negative predictive value for adverse outcome/critical illness criterion, Number and type of clinical guidelines, Types of Early Warning Scores or TTS in use, Sensitivity/ Specificity for adverse outcome/ critical illness criterion, Strategies and methods to evaluate education programmes, Positive predictive value for adverse outcome/critical illness criterion, Types of education programmes |
| Jayasundera (2018)[16] | 5 | 5,321 | Adult patients (≥ 65 years old) with sepsis and/ or acute cardiovascular event | Acute hospital | EWS, MEWS | LOS, Morbidity, Mortality |
| Smith (2014)[46] | 21 | 757,028 + 2 studies with NR | Adult patients | GW, SD | CART, EWS, NEWS, VIEWS | 30-day mortality, 48-hour mortality, Cardiac arrest or pulmonary arrest Cardiovascular events, ICU admission, LOS, No. of days on a ventilator, Respiratory failure, RRT activation, Vasopressors use |

*BEWS,* Bispebjerg Early Warning Score; *CART,* Cardiac Arrest Risk Triage; *GW,* general ward; *HDU,* high dependency unit; *ICU,* intensive care unit; *LOS*, length of stay; *MEWS,* Modified Early Warning Score; *NR,* Not reported; *SAE,* Serious Adverse Events; *mREMS,* Modified Rapid Emergency Medicine Score; *NEWS,* National Early Warning Score; *NEWS-L,* National Early Warning Score–Lactate; *RRT,* rapid response team; *SD,* surgical department; *TEWS,* Triage Early Warning Score; *ViEWS,* VitalPAC Early Warning Score; *ViEWS-L,* VitalPAC Early Warning Score–Lactate.

hospital mortality after EWS implementation, but underlying studies were largely non-randomized and heterogeneous. Other reviews similarly describe a pattern of variable effects, with frequent risk of bias and inconsistent findings across settings.[1,18,42,43,45]

*Intensive Care Unit/High-Dependency Unit Admission*

Effects of Early Warning Scores/Rapid Response System implementation on ICU/HDU admissions are inconsistent. Randomized evidence does not show a clear reduction in unplanned ICU admissions, while before-and-after studies suggest changes in escalation patterns rather than consistent reductions.[1,18,42,43,45]

*Cardiac Arrest*

Effects on in-hospital cardiac arrest after EWS implementation are inconsistent. Some before-and-after studies report reductions, whereas others report no change or increases; randomized evidence does not demonstrate a consistent reduction.[1,18,42,43,45]

**Table 5.** Selected tools reported in included systematic reviews and their main characteristics.

| Tool* | Simple inputs | Complex observation | Settings |
|---|---|---|---|
| Acute Physiology and Chronic Health Evaluation II (APACHE II) | RR, HR, Temp, Consciousness (GCS), $FiO_2$, MAP, Age | Yes (ABG, Sodium, Potassium, Creatinine, Haematocrit, WBC and comorbidity input) | ICU |
| Cardiac Arrest Risk Triage (CART) | RR, HR, DBP, Age | No | ED/Wards |
| Confusion, Urea, Respiratory rate, Blood pressure and age 65 years and over (CURB65/CRB65) | RR, HR, Confusion, Age | Yes (Labs; BUN - only in CURB65) | ED |
| Emergency Severity Index (ESI) | RR, HR, SpO2, Consciousness | No (Expected clinical judgment) | ED |
| Charlson Comorbidity Index (CCI) | Age | Yes (Comorbidity) | Wards |
| Modified Early Warning Score (MEWS) | RR, HR, SBP, Temp, Consciousness (AVPU) | No | ED/Wards |
| Mortality in the Emergency Department Sepsis score (MEDS) | RR, SpO2, Consciousness (AVPU), BP, Age | Yes (Labs and comorbidity) | ED |
| National Early Warning Score (NEWS) | RR, $SpO_2$, $O_2$ supplement, HR, SBP, Temp, Consciousness (AVPU) | No | ED/Wards |
| National Early Warning Score 2 (NEWS2) | RR, $SpO_2$, $O_2$ supplement, HR, sBP, Temp, Refined consciousness (cAVPU), $SpO_2$ scoring (incl. Scale 2 for hypercapnic risk) | No | ED/Wards |
| quick Sequential Organ Failure Assessment (qSOFA) | RR, SBP, mental status (GCS/AVPU) | No | ED |
| Rapid Emergency medicine score (REMS) | Age, GCS, MAP, HR, RR, $SpO_2$ | No | ED/non-surgical |
| Revised Trauma Score (RTS) | RR, sBP, GCS | No | Trauma |
| Glasgow, Age, Arterial pressure (GAP) | sBP, GCS, Age, | No | Trauma |
| Sequential Organ Failure Assessment (SOFA) | MAP, GCS, Urine output, Vasopressor use | Yes (ABG, Plt, bilirubin, creatinine) | Sepsis/ICU |
| Systemic Inflammatory Response Syndrome (SIRS) | RR, Temperature, HR | Labs ($PaCO_2$) | Sepsis/ED |
| ViEWS/HEWS/TEWS/SEWS | NEWS/MEWS like sets with local calibrations | No labs | Wards/ED |

*Complete list with detailed characteristics described in Appendix E.
*ABG,* arterial blood gases; *cAVPU,* confusion, Alert, Voice, Pain, Unresponsive; *BUN,* blood urea nitrogen; *CURB-65,* Confusion, Urea nitrogen, Respiratory rate, Blood pressure and age 65 years and over; *HR,* heart rate; *GCS,* Glasgow Coma Scale; *ICU,* intensive care unit; *Plt,* platelet count; *MAP,* mean arterial pressure; *RR,* respiratory rate; *sBP,* systolic blood pressure; *$SpO_2$*, peripheral oxygen saturation.

*Serious Adverse Events*

Definitions of serious adverse events varied widely across studies, limiting synthesis. Some ward and surgical cohorts reported improvements in selected serious adverse events endpoints after implementing EWS observation/escalation protocols, but results were inconsistent and generally low certainty.[1,18,42,45]

*Length of Stay*

Across reviews, the effect of EWS/Rapid Response System implementation on hospital LOS was small or inconsistent. Randomized evidence suggests little to no effect, and observational findings are mixed and likely influenced by differences in baseline severity.[1,18]

*Implementation Evidence in Emergency Departments*

Evidence on ED implementation was more limited than evidence on predictive performance. A review of EWS use after ED triage found only limited comparative evidence, including one nonrandomized controlled trial suggesting changes in patient management but no clear reduction in adverse events.[15] A further mixed-setting review reported improved outcomes after implementation, but without ED-specific pooled estimates.[18]

### Summary of Recommendations

Across included reviews, practice-oriented recommendations emphasized limitations, appropriate use, and implementation considerations. In suspected sepsis or infection, reviews consistently flagged that EWS should not be used in isolation for prognostication or high-stakes disposition decisions; instead, they should support ongoing monitoring and a structured clinical response.[33,40,41] Where multiple scores/criteria were compared, some reviews recommended combining criteria to balance sensitivity and specificity.[35,37,39] Implementation-focused reviews report the importance of linking scoring to clear escalation pathways (including outreach/Rapid Response System) and tailoring to local resources.[43,44] In ED settings, this also implies that EWS should be integrated into triage, reassessment, and escalation workflows rather than interpreted as isolated single time-point measurements.[15,38,40] Several reviews called for more rigorous prospective evaluations of EWS/Rapid Response Systems (including multicenter and cluster-randomized designs), ideally using a single standardized score (eg, NEWS/NEWS2) and agreed outcome definitions, with reporting of adherence to escalation protocols, to enable stronger synthesis.[1,18,32,42,43,45,46] Recurrent priorities also included validation in specific patient subgroups and settings (older adults and other high-risk groups; low-resource settings), assessment of health-economic impact, and further tool development/improvement.[15,16,30,31,34,36,38] Detailed review-level recommendations are provided in Appendix B.

## DISCUSSION

### Interpretation

In this overview of reviews, we synthesized secondary evidence on the predictive performance and clinical impact of EWS across ED and acute-care settings. Overall, EWS-based tools demonstrated moderate-to-good discrimination for identifying patients at risk of short-term deterioration, particularly early mortality and need for escalation of care in ED populations. However, evidence that implementation of EWS-based systems improves patient-important outcomes remained limited and inconsistent across both ED and inpatient settings.

### Summary of Main Findings

Most often studied scores, such as NEWS/NEWS2 and MEWS, discriminate patients at risk of in-hospital or 30-day mortality with AUROCs typically ranging from 0.70 to 0.80 outside the ICU, with somewhat higher values in acute medical and ED cohorts, while sepsis-focused scores show variable sensitivity–specificity.[31–33,35,37–41] Intervention reviews of rapid response or track and trigger systems based on EWS show, at best, small and inconsistent reductions in unexpected deaths, ICU admissions, cardiac arrests, or length of stay.[1,18,42–46] Together, these findings support viewing EWS as one component of a robust rapid response system rather than a standalone solution for preventing unexpected deterioration.

Across general ward and ED settings, EWS achieved better discrimination for mortality and deterioration than single-parameter criteria, while still generating false positives.[15,31,32,37–41,44] In ED populations, EWS-based tools predicted in-hospital or 30-day mortality with AUROCs ranging between 0.77 and 0.87. In contrast, qSOFA offered higher specificity but considerably lower sensitivity, meaning many deteriorating patients would be missed if it were used as a single trigger.[15,32,37–39] Meta-analyses confirmed that no bedside score combining vital signs and simple clinical variables offers both high sensitivity and high specificity for mortality; SOFA had high sensitivity and moderate specificity, whereas qSOFA and NEWS traded higher specificity for reduced sensitivity.[30,33,35,37–39]

Across included implementation reviews, EWS generally show favorable trends (eg, improved monitoring and escalation). The effects on mortality after implementation remain uncertain and highly variable across settings and study designs. Randomized evidence suggests little or no difference in hospital mortality and serious adverse events.[1,18,42–46]

Considerable heterogeneity in patient populations, inclusion criteria, outcome definitions and threshold values was a consistent finding in almost all reviews, with $I^2$ statistics frequently exceeding 75–90% for sensitivity and specificity estimates.[18,31,33,35,37–39,44,46] This variability reflects differences in case mix and processes between various clinicians, together with inconsistent reporting and variable adherence to escalation protocols, which limit the interpretability of pooled estimates.[15,44,31,32,37–39,18,46]

### Comparison to Previous Studies

We address a specific gap in the literature by synthesizing secondary evidence on predictive performance and clinical outcomes for adult in-hospital populations, with a focus on ED settings. Previous systematic reviews have typically focused on either particular tools, specific conditions, or single care settings, such as the ED or ICU.[15,18,30,32,35–39,42–46] By including 21 reviews and 343 primary studies, we provide a higher-level view of how EWS function within contemporary RRS and where the main uncertainties lie. A recent rapid umbrella review of EWS also reported substantial heterogeneity in both results and evidence levels across EWS reviews and concluded that no general recommendation can currently be made for or against widespread EWS implementation, while suggesting that implementation may be most appropriate in high-risk settings.[47] Our overview extends this knowledge by focusing on adult inpatients, quantifying primary study overlap and integrating both prognostic and implementation outcomes, thereby providing a more detailed map of where evidence is relatively robust and where it remains fragmentary. Importantly, our overview also separates two questions that are often discussed together in the literature: the prognostic performance of EWS and the clinical impact of their implementation within escalation systems.

The Cochrane review[1] and subsequent systematic reviews concluded that EWS-based RRSs may reduce cardiopulmonary arrests and unexpected ICU admissions, but have uncertain effects on in-hospital mortality because of nonrandomized designs.[1,18,42–46] This more cautious interpretation contrasts with some earlier reviews and meta-analyses that suggested more favorable effects on mortality or cardiac arrest, and likely reflects the use of stricter methodological criteria and greater attention to heterogeneity in more recent syntheses, particularly the updated Cochrane review. Earlier EWS reviews also highlighted similar methodological problems, including small single-center cohorts, inconsistent thresholds, and limited adjustment for sampling, which are also evident in the more recent intervention literature summarized in this overview.[18,42–46]

In ED populations, previous systematic reviews have reported that vital signs-based scores, such as NEWS and MEWS, outperform traditional triage scales for predicting short-term mortality or ICU admission; however, the incremental value of any single score is modest and setting-dependent.[15,32,36] Our synthesis aligns with recent sepsis-focused meta-analyses showing that qSOFA has high specificity but low sensitivity, whereas NEWS and SIRS offer better sensitivity at the cost of more false positives, and that SOFA-based approaches provide the highest overall prognostic accuracy at the expense of resources.[30,33,35,37–39] These reviews consistently show that no score simultaneously achieves both high sensitivity and high specificity, which our overview confirms across a broader inpatient context.[30,33,35,37–39]

### Strengths

Our research highlights the need for synthesized evidence on various EWS and track and trigger systems, which is currently lacking in both the research literature and clinical practice. The robust findings, supported by a standardized methodological approach, cover a high quality of systematic reviews. The results offer valuable insights for clinicians, researchers, and policymakers on the efficiency of EWS and its modifications.

### Clinical Implications

For emergency medicine practice, the available evidence supports the use of structured Early Warning Scores (particularly NEWS/NEWS2 and MEWS) as adjuncts to clinical assessment for identifying patients at risk of deterioration. In ED settings, EWS may help support triage, serial reassessment, escalation of care, and disposition decisions by providing a standardized assessment of physiological instability using routinely collected vital signs.

However, the moderate discriminatory performance of currently available scores and the substantial heterogeneity across studies indicate that EWS should not be used as standalone decision-making tools. In suspected infection or sepsis, qSOFA generally provides higher specificity but lower sensitivity than NEWS/NEWS2, meaning that reliance on qSOFA alone may fail to identify a substantial proportion of deteriorating patients. Although SOFA-based approaches demonstrate higher sensitivity, their practical applicability in the ED may be limited by the need for laboratory data and greater complexity.

The effectiveness of EWS in emergency care likely depends not only on score performance itself but also on integration with clinical judgment, established triage systems, staffing resources, repeated patient assessment, and clearly defined escalation pathways. This may be particularly important in crowded or resource-constrained ED environments where patient acuity and clinical priorities can change rapidly.[39–41]

### Research Implications

The limited and low-certainty effect of EWS-based tools on mortality highlights the need for methodologically robust trials that compare different escalation strategies and support comparability.[1,3,4,18,42–45] Future studies should adopt a standardized set of outcomes–including early and in-hospital mortality, unplanned ICU admission, in-hospital cardiac arrest, well-defined serious adverse events, and patient-centered outcomes. We recommend clearly reporting decision threshold levels in studied scores to prevent high heterogeneity.[31–33,37,38,43,44,46] We also recommend focusing future studies on healthcare personnel's compliance with EWS-based systems.[18,46]

In emergency medicine and sepsis, comparative prognostic studies of NEWS/NEWS2, qSOFA, SOFA, and emerging machine learning models should focus on the incremental value over existing triage systems and clinician gestalt, particularly in high-risk subgroups such as older adults and patients with immunosuppression.[15,30,32,35,37–39,48,49] Implementation research is also needed to understand how staffing, training, electronic alert design and local escalation protocols influence the effectiveness of EWS in real-world settings, including low and middle-income countries where case mix and resources differ substantially.[7–9,15,18,30,35,36,39,46]

## LIMITATIONS

This review is limited by heterogeneity across included systematic reviews, most of which synthesized observational studies with varying thresholds, outcome definitions, and implementation strategies. We did not formally grade certainty of evidence because substantial clinical and methodological diversity would have made such ratings difficult to interpret. Risk of bias in individual primary studies was not reassessed, and our findings therefore depend on the quality and reporting of the included reviews. In addition, implementation effects are difficult to attribute solely to EWS due to co-interventions, time-related changes in care, and the predominance of nonrandomized study designs, while agreement between predicted and observed risk and other clinical utility measures were inconsistently reported.

## CONCLUSION

In ED settings, Early Warning Scores, particularly NEWS/NEWS2 and MEWS, provide clinically useful support for early risk stratification and identification of patients at risk of deterioration, especially for short-term mortality and escalation of care. However, their overall impact on patient-important outcomes remains uncertain, and current evidence supporting implementation effectiveness in ED workflows is limited and heterogeneous.

In suspected infection/sepsis cohorts, NEWS/NEWS2 (and, where evaluated, MEWS) generally show higher sensitivity than qSOFA at commonly used thresholds, whereas qSOFA tends to be more specific. Overall, Early Warning Scores can help reduce the risk of unexpected deterioration, but they must be embedded in clear escalation protocols and supported by adequate staffing, resources, and clinical judgment, rather than used as standalone solutions.

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# Resident Exposure to Acutely Ill Patients Over the Course of Residency

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**Introduction:** Emergency medicine literature has long debated the "black cloud" and "white cloud" phenomena, which suggest individual variability in exposure to acutely ill patients. If true, this variation may have significant implications for resident training. This study investigates whether emergency medicine (EM) residents consistently encounter differing volumes of high-acuity clinical encounters throughout their training.

**Methods:** This retrospective cohort study analyzed 11 years of electronic health record (HER) data from a Midwestern academic emergency department to quantify the number of acutely ill adult patients seen by EM residents across three years of training, using a consensus-based set of clinical criteria. Our primary outcome was the concordance of the ranking of each resident within their cohort by number of acutely ill patients seen during postgraduate year one (PGY 1) compared to PGY 3. Statistical analyses to assess this outcome included weighted kappa and linear regression.

**Results:** A total of 93 EM residents met the criteria for inclusion and saw a total of 359,736 patients during their residency (average 3,493 per resident). Residents saw an average of 167.5 (19.8) acutely ill patients during their residency training. This volume increased sharply by year, with PGY-1 residents seeing an average of 23.8 (7.3) acutely ill patients, and PGY-3 residents seeing an average of 100.3 (19.4). Both weighted kappa ($\kappa$ = -.274) and linear regression analysis ($\beta$ = -0.84; 95% CI, -1.4 to -0.31; $P$ = .002) indicated that a resident who saw more acutely ill patients than average in PGY 1 was more likely to see fewer acutely ill patients than average during PGY 3. Results were unaffected by the COVID-19 years or subsequent critical care fellowship pursuit.

**Conclusion:** "Cloud type" (as measured by EHR-documented care for acutely ill patients) does not appear to be a stable trait over time. Our findings are consistent with previous studies that found no association between residents' "cloudiness" and objective measures of workload. Using EHR data to track resident clinical exposures helps educators identify training gaps and target remediation through in situ or simulated experiences. [West J Emerg Med. 2026;27(5)1235–1242.]

## INTRODUCTION

Emergency physicians have long been superstitious about the mysterious ebbs and flows of their practice environment, suspecting that everything from full moons,[1,2] Friday the 13th,[3] New York Yankees souvenir bat days,[4] and use of the word "quiet"[5,6] can impact emergency department (ED) volumes. Empirical studies of these phenomena have failed to find statistically or clinically significant, measurable differences in clinical volumes or patient acuity to back up these superstitions.

However, another medical superstition that may have greater empirical support is the concept of "black clouds" and "white clouds," in which some physicians consistently see a

higher or lower proportion of critically ill patients compared to their peers.[7] A study by Zhao and colleagues found that "black cloud" hand surgeons saw a higher number of add-on cases and patient transfers.[8] Similarly, Tan and colleagues found that "stormy" neurosurgery trainees saw more consults.[9] However, empirical data supporting a "cloud type" for neurosurgery residents is not consistent across institutions,[10] and a small study in a pediatric emergency medicine (EM) population found no signs of this effect when examining ED visits and admissions.[11] Similarly, this effect has not been seen when studied in general surgery residents.[12] More recently, researchers at a large health system in Turkey found that there was no statistically significant difference in daily volumes, admissions, intensive care unit (ICU) admissions, high-acuity triage patients, traumas, or in-ED deaths among clinicians deemed the "luckiest" or "unluckiest," via a survey of the physician group.[13] Importantly, the definition of "black cloud" varies across the published research, with some defining it based on patient volumes (eg, number of consultations) and others defining it based on patient acuity (eg, ED admissions).

If present, the acuity-based "black cloud" and "white cloud" phenomena would have important implications for clinical training. By the time of graduation, EM residents have been found to have significant differences in their exposure to a variety of patient types, including differences in overall patient complaint distributions,[14] number of pediatric patients,[16] and critically ill pediatric patients.[17] Experiential learning theory suggests that clinical exposures are essential for growth by allowing residents to actively experiment with learned knowledge and critically reflect on what happened.[18] "White cloud" residents with less clinical exposure to acutely ill patients than their cohort may lack these essential exposures and might benefit from additional opportunities to simulate these cases or have additional rotations in the ICU to bolster their experience. However, to our knowledge, no study has looked at variability in EM resident clinical exposure to acutely ill adult patients during their EM training.

The goal of this study was to determine whether some residents saw a significantly higher or lower number of acutely ill patients than other trainees. We also examined whether that difference was stable over time—that is, do residents have a stable cloud type—operationally defined as being in the top tertile (most acutely ill patients; "black cloud") or bottom tertile ("white cloud") within their residency cohort of electronic health record (EHR)-attributed exposure to acutely ill patients. We also assessed whether residents who pursue a critical care fellowship are more likely to have consistently treated acutely ill patients during residency training than their peers. The motivating goal of this work was to investigate the possibility of identifying residents at risk of having insufficient experience with treating acutely ill patients during residency and to provide residency leaders with a tool to track resident progress, allowing targeted intervention (eg, additional simulation lab time) as needed.

*Population Health Research Capsule*

What do we already know about this issue?
*The number of acutely ill patients a resident sees over residency is important for experiential learning and growth.*

What was the research question?
*Is exposure to acutely ill patients, relative to cohort, stable over residency?*

What was the major finding of the study?
*Residents saw an average of 167.5 (19.8) acutely ill patients during residency. We found a negative correlation between postgraduate year one (PGY-1) and PGY-3: (weighted Kappa -.274; 95% CI, -0.42 to -0.04).*

How does this improve population health?
*Tracking resident exposures to acutely ill patients via the electronic health record can identify shortfalls and highlight need for increased exposure in situ or via simulation.*

## METHODS

### Setting

This retrospective cohort study used data from EM residents at an ED that treats approximately 70,000 patients per year. It is associated with an academic medical system and Level I trauma center in the Midwestern United States. The ED has both pediatric and adult beds with separate faculty, and residents work shifts in both areas. This program hosts a three-year residency program that currently accepts 13 residents per year (during 2015-2022 cohorts were 12 residents). We extracted 11 years of EHR data from July 2015 to June 2025, representing nine complete cohorts of EM residents. For most of the study period, the adult ED functioned under an "open" model where all patients (other than low-acuity patients seen in the fast track area) could be seen by any resident. For the years 2019 to 2022, the ED functioned under a pod system where an ED team was responsible for predefined beds. These models mostly affected faculty assignments because residents were allowed to assign themselves to patients when they felt ready to do so under both models.

All resident physicians who completed the residency program uninterrupted in the normally scheduled three years were included for analysis. The number of residents per cohort varied due to a small number of interruptions in or withdrawals from training, but most residency cohorts had 12 residents. We included all adult patient (greater than 18 years

of age) encounters seen by any of the eligible residents; pediatric visits were excluded due to the relatively low overall percentage of acutely ill children and the potential need for different criteria to define acutely ill pediatric patients.

This was a retrospective review of EHR data, which was deemed exempt quality improvement by our institution's health sciences institutional review board. Data were extracted—not abstracted—as discrete data from a relational database by an experienced data scientist (DJH); thus, abstractor-related measures outlined in Worster and Bledsoe were not applicable.[19] SQL was used for data retrieval, and R was used for processing and analysis.[20]

**Primary Outcome**

Our primary outcome was the number of acutely ill patients seen by each EM resident during each year of their residency. For the purposes of this study, we defined acutely ill based on the potential for acute decompensation while in the ED. We excluded categories such as "stroke code" activations and "code sepsis" activations because these activation criteria are intentionally broad and include patients who are not acutely ill. By contrast, patients receiving intravenous (IV) insulin drip were classified as acutely ill due to the use of medications exclusively for treating highly acute disease, including diabetic ketoacidosis and severe hyperkalemia. A patient was identified as acutely ill if they met any of the following criteria (documentation source):

- Emergency Severity Index (ESI) 1-Red (triage)
- Admission to ICU (admission, discharge, transfer [ADT] documentation)
- Level I trauma (triage)
- ST-elevation myocardial infarction (STEMI) (diagnosis)
- Death in ED (patient record)
- Central line placement (procedure order)
- Arterial line placement (procedure order)
- Vasopressors given (medication order based on pharmaceutical subclass)
- Vasodilators given (medication order based on pharmaceutical subclass)
- Anaphylactic shock (diagnosis)
- Ketamine IV drip (medication)
- IV insulin drip (medication)

This list was derived by consensus by a panel of experienced faculty emergency physicians. These criteria are dependent on institutional documentation practices and should not be interpreted as an exhaustive list of acutely ill criteria or a future "gold standard" applicable across all EDs. However, the authors and the residency leadership at our institution believe that, taken together, this list will likely identify nearly all acutely ill patients, especially those that residents at our program would be expected to gain experience treating per Accreditation Council for Graduate Medical Education guidelines. For example, a patient with severe respiratory distress requiring intubation or one requiring resuscitation is likely to arrive as an ESI 1 and/or be admitted to the ICU; therefore, the patient would be included in this analysis, even though intubation or resuscitation themselves are not included as a criteria due to difficulties within the data source of performing service attribution. Other studies and national benchmarks use billing information (eg, level of service 5 and/or critical care) to identify high-complexity patients;[21] we chose not to use billing information because it relies on attending physician documentation rather than on clinical activities of the resident as documented in the EHR. While such a definition focused on resident documentation may have limitations, it was consistently applied to all residents across the study period to minimize bias.

**Resident Attribution**

Resident physicians are matched with acutely ill patient care in three ways, depending on the type of acute illness flag. For medication-based flags, attribution was based on the resident who was the ordering clinician for the medication. For procedure-based flags, attribution was based on the resident who was the performing clinician listed on the procedure order in the EHR. For all other flags, resident attribution was based on the resident physician to first sign the primary clinician note in the ED. Thus, it was possible for the same patient to be attributed to multiple residents if the patient met multiple flags with different attributions. For example, for a patient who arrived as a Level I trauma and was initially treated by Resident A but was handed off after shift change to Resident B who placed a central line, both residents A and B would get credit for seeing this acutely ill patient. However, even if a patient qualified for multiple flags, they would only be matched with qualifying residents once (code available in the supplemental materials). In other words, a single patient with multiple flags might be matched to multiple residents, but only once per resident. This is similar to the attribution method we have used in previously published work.[14,22] Although we sought to accurately attribute resident documentation using notes and orders, it should be noted that this approach may not capture activities not documented in the EHR, such as a senior resident providing a "fly-by consult" or other assistance to a more junior resident. We operationally defined a black-cloud resident as being in the top tertile for cohort for the entire academic year.

Because we determined our sample size by availability rather than an a priori power calculation, we conducted a post hoc power calculation that suggests we have 71% power to detect an association between being a black cloud during postgraduate year one (PGY 1) and being a black cloud during PGY 3. (See Supplemental Document for power calculation.)

**Statistical Methods**

*Weighted Kappa*

For the primary analysis, the count outcome of "acutely ill

patients seen" was categorized into tertiles to improve interpretability. The primary statistical analysis compares the correspondence between being in the top tertile of residents during PGY 1 with being in the top tertile during PGY 3 using a weighted kappa statistic for interrater reliability, where the "raters" in this case is the residents' tertile rank during PGY 1 and PGY 3. This identifies whether cloud color was a stable attribute maintained during a trainee's entire residency—as the superstition suggests. More importantly, tertile grouping provides a more actionable grouping for the pragmatic aim of this work: identifying EM residents at risk of having insufficient exposure to acutely ill patients during their residency.

*Linear Regression*

While the weighted kappa analysis is highly interpretable, using tertiles risks coarsens the metrics and potentially obfuscates the association. To complement this approach, we performed a linear regression evaluating number of acutely ill patients seen as a PGY-3 resident as a function of acutely ill patients seen in previous years:

$$Y_{3i}=\beta_0+\beta_1 Y_{1i}+\beta_2 Y_{2i}+\epsilon_i$$

where $Y_{ji}$ is the count of acutely ill patients seen in year $j$ by resident $i$.

For both the weighted kappa and linear regression analyses, data were aggregated by year, which mitigated confounding from shift distribution and rotations throughout the year.

*Subgroup and Sensitivity Analyses*

Because graduates of our residency program often pursue further training, residents interested in critical care may intentionally seek out acutely ill patients. Therefore, we performed a subgroup analysis to compare residents who entered a critical care fellowship directly after graduation with all other residents.

While the COVID-19 pandemic disrupted training environments, we minimized impact on our primary findings by evaluating relative tertile differences rather than absolute changes over time. Nevertheless, operational disruptions during 2020 and 2021 had varied manifestations; therefore, we reran the primary (weighted kappa) analysis without the cohorts who finished residency in 2020 and 2021 to confirm that results were not affected by the pandemic and associated disruptions to ED care.[23–25]

Finally, we augmented our linear model to adjust for overall patient volume during PGY 3 to ensure differences in acutely ill patients seen was not primarily a function of differences in overall resident throughput.

*Missing Data Handling*

It is likely that some EHR data were missing, such that our definition of acutely ill patients was not perfectly sensitive or some patient encounters may not have been attributed to the residents who provided their care. We assumed that missing data occurred uniformly due to systemic features (eg, shift timing or crowding). Because these features were equally distributed across residents, the data were pooled for aggregation.

## RESULTS

A total of 93 residents met the criteria for inclusion. Residents saw an average (standard deviation [SD]) of 167.5 (19.8) acutely ill patients during their residency. As shown in Table 2, this increased sharply by year, with PGY-1 residents seeing an average of 23.8 (7.3) acutely ill patients, PGY-2 residents an average of 43.3 (9.0), and PGY-3 residents an average of 100.3 (19.4). Trajectories of residents by month of residency are presented in Figure 1.

The counts of patients identified as acutely ill and treated by residents are in Table 1. Note that because patients could have qualified for multiple criteria (eg, ESI-1, received vasopressors, and admitted to ICU), the sum of this table does not match the resident-specific totals noted above.

Average number of acutely ill patients seen by residency year is shown in Table 2. In our primary analysis, we found a weighted κ association of -0.274 (ie, a negative agreement between intern and senior residency years for being in the top tertile for seeing acutely ill patients), shown in Table 3. These results were corroborated by our linear analysis of continuous data (Table 4), which also found a negative association between seeing more acutely ill patients as a PGY-1 resident with seeing additional patients as a PGY-3 resident, relative to the overall average. The coefficient of interest—*PGY-1 count of* acutely *ill patients*—was 0.84 (95% CI, -1.4 to -0.31),

**Table 2.** Center and spread of acutely ill patients seen by residency year.

| | Count of Acutely Ill Patients Seen | | | | | | Acutely Ill Proportion of All Patients Seen | | |
|---|---|---|---|---|---|---|---|---|---|
| Residency Year | Minimum | Maximum | Mean | Standard Deviation | Median | Interquartile Range | Minimum | Maximum | Mean |
| PGY-1 | 11 | 47 | 23.8 | 7.3 | 23 | (18.0-29.0) | 1.47% | 4.48% | 2.86% |
| PGY-2 | 25 | 62 | 43.3 | 9 | 44 | (37.0-49.0) | 2.56% | 5.78% | 3.78% |
| PGY-3 | 59 | 150 | 100.3 | 19.4 | 101 | (86.0-114.0) | 4.18% | 10.85% | 6.64% |

*PGY*, postgraduate year.

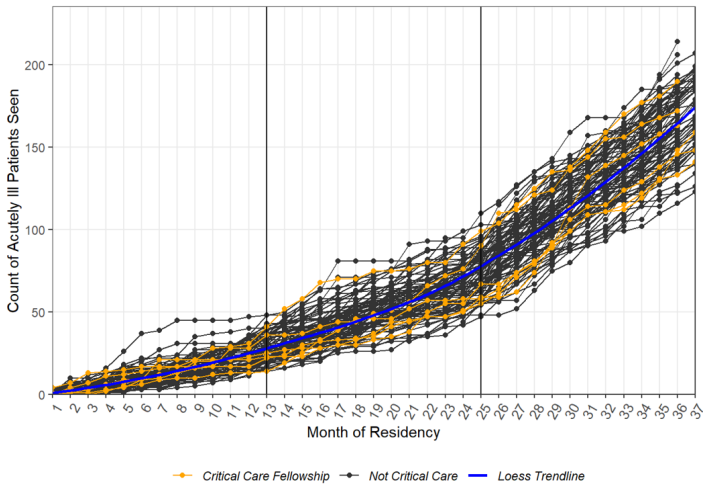


**Figure 1.** Cumulative trajectories of acutely ill patients seen by resident during the course of a three-year emergency medicine residency.

**Table 1.** Distribution of acutely ill patients seen by residents by indication in a study of the concordance of acutely ill patients seen by residents by postgraduate year.

| Acute Patient | Total Patients | Average Patients per Resident |
|---|---|---|
| Anaphylactic shock (diagnosis) | 484 | 5.20 |
| Arterial line placement (procedure order) | 244 | 2.62 |
| Central line placement (procedure order) | 211 | 2.27 |
| Death in ED (patient record) | 308 | 3.31 |
| ESI 1-Red (triage) | 4,681 | 50.33 |
| Admission to ICU (ADT Documentation) | 9,656 | 103.83 |
| IV insulin drip given (medication) | 534 | 5.74 |
| IV ketamine drip given (medication) | 17 | 0.18 |
| Level I trauma (flowsheets) | 4,014 | 43.16 |
| STEMI (diagnosis) | 1,589 | 17.09 |
| Vasodilators given (medication) | 331 | 3.56 |
| Vasopressors given (medication) | 750 | 8.06 |

*ADT*, admission, discharge, transfer; *ED*, emergency department; *ESI*, Emergency Severity Index; *ICU*, intensive care unit; *IV*, intravenous; *STEMI*, ST-elevation myocardial infarction.

suggesting that for every acutely ill patient seen during intern year, that resident saw 0.84 fewer acutely ill patients than average their final year of residency.

Of the six residents who pursued a fellowship in critical care, only 33% were in the top tertile of residents during their PGY 1, and only 50% were in the top tertile of residents their final year (PGY 3).

### Sensitivity Analyses

Results of both the weighted kappa and linear regression analyses were fundamentally unchanged when excluding COVID-19–affected years, suggesting our results were robust to the operational disruptions posed by the pandemic. Our findings were also robust to overall patient throughput. It is possible for residents to see more acutely ill patients by seeing more patients overall. However, the negative association between acutely ill patients seen during PGY 1 and those seen in PGY 3 persists. The details of both sensitivity analyses are in the Supplemental Document.

## DISCUSSION

We do not see evidence that EHR-documented treatment of acutely ill patients—a working definition for "cloud type"—is a stable trait over time for EM residents. Among all residents, there was a negative association between being in the top (third) tertile for treating acutely ill patients as a PGY-1 resident with being the top tertile as a PGY-3 resident. This was true for residents in general as well as those who pursued a fellowship in critical care. Figure 2 shows that there is a great deal of movement between tertiles across years. Table 2 demonstrates a substantial longitudinal increase in both the absolute number and proportion of acutely ill patients seen by residents. This trend reflects changes in the resident shifts and expectations as residents progress—more adult ED shifts, more trauma shifts, and increased patient throughput expectations—which is why all analyses are relative within a residency cohort.

Our finding is consistent with previous studies that found no association between residents' perceived cloud-type (assessed with many different instruments and operational definitions) and objective measures of workload.[9,12,26] It is possible that there may be a tendency that once a resident thinks they have seen a lot of acutely ill patients and that perception is reinforced by peers and faculty through confirmation bias, there is less urgency to maintain that perception. Conversely, residents who view themselves as white clouds may actively seek out acutely ill patient encounters to increase their exposure to real or perceived deficits in their medical experience. Despite the level of movement overall, 2/93 residents (2.15%) stayed in the top tertile for all three PGYs, and 3/93 (3.23%) stayed in the bottom tertile for all three PGYs. Both proportions are less than would be expected by chance (albeit not statistically significantly, see supplemental document for calculations), which suggests there could be some level of intention by residents regarding the number of acutely ill patients they treat. An alternative explanation would also be regression to the mean, which would explain our observed data without requiring intentional action by residents. However, the high level of dispersion across all tertiles shown in Figure 2

**Table 3.** Concordance of being in the top tertile for acutely ill patients seen across residency by postgraduate year.

| | PGY-3 Tertile | | | |
|---|---|---|---|---|
| | Tertile 1 (Lowest) | Tertile 2 | Tertile 3 (Highest) | Total |
| PGY-1 tertile | | | | |
| Tertile 1 (lowest) | 7 | 11 | 13 | 31 |
| Tertile 2 | 7 | 12 | 12 | 31 |
| Tertile 3 (highest) | 17 | 8 | 6 | 31 |
| Total | 31 | 31 | 31 | 93 |

*PGY*, postgraduate year

suggests that regression to the mean is an incomplete explanation. More work is needed to understand the reason for these shifts in behavior.

While most residents appear to move around the tertiles of acutely ill patient exposure, it is still important to identify those residents who remain in the bottom tertile for targeted additional educational opportunities (eg, critical care simulation). Precision education and targeted learning opportunities are a pillar of competency-based medical education,[27] and the EHR has previously been shown in emergency medicine to be useful for identifying potential training deficits and highlighting opportunities for informed self-assessment and improved goal setting.[15]

One might expect residents interested in critical care to be more inclined to seek out acutely ill patients while working in the ED. However, we did not find evidence that critical care-interested residents see a greater proportion of these patients, although the limited number of residents pursuing a critical care fellowship prevents further generalization. We surmise that this finding could also indicate that critical care-bound residents find a way to be involved with these cases in a teaching role instead, mentoring junior residents through the cases, which would not be reflected in our data due to our method of attributing patients via the EHR. This is an area for future study, ideally with a larger pool of critical care-bound residents from multiple academic centers.

**Table 4.** Linear regression results of acutely ill patients seen in final year of residency for a study of the concordance of acutely ill patients seen by residents by postgraduate year.

| Characteristic | Beta | 95% CI | *P* value |
|---|---|---|---|
| (Intercept) | 128 | 107, 149 | < .001 |
| PGY-1 count of acutely ill patients | -0.84 | -1.4, -0.31 | .002 |
| PGY-2 count of acutely ill patients | -0.18 | -0.61, 0.26 | .40 |

*PGY*, postgraduate year.

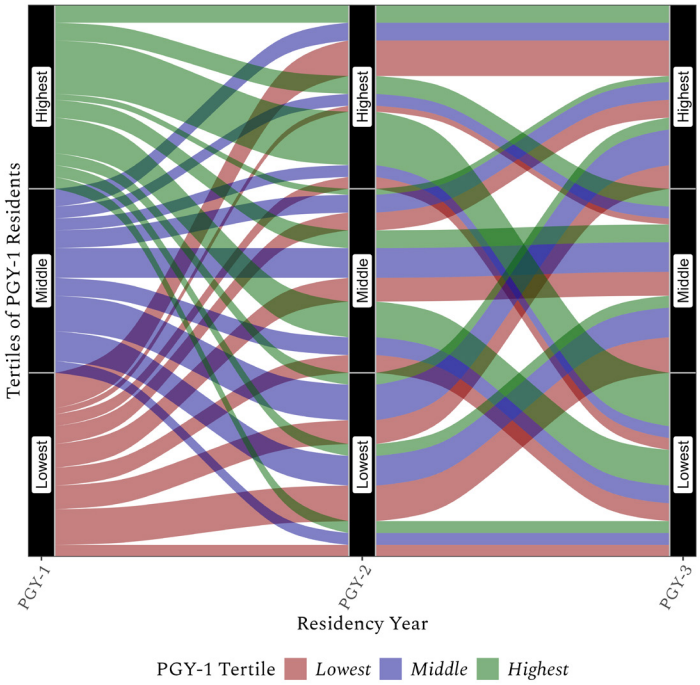


**Figure 2.** Alluvial plot of resident tertile rankings by postgraduate year for a study of acutely ill patients seen during residency. *PGY*, postgraduate year.

## LIMITATIONS

This study has several limitations. First, it was conducted at a single academic medical center with a three-year residency. While residency length alone is unlikely to substantially influence these findings, the culture and catchment area of this center may not be representative of other residency programs and patient populations.

Second, some acutely ill EHR phenotypes may not be obvious at the time of a resident's decision to sign up for a patient. Some phenotypes, especially patients triaged as ESI 1, are clearly indicated in the EHR at the time the resident signs up for the patient. Others, like those identified as acutely ill by diagnosis, would not have met our study criteria at the time the resident assumed care. This would be a limitation for any causal analysis where the unit of analysis was the patient; however, in the real world setting of the ED, we believe it is a reasonable assumption that residents generally recognize whether they are assuming care of an acutely ill patient. For example, a resident who signs up for a patient who will eventually be diagnosed for anaphylaxis compared to a sprained wrist is likely to recognize whether they are signing up for an acutely ill patient.

Third, this analysis does not address the quality of care. It could be that the residents seeing the fewest acutely ill patients are nevertheless doing the best job at caring for those patients. This is very likely the case for some of the lower volume residents who pursue a critical care fellowship. Additionally, it is not clear what level of clinical experience defines

competency; it is possible that all residents far exceed (or undershoot) the bar for minimum competence in caring for critical patients. More research on competency and clinical exposure with a more comprehensive dataset including patient outcomes is indicated.

Fourth, we do not compare our objective measure (tertiles of acutely ill patients cared for) to perceived measures of black versus white clouds, either by residents' self-assessments or by residents rating each other's "cloud type." This also remains an area for subsequent study. Fifth, in the absence of a clear, gold standard definition of "acutely ill," we made our own definition based on available data and attending physician experience. It is possible that patients who were acutely ill were not captured by our definition, but we believe this definition has construct validity and matches the experience of residents at the study institution, although it should be acknowledged that this definition is contingent on the documentation practices of the study institution and may not have strong external validity at other institutions.

Finally, we used EHR data for this study. Electronic health record data are objective and clearly important in medical care today. However, they do not necessarily reflect the whole experience of residents. Expanding this work by collaborating with other institutions to increase the sample size and variability of resident experiences would help to address many of these limitations and remains a hoped-for future direction. Increasing the pool of residents and data would also allow for analysis of tail-end effects, such as whether the "darkest" or "whitest" clouds (eg, 1st or 10th decile) are more or less likely to change cloud group than their peers in the "messy middle."

## CONCLUSION

We did not find evidence that high or low EHR-attributed exposure to acutely ill adult ED patients is a stable, resident-specific trait over the course of EM residency. This finding questions the narrative that some resident physicians are "black clouds" or "white clouds" who seem to attract or deflect the most serious cases in the ED. Residents who start off seeing many acutely ill patients often end up seeing fewer of those patients than their peers later in residency. Residency programs may benefit from considering the percentage of acutely ill patients that their residents see as a part of providing precision education.

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# A Decade Later: Trends in Fellowship Training and Secondary Board Certification Among Emergency Medicine Residency Leaders

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**Introduction:** Residency program leaders shape the academic pipeline in emergency medicine (EM). We assessed current demographics and postgraduate training among EM residency leadership in the United States.

**Methods:** We conducted a national, cross-sectional survey of all Accreditation Council for Graduate Medical Education–accredited EM residency program leadership via an online, confidential questionnaire. Primary outcomes were the prevalence of any postgraduate fellowship training and any secondary board certification (ie, additional board certification beyond EM) as a complementary marker of advanced credentialing distinct from fellowship training. Programs were grouped by National Resident Matching Program (NRMP) region.

**Results:** We received 103 program responses (35.9%). Any fellowship training was reported by 25.5% of program directors (PD), 40.0% of associate program directors (APD), and 42.8% of assistant PDs. Compared with the 2014–2015 national survey, fellowship training increased from approximately 20–25% to 40–43% among APD and assistant PDs, while remaining similar among PDs (~25% previously vs 26% currently). Any secondary board certification was reported by 8.8% of PDs, 5.0% of APDs, and 8.2% of assistant PDs. Medical education was the most common fellowship ($n$ = 54), followed by ultrasound ($n$ = 24), toxicology ($n$ = 16), simulation ($n$ = 15), pediatric EM ($n$ = 11), critical care ($n$ = 7), emergency medical services ($n$ = 5), and administration ($n$ = 3). Programs in the western United States reported the highest proportions of leaders with either fellowship or secondary certification across roles.

**Conclusion:** Postgraduate fellowship and secondary board certification remain uncommon overall among EM residency leaders, but fellowship completion is more prevalent among junior leaders compared with a decade earlier. These data provide an updated, role-specific snapshot to inform leadership development and workforce planning. [West J Emerg Med. 2026;27(5)1243–1249.]

## INTRODUCTION

Residency leaders in emergency medicine (EM), including program directors (PD), associate PDs (APD), and assistant PDs, shape curricula, recruitment, mentorship, and scholarly priorities for the specialty's future workforce. Interest in postgraduate fellowship training has expanded over time, but peer-reviewed data about how such training is represented among EM residency leadership are limited. In a prior national survey (2014–2015) of Accreditation Council for Graduate Medical Education (ACGME)–accredited EM programs, –fellowship training among residency leaders was relatively uncommon (PDs, 21.4%; APDs, 20.3%; assistant PDs, 24.9%), and secondary board certification was even less prevalent. Regional variation was observed, with the Western United States reporting the highest proportion of additional training.

Over the same period, the landscape of EM training has expanded substantially. Between 2005 and 2019, the number of accredited EM residency programs approximately doubled, and more recent national reports document continued growth. In parallel, the breadth and availability of EM fellowships and subspecialty pathways have expanded, including the emergence of additional accredited subspecialty–training options. These changes have practical implications for interpreting our findings: Junior faculty entering leadership roles today are more likely to have trained during an era with greater fellowship availability, and the decision to pursue fellowship also carries a meaningful opportunity cost relative to entering independent practice earlier.

Concurrently, literature from other specialties suggests that advanced training and credentialing are common among faculty in leadership roles, although patterns vary by field and are associated with persistent demographic disparities. Because fellowship training is not universally required in EM, we cite these cross-specialty studies primarily to illustrate how additional training and credentialing can shape leadership pipelines, rather than to imply equivalence in baseline fellowship expectations across fields. For example, ophthalmology leadership and fellowship directors are frequently subspecialty–trained, with studies documenting high rates of fellowship training among leaders across organizations and programs. Given ongoing interest in leadership representation, we also describe sexdistribution across EM residency leadership roles.

It remains unclear whether the training profile of EM residency leadership has shifted over the last decade. It is unclear whether fellowship completion and secondary board certification have become more prevalent, whether regional differences persist, and whether the earlier finding that assistant PDs with shorter leadership tenure are more likely to report fellowship training reflects a generational shift in leadership qualifications. The objective of this study was to describe current demographics, fellowship training, and secondary board certification among EM residency leaders in the US and to compare these patterns with those reported a decade earlier, including variation by leadership role and geographic region.

*Population Health Research Capsule*

What do we already know about this issue?
*Fellowship training was previously uncommon among emergency medicine (EM) residency leaders.*

What was the research question?
*How common are fellowship training and secondary board certification among EM residency leaders?*

What was the major finding of the study?
*Fellowship training was reported by 25.5% of program directors (PDs), 40.0% of associate PDs, and 42.8% of assistant PDs.*

How does this improve population health?
*These data inform EM leadership development, mentorship, and workforce planning across training programs.*

## METHODS

### Design and Setting

We conducted a national, cross-sectional survey of all ACGME–accredited EM residency programs in the United States. The sampling included each categorical EM residency identified through Emergency Medical Residents Association Match and program/department websites at the time of survey launch. Only ACGME–accredited programs were included ($N$ = 287). Eligible respondents were PDs, APDs, assistant PDs, or a designated program administrator who could report leadership characteristics for their program. Length of time in residency leadership reflected cumulative tenure in leadership roles regardless of whether service occurred at a single or multiple institutions. This study received an exempt determination from the Northwell Health Institutional Review Board.

### Recruitment and Survey Administration

An online, confidential questionnaire was distributed to program leadership via the Council of Emergency Medicine Residency Directors (CORD) listserv and direct program emails during February–April 2025. The initial invitation was sent in February 2025, with follow-up reminders through April 2025. Nonrespondents received up to two reminder emails at approximately two-week intervals. The survey instrument was identical to the one used in the prior 2014–2015 study to

enable direct comparison across time. Before survey closure, programs that had not responded were contacted individually to encourage participation.

**CHERRIES Checklist Reporting (Internet Survey Specifics)**

This was an internet-based survey distributed via the CORD listserv and direct program emails during February–April 2025, with up to two reminders sent at two-week intervals to nonrespondents. Participation was voluntary with implied consent by completion. We requested one response per program, with preference for the PD. If duplicate program responses were received, we retained the most complete or, when equal, the earliest complete record. No personal identifiers were collected. Data were stored in institutional systems and then exported to Microsoft Excel (Microsoft Corporation, Redmond, WA) for analysis. The overall response rate was 35.9% (103/287), and the survey completion rate was 35.2% (101/287). Among those who responded, 98.1% (101/103) completed the section on sex. Responding programs were similar to the national distribution of ACGME EM programs by National Resident Matching Program (NRMP) region and program length. Percentages were computed using nonmissing denominators. We did not use view-rate metrics such as email opens, IP- or cookie-checks, or incentives. See Appendix 1 (CHERRIES checklist) for itemized reporting.

**Measures**

Our primary outcome measure was the prevalence of any postgraduate fellowship training among EM residency leaders. Secondary outcome measures included the prevalence of secondary board certification, differences in training patterns by leadership role, regional variation by NRMP region, and the distribution of reported fellowship types. For each leadership role, respondents reported sex, combined years in residency leadership, completion of any postgraduate fellowship, and any secondary board certification. Because leadership structures vary across institutions, APD and assistant PD titles are not standardized nationally; we therefore report role-specific findings as described by each program. The survey collected data for one PD, up to two APDs, and up to four assistant PDs per program, consistent with the prior instrument. If a program had more individuals in a role than the survey allowed, the designated respondent reported the individuals most directly involved in residency leadership, and each individual was counted only once.

The following operational definitions were used for training and credentialing: fellowship training, completion of a postgraduate fellowship after residency; and secondary board certification, any additional board certification beyond EM. For pediatric pathways, a pediatric EM fellowship paired with pediatrics board certification was considered fellowship training and not dual-counted as secondary board certification.

Programs were assigned to NRMP regions (Western, Northeastern, Central, Southern). A priori, pediatric EM fellowships with pediatrics board certification were classified as fellowships (not dual-counted as secondary certification) for consistency. The complete survey instrument and response options appear in Appendix 2.

**Data Management and Analysis**

We aggregated responses at the program level and calculated descriptive statistics. Prespecified sensitivity analyses to test robustness included (1) excluding programs with incomplete role reporting and (2) reclassifying programs requiring a. pediatric EM fellowship and pediatrics board certification as requiring both a fellowship and a secondary board certification to test robustness. Analyses were performed in Microsoft Excel.

## RESULTS

Surveys were sent to all ACGME–accredited EM residency programs ($N = 287$). We received 103 program responses (35.9%), of which 101 were complete (35.2%). Regional response rates were as follows: Northeast, 52.4% (43/82); Central, 23.6% (17/72); South, 31.9% (30/94); and West, 30.8% (12/39). One responding program did not report a region. These produced 410 role-level entries, including 102 PDs, 100 APDs, and 208 assistant PDs. Respondents represented all NRMP regions and both three-year and four-year program lengths (Table 1). Additional descriptors are provided in Table 2.

The prevalence of any postgraduate fellowship training was 25.5% among PDs (26/102), 40.0% among APDs (40/100), and 42.8% among assistant PDs (89/208). The prevalence of any secondary board certification was 8.8% among PDs (9/102), 5.0% among APDs (5/100), and 8.2% among assistant PDs (17/208) (Figure 1).

Across all leaders, reported fellowships included medical education (54/410, 13.2%), ultrasound (24/410, 5.9%), toxicology (16/410, 3.9%), simulation (15/410, 3.7%), pediatric EM (11/410, 2.7%), critical care (7/410, 1.7%), emergency medical services (5/410, 1.2%), and administration (3/410, 0.7%). An additional 20 leaders (20/410, 4.9%) reported "Other" fellowship types. No fellowship was reported for 255 leaders (255/410, 62.2%).

Secondary board certifications included internal medicine (9/410, 2.2%), pediatrics (6/410, 1.5%), critical care (5/410, 1.2%), and other specialties (11/410, 2.7%), while no secondary board certification was reported for 379 leaders (379/410, 92.4%).

The proportion identifying as female was 37.3% among PDs (38/102), 42.0% among APDs (42/100), and 50.5% among assistant PDs (105/208). The proportion identifying as male was 61.8% among PDs (63/102), 57.0% among APDs (57/100), and 46.6% among assistant PDs (97/208). "Prefer not to answer" responses accounted for 1.0% of PDs (1/102), 1.0% of APDs (1/100), and 1.9% of assistant PDs (4/208),

**Table 1.** Characteristics of emergency medicine leaders in a national survey of Accreditation Council for Graduate Medical Education–accredited programs.

| | Program Director (*n* = 102) | Associate Program Director (*n* = 100) | Assistant Program Director (*n* = 208) | Total (*N* = 410) |
|---|---|---|---|---|
| Postgraduate Training and Board Certification | | | | |
| Any fellowship training | 26 (25.5%) | 40 (40.0%) | 89 (42.8%) | 155 (37.8%) |
| Any secondary board certification | 9 (8.8%) | 5 (5.0%) | 17 (8.2%) | 31 (7.6%) |
| Fellowship Type | | | | |
| Medical Education | 12 (11.8%) | 10 (10.0%) | 32 (15.4%) | 54 (13.2%) |
| Ultrasound | 3 (2.9%) | 10 (10.0%) | 11 (5.3%) | 24 (5.9%) |
| Toxicology | 0 (0.0%) | 4 (4.0%) | 12 (5.8%) | 16 (3.9%) |
| Simulation | 1 (1.0%) | 6 (6.0%) | 8 (3.8%) | 15 (3.7%) |
| Critical Care | 2 (2.0%) | 2 (2.0%) | 3 (1.4%) | 7 (1.7%) |
| Emergency Medical Services | 2 (2.0%) | 1 (1.0%) | 2 (1.0%) | 5 (1.2%) |
| Administration | 0 (0.0%) | 1 (1.0%) | 2 (1.0%) | 3 (0.7%) |
| Pediatric Emergency Medicine | 1 (1.0%) | 2 (2.0%) | 8 (3.8%) | 11 (2.7%) |
| Other* | 5 (4.9%) | 4 (4.0%) | 11 (5.3%) | 20 (4.9%) |
| Secondary Board | | | | |
| Internal Medicine | 5 (4.9%) | 2 (2.0%) | 2 (1.0%) | 9 (2.2%) |
| Pediatrics | 1 (1.0%) | 0 (0.0%) | 5 (2.4%) | 6 (1.5%) |
| Critical Care | 1 (1.0%) | 1 (1.0%) | 3 (1.4%) | 5 (1.2%) |
| Other | 2 (2.0%) | 2 (2.0%) | 7 (3.4%) | 11 (2.7%) |
| Sex | | | | |
| Female | 38 (37.3%) | 42 (42.0%) | 105 (50.5%) | 185 (45.1%) |
| Male | 63 (61.8%) | 57 (57.0%) | 97 (46.6%) | 217 (52.9%) |
| Prefer not to answer | 1 (1.0%) | 1 (1.0%) | 4 (1.9%) | 6 (1.5%) |
| Leadership Experience | | | | |
| < 5 years | 29 (28.4%) | 28 (28.0%) | 137 (65.9%) | 194 (47.3%) |
| 5–10 years | 35 (34.3%) | 53 (53.0%) | 56 (26.9%) | 144 (35.1%) |
| > 10 years | 37 (36.3%) | 18 (18.0%) | 14 (6.7%) | 69 (16.8%) |

*Other includes free-text entries such as sports medicine, resuscitation, informatics, and non–ACGME training.

with missing sex data for 1.0% of assistant PDs (2/208).

Cumulative time in residency leadership was as follows: < 5 years for 28.4% of PDs (29/102), 28.0% of APDs (28/100), and 65.9% of assistant PDs (137/208); 5–10 years for 34.3% of PDs (35/102), 53.0% of APDs (53/100), and 26.9% of assistant PDs (56/208); and > 10 years for 36.3% of PDs (37/102), 18.0% of APDs (18/100), and 6.7% of assistant PDs (14/208).

For the combined endpoint of either fellowship training or secondary board certification, proportions by NRMP region and leadership role are shown in Figure 2. In the Western region, 41.7% of PDs (5/12), 60.0% of APDs (6/10), and 51.9% of Asst PDs (14/27) reported advanced training. In the Northeastern region, the corresponding proportions were 34.9% (15/43), 42.1% (16/38), and 47.8% (33/69). In the Central region, 17.6% of PDs (3/17), 52.9% of APDs (9/17), and 48.8% of Asst PDs (20/41) reported advanced training. In the Southern region, the proportions were 26.7% (4/15), 26.7% (4/15), and 33.3% (22/66), respectively.

## DISCUSSION

This national, cross-sectional survey of ACGME-accredited EM residency programs in the US provides an updated assessment of leadership demographics and postgraduate training a decade after the original analysis.[1] Surveys were distributed to 287 programs, with 103 responses (35.9%), of which 101 were complete (35.2%). Although the response rate was lower than that of the prior study, the absolute number of programs represented remains substantial and includes broad geographic and institutional diversity. In the 2014–2015 survey, responses were obtained from 145 of

**Table 2.** Survey response metrics of Accreditation Council for Graduate Medical Education–accredited emergency medicine residency programs.

| | Number of Respondents | Percentage (%) |
|---|---|---|
| Program Length | | |
| 3-year program | 80 | 79.2 |
| 4-year program | 21 | 20.8 |
| Program Size (PGY-1 intake per year) | | |
| Large (≥ 13 residents per year) | 39 | 38.2 |
| Medium (7-12 residents per year) | 53 | 52 |
| Small (1-6 residents per year) | 10 | 9.8 |
| Institution Type | | |
| Academic medical center | 51 | 50 |
| Community hospital | 14 | 13.7 |
| County hospital | 11 | 10.8 |
| Hybrid (eg, community-academic affiliation) | 26 | 25.5 |
| Associate Program Directors per program | | |
| 0 | 26 | 25.5 |
| 1 | 52 | 51 |
| 2 | 24 | 23.5 |
| Assistant Program Directors per program | | |
| 1 | 34 | 33.7 |
| 2 | 36 | 35.6 |
| 3 | 21 | 20.8 |
| ≥ 4 | 10 | 9.9 |

Percentages calculated with nonmissing denominators. Missing data included program length (1.9%), program size (1.0%), institution type (1.0%), associate program director count (1.0%), and assistant program director count (1.9%).
*PGY*, postgraduate year.

164 ACGME–accredited EM programs (88%).

Compared with the prior national survey conducted in 2014–2015, fellowship training among residency leaders has increased most notably among faculty in junior leadership roles. In the earlier study, fellowship completion was reported by 21.4% of PDs, 20.3% of APDs, and 24.9% of assistant PDs. In the current study, corresponding rates were 25.5% for PDs, 40.0% for APDs, and 42.8% for assistant PDs, representing an absolute increase of approximately 15–18 percentage points among associate and assistant PDs. The distribution of fellowship types has also changed, with medical education now the most frequently reported fellowship, whereas toxicology was previously the most frequent. Regional differences persist, with Western region programs continuing to report higher proportions of leaders with advanced training across roles. Secondary board certification remains uncommon across leadership positions in both study periods.

These findings suggest that fellowship training remains relatively uncommon among senior leaders but is more frequently represented in junior leadership roles, supporting a possible shift in the leadership pipeline over time.

Prior work examining outcomes among EM residency graduates in the US found that pursuing postgraduate fellowship training was uncommon overall, with approximately 4–9% of graduates entering fellowship, depending on residency format. In this context, the fellowship completion rates observed among residency leaders in the present study, particularly among APDs and assistant PDs, are substantially higher than historical baseline rates among EM graduates. This suggests that residency leadership represents a selected subgroup with greater engagement in formal postgraduate training than the broader EM workforce.

Secondary board certification was relatively uncommon, reported by fewer than 10% of respondents across all leadership roles. Pediatric board certification, often paired with a pediatric EM fellowship, was the most frequent category. The overall low prevalence of secondary certification mirrors the findings of the prior national survey, suggesting that this pathway remains a less common route to residency leadership.[1]

Sex distribution varied by leadership role, with greater

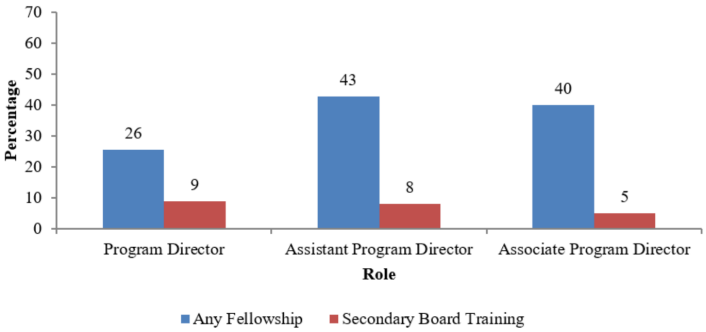


**Figure 1.** Prevalence of any fellowship training versus any secondary board certification by leadership role in a national survey of Accreditation Council for Graduate Medical Education-accredited emergency medicine residency programs in the United States.

representation of women in more junior roles (Table 1), consistent with broader trends in academic EM. Leadership tenure similarly differed by role, with PDs reporting longer time in position and assistant PDs more commonly earlier in their leadership trajectory (Table 1). This pattern suggests that fellowship training is more prevalent earlier in leadership roles and less common at the PD level.

We observed regional differences in fellowship training and secondary board certification. Program heads in We programs in the Western US reported the highest prevalence of fellowship or secondary board certification across all roles, followed by the Northeast and Central regions, with the Southern region reporting the lowest prevalence. These trends may reflect regional differences in academic infrastructure, fellowship availability, or institutional emphasis on postgraduate training.

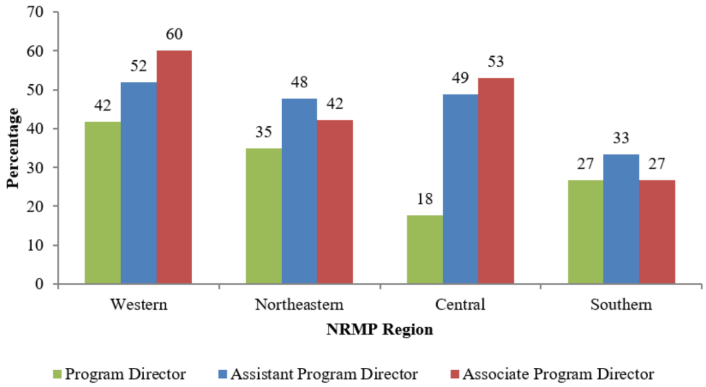


**Figure 2**. Prevalence of either fellowship training or secondary board certification by NRMP region and leadership role in a national survey of ACGME-accredited emergency medicine residency programs.
*ACGME*, Accreditation Council for Graduate Medical Education; *NRMP*, National Resident Matching Program.

Taken together, the findings in this study provide an updated, role-specific snapshot of qualifications within EM residency leadership that programs, departments, and trainees can use for workforce planning and mentorship. For programs recruiting future leaders, the pattern suggests growing value placed on structured postgraduate training, especially in education-facing domains, without implying it is universally required. For trainees aspiring to leadership, the data highlight common pathways and may help guide career planning.

Future work should investigate whether increased fellowship training among junior leaders ultimately results in higher fellowship rates among PDs. It should also examine whether similar patterns are present among practicing emergency physicians outside leadership roles and whether advanced training is associated with measurable program outcomes, such as educational quality, scholarly productivity, or trainee recruitment. Repeating this analysis in another decade, using consistent methods and stronger response strategies, will be essential to confirm these trends and refine the implications for EM leadership.

## LIMITATIONS

This study has several limitations. The first is the survey response rate. We received 103 responses from 287 ACGME–accredited EM residency programs (35.9%), with 101 complete submissions (35.2%). A response rate in this range raises the possibility of nonresponse bias if programs with particular characteristics (eg, greater emphasis on fellowship training, specific leadership structures, or certain regions) were more or less likely to participate. Although this risk cannot be excluded, similar response rates are common in national surveys of EM educators and residency leadership and have been used to describe workforce characteristics when methodological transparency is maintained.- The absolute sample size is large and includes programs from all NRMP regions, as well as a mix of program lengths, sizes, and institution types, supporting descriptive generalizability. Key directional patterns replicate prior national observations (eg, higher fellowship prevalence among junior leaders and low overall rates of secondary board certification), which bolsters confidence that the principal signals are not artifacts of selective response. We do not make population-level causal claims, and our conclusions are framed accordingly. Ultimately, these analyses are descriptive rather than inferential. We do not draw causal conclusions, and our findings should be interpreted accordingly. As a preliminary nonresponse check, the respondent pool reflected all NRMP regions and both 36- and 48-month formats in proportions consistent with national profiles.

Second, as with any self-report survey, responses are subject to recall and classification error. To minimize this, we prespecified operational rules. For example, the pediatric EM fellowship paired with the pediatrics boards was counted only as a fellowship, rather than being dual counted. We also

reported free-text "other" entries transparently, such as medical education, simulation, sports medicine, resuscitation, and informatics (see Table 1 footnote). Still, some respondents may have used "other" to describe non-ACGME educational experiences, potentially misrepresenting formal fellowship categories.

The third limitation is the cross-sectional design. We describe prevalence at a single point in time and cannot determine trajectories for individual leaders or programs. The higher fellowship rates among assistant PDs could reflect differences between training eras rather than progression within leadership roles. As fellowship opportunities have expanded over the past decade, more recent graduates may enter leadership positions with higher baseline rates of postgraduate training, which could amplify these apparent generational differences.

A fourth limitation is the grouping of programs into the four NRMP regions for comparability. This grouping may hide variation within regions. Programs also differ in the number of APD and assistant PDs, which changes role denominators and can affect role-specific estimates. Finally, the percentage of missing data was low but present (generally ≤ 2% across program-characteristic items; see Table 2). We calculated percentages using nonmissing denominators and reported missingness and "other" categories in table footnotes for transparency.

## CONCLUSION

In this national survey of ACGME–accredited emergency medicine residency programs, fellowship training was uncommon among program directors but more prevalent among junior residency leaders, while secondary board certification remained infrequent. These data update the 2014–2015 baseline and inform future work on how training pathways relate to leadership development and program outcomes.

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# Impact of a Residency-Run Emergency Medicine Podcast Summary on Learning Retention and Engagement

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**Introduction:** Podcasts have become a widely used educational tool in emergency medicine. In this study, a podcast was used as the intervention. This podcast consisted of a brief audio summary of weekly in-person conference content produced by residents and faculty. We assessed whether a resident-led, curriculum-based podcast summary improved knowledge retention and learner engagement compared to a standard written summary format.

**Methods:** This mixed-methods prospective cohort study conducted at a single urban academic hospital included 54 emergency medicine residents and approximately 66 attending physicians. The study unfolded in three phases: eight weeks of standard written conference summaries (control); followed by eight weeks of written plus podcast conference summaries (intervention); and a four-week post-intervention period with surveys. The primary outcome was knowledge retention, measured by weekly postconference quiz scores comparing the written-summary phase (control) with the podcast phase. Secondary outcomes included learner satisfaction, podcast usage patterns (downloads and self-reported listening), and self-reported impact on clinical application of conference content. Data included quiz scores, survey responses, and podcast analytics. Statistical comparisons of quiz performance were made using paired *t*-tests. Thematic analysis of open-ended responses was performed using Braun and Clarke's framework.

**Results:** Mean quiz scores were 73.1% (standard deviation [SD] 6.6) during the written phase and 73.7% (SD 14.4) during the podcast phase with no statistically significant difference in weekly quiz performance between conditions (paired *t*-test, $P = .92$). An exploratory linear trend analysis suggested a steeper week-to-week improvement during the podcast phase, but this post-hoc finding should be interpreted cautiously. Although the podcast did not improve knowledge retention compared with the existing written summary, learners reported high satisfaction, perceived reinforcement of key concepts, and convenient asynchronous access.

**Conclusion:** In this mixed-methods study, a residency-run podcast summary did not improve quiz-based knowledge retention compared with an existing written conference summary. However, learners reported high satisfaction, perceived reinforcement of key concepts, and convenient asynchronous access. [West J Emerg Med. 2026;27(5)1250–1257.]

## INTRODUCTION

Over the past 10 to 15 years, podcasts have become integral to modern medical education, particularly in emergency medicine (EM), with numerous content-related podcasts available.[1] Surveys of EM residents demonstrate widespread use of educational podcasts as a core component of asynchronous learning and that core content is increasingly delivered through this medium.[2] Longitudinal analyses of popular podcasts show substantial coverage of core content over time.[3,4] Podcasts are particularly attractive to trainees because they are portable, flexible, and readily integrated into busy clinical schedules, allowing learners to review high-yield material during commutes or between shifts.[5-8] Although audio and visual learning modalities have been widely studied, no consistent superiority has been established; outcomes often depend on learner preference and context.[8,9] Podcasts can serve as a concise modality for summarizing key information and offer flexible, on-demand access that learners can integrate into busy clinical schedules, particularly during residency training.[5-7,10] This study evaluates the impact of a resident-led curriculum-based podcast on knowledge retention and learner engagement compared to a written summary format.

Podcasts have demonstrated effectiveness in immediate knowledge retention; however, the existing literature has primarily focused on creation, short-term outcomes, and learner satisfaction.[6-8,11,12] There is a paucity of research evaluating sustained knowledge retention when an original, curriculum-based podcast, produced within an EM residency program, is compared with a standard written conference summary over multiple weeks. While several studies have explored learning satisfaction and feelings associated with podcasts, an information gap in the literature exists regarding the optimal structure of podcasts, higher level learning outcomes, and their integration into formal curricula.[2,7,12] Emergency medicine residents widely use podcasts for off-shift learning, highlighting their significance in medical education.[6] A national survey of EM residents underscores the prevalence of podcast use, with preferences for shorter durations and reported impacts on clinical practice.[2] Although podcasts have shown promise in supporting classroom teaching with minimal expenses, the existing literature lacks comprehensive research on their efficacy as teaching tools and best practices in podcast creation.[1,7,13]

While some case-control studies have explored the impact of podcasts in educational settings, none specifically address learning retention in the context of an original EM residency curriculum-based podcast versus a standard EM residency curriculum. For example, a study on electroencephalography readings after a podcast intervention demonstrated podcasts as noninferior to traditional lectures, with some showing score improvement.[14] However, the literature review reveals a notable gap in assessing learning retention following the implementation of an original curriculum-based podcast.

## METHODS

This prospective cohort study, conducted at a single-center urban teaching hospital, included 54 EM residents and approximately 66 EM attending physicians at this institution. For several years prior to the study, the residency program had used a locally developed written conference summary compiled weekly by chief residents and faculty. Eligibility criteria for participation in this study included all postgraduate year (PGY) 1–3 EM residents and EM attending physicians at the institution. There were no exclusion criteria. The study focused on an educational intervention using a weekly original audio-format EM curriculum-based conference day summary, compared to the standard written format. Our primary outcome measure was the difference in mean weekly postconference quiz scores between the written summary phase and the podcast summary phase, used to evaluate knowledge retention. We also had several secondary outcomes that included the following: learner satisfaction measured through survey responses assessing participant satisfaction with the podcast format compared to the written summaries; podcast engagement tracked by number of downloads per episode and weekly listening data to assess reach and usage patterns; and self-reported impact on clinical application, assessed via open-ended survey responses where residents and faculty described changes in clinical confidence, behavior, or knowledge application related to podcast use.

The standard residency academic conference day format consists of five hours of dedicated lectures and small groups each week, followed by a structured written email summary that has been used for several years at our institution. This summary is compiled by the residents and includes conferences high-yield "pearls," key diagnostic and management take-aways, and links to selected resources, and is distributed to residents and attending physicians later that same evening. The intervention involved creating an audio summary in the form of a podcast based on the written summary, in which one or two hosts discussed the same high-yield points in a conversational style, expanded on illustrative cases, and highlighted practical bedside applications. The podcast did not introduce new curricular content but mirrored and elaborated on the written summary to support spaced repetition. Learning retention was assessed through post-conference assessments at each conference day the following week, in comparison to the standard written summary.

According to a national survey of EM residents, the ideal podcast length was reported to be 11–30 minutes.[2] The podcasts recorded in this study were designed to last 10–20 minutes, featuring one to two speakers discussing material from the prior week for spaced repetition and highlighting conference learning pearls. One speaker remained consistent as the primary or secondary investigator, and the second speaker was a member of the department (attending, fellow, resident, etc). To support implementation, the program

purchased a PodBean Tech Inc hosting plan (approximately $14 per month, excluding tax) and two Zoom Video Conferencing Inc ZDM-2 podcast microphones (approximately $100 each). Across the 12 episodes produced during the full project period (including pilot and study episodes), the direct financial cost was approximately $400–$450. Faculty and resident time for planning, recording, and editing was estimated at 1–1.5 hours per episode (10 minutes, 30 to 60 minutes, 30 minutes, respectively), in addition to time for quiz and email summary preparation. These estimates were collected retrospectively to characterize the resource requirements of the intervention.

Approximately four weeks prior to the study's initiation, all residents received a mixed-methods pre-study survey assessing demographics, study habits, and podcast-related preferences using both quantitative and qualitative items. Surveys were developed by the investigative team, informed by prior literature on podcast use in medical education, and piloted with a small group of residents and faculty for clarity; they were not formally validated instruments. Individual responses were tracked using Research Electronic Data Capture (REDCap) surveys distributed to each participant's institutional email address. This was a self-controlled study in which each resident functioned as their own control. There were no incentives to participate, and participation was not mandatory. The study unfolded in three parts. Part 1 (eight weeks) represented the control condition, during which only the existing written conference summary was provided. Part 2 (eight weeks) represented the intervention condition, during which the written summary was accompanied by a resident-produced podcast summarizing the same content. Part 3 (four weeks) included continued access to both formats and postintervention surveys. Survey data from residents and attending physicians regarding satisfaction and feedback were collected during this third phase of the study. The timing of this survey distribution was intentionally delayed to mitigate potential bias. Prior to the study's start, residents were informed that the postconference assessments would have no impact on their academic records, evaluations, or standing within the residency program.

Our primary outcome was knowledge retention, operationalized as weekly quiz performance comparing the written and podcast phases (Kirkpatrick level 2: learning).[15] Secondary outcomes reflected Kirkpatrick levels 1 and 3 and included learner satisfaction with the podcast, perceived understanding and retention of conference material, and self-reported changes in clinical practice attributed to the intervention.[15]

The study was reviewed by the institutional review board on June 26, 2024 and was determined to be exempt as an educational quality improvement/medical education research project. Participation in quizzes and surveys was voluntary, and completion of these instruments was considered implied consent. All data were de-identified prior to analysis.

**Data Collection Procedures**

REDCap surveys were used to collect prestudy survey data on podcast structure and learning preferences. Google Forms were employed for creating and collecting postconference assessments and poststudy surveys. Open-ended questions in surveys also captured qualitative insights on perceived learning and feelings of knowledge retention or improvement. Surveys were distributed via a QR code during the conference. We also assessed the number of plays of each podcast, listener demographics, and listening trends through PodBean (distributed across most platforms such as Apple Podcasts and Spotify).

**Data Analysis**

Quiz scores were summarized as means and standard deviations for each phase (written-only vs podcast-only) and compared using paired-samples *t* tests with a significance threshold of $P < .05$ (the eight weekly phase means were paired by study week). Likert-scale survey items were summarized using medians and interquartile ranges, and between-group comparisons of ordinal data were performed with nonparametric tests (eg, Wilcoxon rank-sum). Descriptive statistics were used for podcast usage (downloads, platforms, geography). An unbiased external statistician conducted the analysis to ensure impartiality. Open-ended responses from resident and attending postintervention surveys were analyzed using Braun and Clarke's six-step reflexive thematic analysis approach.[16] Two experts (CR, HB) in medical education independently reviewed all responses to generate initial codes. The coding team then met to discuss, refine, and organize codes into candidate themes, iteratively revisiting the data to ensure coherence and representativeness. Discrepancies in coding or theme interpretation were resolved by discussion and consensus. Themes were refined until no new concepts emerged, indicating thematic sufficiency.

## RESULTS

Of the 54 eligible residents, 44 (81%) completed the prestudy survey. Most were PGY 1 or PGY 2 (64%), and 52% identified as female. Prior to the intervention, 91% reported listening to at least one medical podcast per month, and 68% preferred episodes shorter than 20 minutes. Written conference summaries were used "often" or "always" by 57% of respondents, typically for brief review rather than in-depth study. Baseline resident characteristics and pre-study learning preferences are summarized in Table 1.

Weekly quiz scores were collected over eight weeks using a standard written summary and then for eight weeks using the podcast summary. Each weekly quiz consisted of six to eight multiple-choice questions aligned with that week's conference objectives. Questions were authored by the study team (core EM faculty and senior residents) and reviewed by at least one additional EM faculty member for accuracy and clarity. Items targeted application of key diagnostic and management

**Table 1.** Baseline resident characteristics and prestudy learning preferences.

| Eligible Residents | 54 |
|---|---|
| Prestudy survey respondents | 44/54 (81.0%) |
| Most were PGY 1 or PGY 2 | 64.0% |
| Female | 52.0% |
| Listened to at least one medical podcast per month before study | 91.0% |
| Preferred podcast episodes under 20 minutes | 68.0% |
| Used written conference summaries often or always | 57.0% |

*Percentages reflect available pre-study survey data reported in the manuscript
*PGY*, postgraduate.

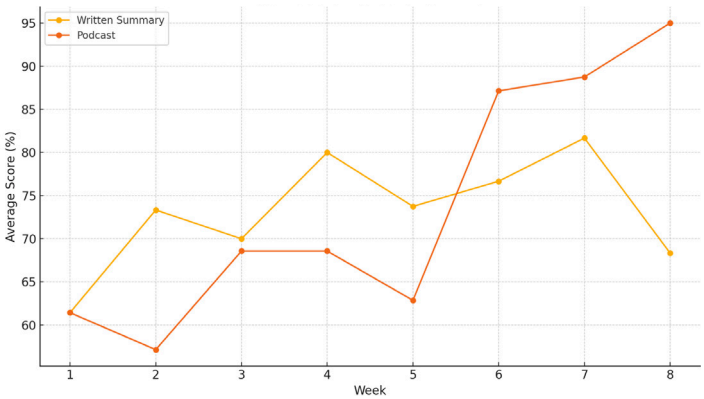


**Figure.** Weekly mean scores during written and podcast phases.

principles rather than simple recall; although not formally validated, the quizzes followed a consistent blueprinting process to ensure parallel structure across weeks. Quiz participation varied over time, with a median of 38.5 residents per week across the full 16-week study period (39.5 during the written-summary phase and 33.0 during the podcast phase). Participation declined later in the academic year, which may have reflected a combination of off-service rotations that limited conference attendance, quiz fatigue because assessments were voluntary and not tied to formal evaluation, and individual decisions not to participate for unknown reasons.

The mean quiz score during the written summary phase was 73.1% (SD 6.6), while the podcast phase yielded a mean score of 73.7% (SD 14.4). There was no statistically significant difference in weekly quiz performance between phases (paired *t* test, $t = -.11$, $P = .92$), indicating that the primary outcome, knowledge retention as measured by quiz scores, did not improve with the podcast intervention compared to the existing written summary approach. An exploratory linear trend analysis suggested a steeper week-to-week improvement during the podcast phase (+5.3% per week vs +1.2% per week for the written phase), but this post hoc finding should be interpreted cautiously and cannot be taken as definitive evidence of superior effectiveness. Figure illustrates the mean weekly quiz scores during the written (control) and podcast (intervention) phases across the study period.

Table 2 illustrates the mean weekly quiz scores during the written (control) and podcast (intervention) phases across the 16-week period.

Postintervention surveys were collected from both resident and attending physicians. Among residents, 81% completed the prestudy survey vs 48% completing the poststudy survey. Among the 26 residents who completed the postintervention survey, 18/26 (69.2%) reported listening to the podcast at least once a month. Self-reported listening frequency was 6/26 (23.1%) at least weekly, 6/26 (23.1%) every two weeks, and 6/26 (23.1%) once a month; 8/26 (30.8%) reported never listening. Resident and attending postintervention survey responses are summarized in Table 3 and Table 4.

We were unable to track individual-level podcast usage, and platform analytics did not distinguish our residents and faculty from external listeners. As a result, we could not determine the proportion of eligible participants who listened to each episode or correlate individual listening behavior with quiz performance. This substantially limits our ability to attribute quantitative outcomes directly to the podcast intervention. Of those who engaged with the podcast, 60% reported improved retention, 50% felt the podcast improved their understanding of conference material, and 70% were moderately to very satisfied with the format. Residents predominantly engaged with the podcast during commutes or while exercising. Preferences for podcast length aligned with national survey data, with 65% of residents preferring episodes under 20 minutes.[2]

Among attending physicians, 66.7% (8/12) reported listening to at least some episodes of the conference-summary podcast, and 83.3% (10/12) reported being satisfied or very satisfied with the podcast as an educational tool. Attendings commonly described the podcast as a useful mechanism to stay aligned with the residency's weekly conference themes and to reinforce high-yield clinical concepts. Some attendings reported that topics discussed in the podcast overlapped with clinical cases on shift and perceived that residents were drawing on conference content in bedside discussions. Representative quotations illustrating this perception are presented in the qualitative themes (Table 5). Open-ended survey responses from both residents and attendings were analyzed using Braun and Clarke's six-step thematic analysis.

During the study period (October 2024–February 2025),

**Table 2.** Weekly quiz scores by study phase.

| Week | Written Summary Mean Score, % | Podcast Summary Mean Score, % |
|---|---|---|
| 1 | 61.4 | 61.4 |
| 2 | 73.3 | 57.1 |
| 3 | 70.0 | 68.6 |
| 4 | 80.0 | 68.6 |
| 5 | 73.8 | 62.9 |
| 6 | 76.7 | 87.1 |
| 7 | 81.7 | 88.8 |
| 8 | 68.3 | 95.0 |

the conference-summary podcast episodes were downloaded a total of 413 times across all platforms. Approximately 50% of downloads occurred via Spotify, 26% via Apple Podcasts, and the remainder through other applications or the embedded web player. Based on PodBean analytics, 86% of downloads originated from the United States, with additional downloads/plays from Brazil, Australia, and Hong Kong. Because the hosting platform did not track user identity or institutional affiliation, we were unable to determine what proportion of downloads represented residents, faculty, or external listeners, nor could we reliably confirm whether episodes were listened to within the week after the conference as intended.

## DISCUSSION

This prospective cohort study evaluated a resident-led podcast intervention in a graduate medical education setting, specifically in EM. While our primary outcome—mean quiz scores between podcast and written summary groups—revealed no statistically significant difference, the upward trend in performance observed during the podcast period suggests a potential benefit to learner engagement and knowledge retention. However, as this trend was explored in post hoc analysis, it must be interpreted with caution and cannot be taken as conclusive evidence of effectiveness. Further studies with prespecified trend analyses are warranted. Importantly, the podcast format aligns with key principles of adult learning theory: spaced repetition; autonomy; and relevance to clinical practice.[8,9]

The sustained and growing engagement with the podcast episodes was demonstrated by a total of 413 downloads and consistent listening trends in this time frame and reinforces the educational value of this intervention. Because we were unable to track who was specifically downloading the podcasts and where those downloads were happening, we can only weakly infer that most podcast downloads in the United States were by our residents and faculty. In EM, where asynchronous, on-demand learning is particularly critical, our findings highlight how a podcast can function as both a primary and reinforcing mode of content delivery. For many residents, revisiting high-yield conference pearls in an accessible, conversational format promoted spaced repetition, reflection, and confidence in applying knowledge during clinical shifts.

Resident feedback revealed that the podcast encouraged engagement during conference and created a platform where learners felt represented. This may have been especially true when their peers were featured as co-hosts. This could be because of the personal connection felt and the familiarity of hearing peers' voices. Faculty respondents echoed similar themes, noting that the podcast helped bridge the gap between academic day learning and bedside application. Implementation required only basic recording equipment, institutional support, and a shared vision. This makes this a low-stakes, high-yield intervention adaptable to diverse educational settings.

Qualitative analysis of open-ended survey responses reinforced several key themes in podcast-based learning. First, reinforcement through repetition emerged as a central benefit. Learners described the podcast as a valuable tool for reviewing and reinforcing core content. This finding aligns with prior research demonstrating that podcasts are an effective medium for spaced repetition and retention of key concepts over time.[1, 13, 17, 18] In particular, students reported that repetition through audio content helped solidify complex material and enhance long-term memory formation.

**Table 3.** Postintervention survey results for residents (n = 26).

| Item (Likert 1–5*) | Residents Responding "Agree" or "Strongly Agree" (≥4), % |
|---|---|
| Listened to the podcast during commute or exercise | 70 |
| Podcast improved understanding of conference material | 50 |
| Podcast improved retention of key concepts | 60 |
| Felt more confident applying concepts from the podcast on shift | 50 |
| Overall satisfaction with the podcast (moderately to very satisfied) | 70 |

*1 = strongly disagree, 5 = strongly agree.

**Table 4.** Attending postintervention survey responses (n = 12).

| Item (Likert 1–5*) | Attending Physicians Responding "Agree" or "Strongly Agree" (≥ 4), % |
|---|---|
| Listened to the podcast regularly | 66.7 |
| Observed residents applying knowledge that overlapped with podcast content on shift | 83.3 |
| Podcast improved engagement with residents around conference topics | 83.3 |
| Overall satisfaction with the podcast (moderately to very satisfied) | 83.3 |

Second, clinical confidence and application were repeatedly cited by participants. Residents noted that engaging with the podcast helped to improve their real-time clinical decision-making and diagnostic acumen. This perception echoes results from prior studies where podcast-based learning contributed to increased self-confidence in applying medical knowledge in clinical settings.[14, 17, 18] It appeared that participants who engaged with podcasts felt more prepared to apply knowledge in practical scenarios, supporting the idea that this format promotes knowledge transfer and clinical relevance.

Third, asynchronous accessibility was frequently identified as a major advantage. Residents appreciated the flexibility of engaging with educational material during commutes or other tasks, which enabled integration of learning into their daily routines. Previous studies suggest that learners favor podcasts because of their portability and accessibility, allowing for just-in-time learning that fits within busy clinical schedules.[5-7] The convenience and mobility of podcasts have been cited as key reasons for their adoption in health professions education, further validating this theme.

Together, these themes support the role of the podcast not only as an educational tool, but also as a vehicle for learner empowerment, reflection, and behavioral change. More broadly, the podcast may have contributed to a cultural shift within the residency program. Even among those who did not listen regularly, the podcast became a recognizable and respected academic product in the department. Its presence reinforced key teaching points, provided structure for longitudinal review, and demonstrated a commitment to educational innovation. This study's model offers a replicable blueprint for programs seeking to enrich learning retention and asynchronous engagement without adding significant burdens to faculty or learners.

Framed within the Kirkpatrick evaluation model, this study provides relatively strong evidence at level 1 (Reaction): Learners and faculty generally reacted positively to the podcast, found it acceptable, and appreciated its accessibility and format. At level 2 (Learning), our primary outcome showed no difference in objective quiz performance knowledge retention between written summaries alone and written summaries plus podcast, indicating that the intervention did not measurably enhance short-term quiz performance. Perceptions of improved understanding and retention should therefore be interpreted as subjective impressions rather than evidence of superior learning. At level 3 (Behavior), some residents and attendings reported that podcast-derived content influenced on-shift discussions or decision-making; however, these data are self-reported and not supported by direct observation or performance metrics. We therefore regard level 3 findings as exploratory and insufficient to claim a demonstrable behavior change.

**Table 5.** Qualitative themes and representative quotations in a study that assessed whether a resident-led, curriculum-based podcast summary improved knowledge retention and learner engagement compared to a standard written summary format.

| Theme | Description | Representative Quotations* |
|---|---|---|
| Reinforcement through repetition | Podcast episodes helped learners revisit and consolidate key conference "pearls" over time. | "Definitely helps reinforce information." (Resident) • "Repetition really helped things stick." (Resident) |
| Clinical confidence and application | Learners reported greater confidence and broader differentials when managing patients on shift. | "It makes me more confident in my decisions." (Resident) • "It helped me expand my differential diagnoses."<br>"I had a resident on shift who referenced something directly from the podcast—we were able to build on it in real time." (Attending) |
| Asynchronous accessibility | The audio format enabled learning during commutes, exercise, or after missed conferences. | "Useful for days I missed conference but still wanted to review." (Resident) • "Easy to listen to on my commute." |

*Quotations paraphrased/de-identified for brevity and anonymity.

This study did not demonstrate an improvement in knowledge retention, our primary outcome, when comparing a resident-run podcast summary with the existing written conference summary. Weekly quiz scores were similar across phases, suggesting that simply adding an audio summary, in the format used here, was not sufficient to achieve a measurable change in performance. First, both conditions provided structured postconference reinforcement, so the written summary itself may already have been an effective tool against which it was difficult for a brief podcast to show incremental benefit. Second, podcast uptake among residents was likely variable and could not be linked to individual quiz performance. Third, episodes were constrained to 10 to 20 minutes and did not include embedded questions or retrieval-practice elements, which may be necessary to translate passive listening into measurable gains. Future interventions could incorporate learner-tracking, interactive features, or targeted support for residents who do not routinely engage with existing written resources to improve the likelihood of detecting a meaningful effect.

## LIMITATIONS

This single-center study may limit generalizability. Listener identity and engagement could not be directly correlated with quiz performance, and the study period may not have captured long-term clinical impact. Initial resident resistance (stemming from perceptions of added responsibility), was mitigated by reframing the podcast as a creative, voluntary contribution. Recruiting consistent faculty contributors also proved challenging due to competing demands and unfamiliarity with podcasting. There was also attrition in resident participation in the poststudy survey. Although 69.2% of resident postintervention respondents reported listening at least once, we could not verify episode-level engagement or link listening behavior to quiz outcomes, and platform analytics could not distinguish resident and faculty downloads from external listeners. Pre- and poststudy survey completion rates differed (81% vs 48% among residents), raising the possibility of response bias, as those more favorable toward the podcast may have been more likely to complete the postintervention survey. We were unable to reliably link individual survey responses, quiz performance, and podcast usage, which limits our ability to correlate engagement with outcomes. In addition, the timing of poststudy survey completion varied, and we did not systematically account for the interval between exposure to specific conference content and survey response, which may have influenced recall. Despite these limitations, the consistent trends in engagement, satisfaction, and perceived learning impact support the feasibility and educational value of residency-run podcast initiatives.

## CONCLUSION

In this mixed-methods, self-controlled study, the addition of a resident-run conference-summary podcast to an existing written summary process did not improve short-term knowledge retention, as measured by weekly postconference quiz scores. Despite this negative primary outcome, learners and faculty reported high levels of satisfaction with the podcast and described it as a convenient, engaging adjunct to the existing curriculum. These findings suggest that, in the context of an already robust written and in-person curriculum, podcast summaries may function more as a learner-preferred adjunct than as a clearly superior modality for improving objective quiz performance.

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# From Stress to Strength: Fostering a Positive Learning Climate to Promote Learning, Performance, and Well-Being

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## INTRODUCTION

The emergency department (ED) can be a challenging context for learners and teachers. Emergency physicians face high rates of burnout and attrition, which impact our ability to teach and learn on shift.[1,2] Anxiety, fear, and uncertainty have been associated with increased diagnostic error among clinicians and impede learning in trainees.[3,4]

In contrast, fostering a positive learning climate offers a number of potential benefits. The broaden-and-build theory posits that when we experience positive emotion, we broaden our mental awareness and we build our capacity for creativity, resilience, and social connection.[5] Tapping into emotion on shift can help residents reflect on new learning goals, and enjoying our shifts can improve patient care.[6-8] For trainees in the ED, positive emotion may also help promote psychological safety, which has been associated with increased patient safety and reduced burnout.[9-10] Positive emotion promotes good health; healthcare professionals who experience awe regularly report less stress and increased well-being.[11] Finally, after a post-pandemic decline in medical students applying to emergency medicine (EM), applicants who chose EM were more likely to have had a positive, early clinical experience in the ED.[12]

The challenges of caring for patients in a complex clinical environment demand systemic solutions, but individual educators have the power to shape the learning experience more than we may realize. Learners notice our enthusiasm for teaching and patient care, reporting that it is one of the hallmarks of an exceptional teacher.[13] The psychology literature presents evidence-based strategies that can promote a positive learning climate on shift to enhance trainee learning, performance, and well-being. Every shift has space to explore and model small practices that help us share the joy of EM.

## 10 TIPS

Consider the following 10 strategies to promote a positive learning climate in the ED:

1. **Connect interpersonally with learners:** Relationships are the foundation of social support and belonging. Many physicians report that these relationships are integral to their happiness at work.[14] Social support from attending supervisors has been shown to help residents recover from difficult cases and medical errors.[15–17] Even during a brief moment of down time between patients, we can ask questions about our learners, and we can share some details about ourselves to reciprocate. Building trust with trainees promotes psychological safety and motivates them to learn.
2. **Draw on emotional contagion.** The ED is a place of heightened emotions, and we absorb the fear, frustration, and grief around us. But the converse is true too. Positive emotions like awe, gratitude, and contentment are also contagious.[18] When we truly enjoy our work, we spread that emotional state with our team, our learners, and our patients. Consider your emotional state on shift and identify moments when you can share your positive emotions with others. Pair your learner with colleagues who display enthusiasm on shift to spread positive energy within the team.
3. **Cultivate flow:** Flow is deep immersion in an activity, the joy of finding rhythm in a task and letting the world fall away.[19] Early studies on flow found that people experience flow more while working rather than in leisure.[20] The clinical environment presents opportunities for flow on every shift, but flow needs the proper balance of challenge and ability. If the challenge exceeds the learner's ability, they experience anxiety instead of flow. As teachers, we can identify challenges that are appropriate for each learner's level, help learners define their goals, and then coach them when they need to troubleshoot. While we cannot force flow to happen, we can cultivate conditions that welcome it.
4. **Engage with play and humor:** The high stakes of our work are not necessarily at odds with having fun. Play emerges in how we relate to our work, and a

playful approach finds ways to make the task at hand more enjoyable. Creating space for play can boost productivity.[21] Appropriate use of humor with teaching can enhance affect, attention, and learning.[22] In the clinical setting, humor can reduce stress in trainees and contribute to camaraderie.[23] This approach must be exercised with caution as negative humor can disengage learners. Create inside jokes with your learners, develop fun traditions for each shift, be willing to laugh at yourself—and you might boost the learning process.

5. **Savor the sacred moments:** Our work is filled with awe. Sacred moments are marked by great meaning, spiritual dimensions, and feelings of peace. Examples include deep listening, comforting an especially vulnerable patient, or guiding a family through end-of-life care. Sacred moments can arise unexpectedly on shift, and noticing sacred moments is associated with lower burnout.[24] We can savor these by taking a few moments to pause, breathe, and be present. Savoring practices may improve well-being and decrease distress.[25] Some researchers have used this practice to nurture creativity and engagement for their learners.[26] On shift, we can name sacred moments when they occur and encourage our learners to savor them before moving on to their next tasks.
6. **Express your appreciation:** When we appreciate our learners, they experience improved confidence, job satisfaction, and professional identity, all of which help them deliver better patient care.[27] Many programs have formal initiatives to recognize residents' outstanding clinical cases.[28] Individual attendings can promote this practice. Most shifts hold opportunities to appreciate the hard work of our trainees. Taking an extra moment to articulate what we genuinely value about our learners can support their learning and well-being. Sharing good saves at resident conference and department meetings can foster a culture of appreciation at the program level as well.
7. **Stimulate the senses.** Our senses are a portal to relief during stressful moments on shift. Music therapy has been linked to emotional regulation and stress relief in the workplace.[29] Touch interventions have been shown to reduce cortisol levels.[30] On shift, this may look like putting on a warm jacket or placing a hand on the heart.[31] Aromatherapy and the taste of comfort foods are also associated with stress relief.[32,33] Pausing to smell a cup of coffee before taking a sip, eating a favorite snack, or playing fun music can improve our mood, making us more present for patient care and teaching. We can role model these practices for learners and invite them to reconnect with their senses too.
8. **Take a break:** Short breaks help us reset while also boosting performance.[34,35] Taking a break can improve attention and performance on challenging tasks, without hurting efficiency or patient safety.[36,37] Sunlight exposure correlates with improved mental health for healthcare workers; therefore, a microbreak to step outside provides both cognitive and physiological benefits.[38] Taking a break is a learned skill but one we can practice ourselves and model for our learners.[39]
9. **Learn from positive deviance.** Positive deviance is an asset-based approach that recognizes creative, sometimes unexpected approaches to difficult circumstances.[40] Positive deviance invites us to notice what others do well and to use positive outliers as a roadmap for our own future behavior. Learning through positive deviance has been shown to improve clinical performance of medical students and well-being of residents.[41,42] On shift, we can highlight successful cases that we may take for granted with the same attention that we pay to cases that did not turn out so well. Case-based error review is a standard part of the residency curriculum, but we can also examine cases with good outcomes using a similar rigor to learn from positive deviance as well.
10. **Practice self-compassion.** Medical training can encourage self-criticism and harsh self-talk. Sometimes this feels like the only way we can improve. Self-compassion offers an alternate approach to personal development.[43,44] Self-compassion has three dimensions: self-kindness; shared humanity; and mindfulness.[44] Teachers who practice self-compassion have been found to support their learners' autonomy more than teachers who do not practice self-compassion.[45] When we show ourselves the compassion that we give to our patients and our learners, we create more internal space to care and teach.

## DISCUSSION AND LIMITATIONS

*"I always believed that students should enjoy learning" bell hooks*[46]

Every shift in the ED is different. Competing clinical responsibilities and frequent interruptions can detract from the space and energy needed for the strategies mentioned above. But promoting a positive learning climate does not need to be grand or time-consuming; instead, clinicians can make small choices that turn toward joy and connection when opportunities arise. Rather than attempting all these strategies at once, we recommend implementing one practice that might work well with your clinical environment and your learner on each shift. While every shift may not be good, there is good in every shift. Educators must also be realistic; while they can cultivate a positive learning climate, learners ultimately control their own emotional state.

We recognize that the clinical learning environment is subject to forces beyond the individual educator's control. Many of the challenges that learners and educators face on shift require systemic solutions beyond these strategies. The clinical learning environment is shaped by the institution, and creating truly positive learning climates requires significant support from the hospital system and may even require a departmental or institutional culture shift.

**Table.** Ten tips to promote a positive learning climate in the emergency department.

| Strategy: | Why this strategy works: | How this strategy might look in practice: |
|---|---|---|
| Connect interpersonally with learners | Social support builds trust, promotes psychological safety, and motivates learners. | Ask residents about their lives or interests outside of medicine and share a few personal details of your own. |
| Draw on emotional contagion | Positive emotions like enthusiasm, gratitude, and awe can easily spread to those around us. | Consider your emotional state on shift and identify moments when you can share your enthusiasm or gratitude with your team. |
| Cultivate flow | The flow state is deep immersion in an activity where one loses track of time. For learners to experience flow, the challenge must match their ability. | Encourage learners to identify their learning goals, assign them to patients that are appropriate for their skill level, and coach them as challenges arise. |
| Engage with play and humor | A playful approach makes tasks enjoyable, enhances attention, and boosts productivity. | Create inside jokes with your learners, develop fun traditions for each shift, and be willing to laugh at yourself. |
| Savor the sacred moments | Reflecting on and sharing sacred moments, such as providing comfort to a patient or guiding a family through end-of-life care, can foster feelings of peace. | Identify and share sacred moments as they occur to help trainees recognize them. Savor them before moving on to the next task. |
| Express your appreciation | When learners feel appreciated, they report improved confidence, job satisfaction, and professional identity–which all enhance patient care. | Articulate moments that you truly appreciate your learner during a shift. Share “good saves” with program leadership and at resident conference. |
| Stimulate the senses | Engaging different senses promotes stress relief during shift. | Pause to smell the coffee before taking a sip, eat a favorite snack, or play a favorite tune during shift—and encourage your learners to do the same. |
| Take a break | Taking a short break can improve attention, boost performance, and improve mental health. This is not intuitive for most learners, and we must model it for them. | Step outside for a few moments to get fresh air and sunlight. Encourage your learner to take a break during shift as well. |
| Learn from positive deviance | Noticing what others do well can improve our clinical performance. | Highlight and review successful cases with the same attention that you pay to cases that did not turn out so well. |
| Practice self-compassion | Self-compassionate teachers promote learner autonomy. Self-compassion creates more internal space to care and learn. | During difficult moments on shift, model self-kindness, mindfulness, or shared humanity instead of self-criticism. |

While the positive-psychology literature suggests strategies that may be easily implemented into our ED workflow, limited empirical evidence exists regarding their effectiveness in clinical practice. Future research should examine how these practices can promote learning, well-being, and performance for emergency physicians.

## CONCLUSION

Cultivating a positive learning climate on shift in the ED can foster learning, enhance performance, and nurture well-being for both educators and learners. We describe multiple strategies from the positive- psychology literature that clinical educators can add to their educational repertoires. Naming these practices encourages broader dissemination of their use, greater experimentation, and future studies of their impact. Emotion is an important component of medical education. Collating these 10 strategies is a starting point to consider how we can all promote a positive learning climate.

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# Low-Energy Chest Trauma in Older Adults: Prospective Study of Indications for Chest Computed Tomography

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**Introduction:** Older adults frequently present to the emergency department (ED) with low-energy blunt chest trauma, and clinically important intrathoracic injuries may be under-detected during the initial evaluation. We aimed to evaluate whether bedside findings—particularly focal chest tenderness patterns (including anterior chest wall tenderness [ACWT] and lateral compression tenderness)—were associated with computed tomography (CT)-confirmed intrathoracic injury in older adults with low-energy blunt chest trauma, while also examining chest pain and early warning scores (EWS) as adjunct clinical variables.

**Methods:** A single-center prospective study included 136 patients 65 years or older presenting within 24 hours of low-energy blunt trauma that did not meet prespecified high-energy criteria. The primary outcome was any intrathoracic pathology on chest CT during the index ED visit. Secondary analyses examined associations between CT-confirmed injury and bedside findings (including chest pain, ACWT, lateral compression tenderness, thoracic spine tenderness, visible chest skin trauma, and auscultatory abnormalities), routine clinical variables, and laboratory measures; rib fracture and disposition were treated as prespecified exploratory analyses. The National Early Warning Score and Modified Early Warning Score were evaluated as exploratory physiologic comparators. Routine laboratory testing at presentation included arterial blood gas analysis. Chest CT performed during the index ED visit served as the imaging reference standard, with intravenous contrast use determined by clinical indication. The National Emergency X-Radiography Utilization Study (NEXUS) chest criteria informed routine imaging selection. Logistic regression identified independent associations, and diagnostic performance metrics were calculated for key bedside tenderness findings.

**Results:** For 136 studied patients, mean age was 78.9 (9.2) years, and 60.3% of patients were female. Ground-level falls accounted for 72.8% of injuries. Chest pain was reported in 19.9% of patients. Lateral compression tenderness (21.3%) and ACWT (25.0%) were the most common examination findings. On univariable analysis, chest pain and lateral compression tenderness were associated with intrathoracic pathology; in multivariable analysis, ACWT was the only independent bedside predictor of the primary outcome (adjusted odds ratio [OR] 4.18, 95% CI, 1.85–9.44; $P < .001$). For rib fracture, ACWT, chest pain, and lateral compression tenderness remained independently associated. For intrathoracic injury, ACWT had a sensitivity of 47.6% (95% CI, 32.0–63.6), specificity of 85.1% (95% CI, 76.3–91.6), positive predictive value of 58.8% (95% CI, 44.5–71.8), negative predictive value of 78.4% (95% CI, 72.9–83.1), a positive likelihood ratio of 3.2 (95% CI, 1.79–5.70), and a negative likelihood ratio of 0.62 (95% CI, 0.46–0.83), supporting its role as a rule-in bedside cue. Lateral compression tenderness was also associated with intrathoracic injury (OR 3.81, 95% CI, 1.62–8.94; $P = .002$).

**Conclusion:** In older adults with low-energy blunt chest trauma, focal chest tenderness findings—especially anterior chest wall tenderness, lateral compression tenderness, and chest pain—were associated with higher odds of CT-confirmed thoracic injury; however, ACWT was the only independent bedside predictor of the primary outcome. These findings function as rule-in rather than rule-out cues. Early warning scores showed limited utility for anatomic injury detection in this cohort and should not be interpreted as trauma-specific imaging decision tools. [West J Emerg Med. 2026;27(5)1263–1270.]

## INTRODUCTION

Older adults frequently present to the emergency department (ED) with low-energy blunt chest trauma, most commonly due to ground-level falls.[1,2] Although many appear clinically stable, intrathoracic injuries—including rib fractures, small pneumothoraces or hemothoraces, and early pulmonary contusions—are often underdetected on initial radiographs.[3,4] Even apparently minor injuries can carry disproportionate morbidity in the context of frailty and reduced physiological reserve.[5-7] These challenges highlight the tension between avoiding missed injuries and minimizing unnecessary imaging, radiation exposure, and downstream resource use.[3,4]

Several decision frameworks provide structured approaches to initial imaging.[8] However, most were developed in general adult populations and may not be calibrated to the risk profiles of older adults with low-energy mechanisms.[8] Age-related changes in pain perception, chest wall compliance, and vital-sign responses can alter the clinical expression of injury, potentially modifying the predictive value of bedside examination findings and physiological indices in this group.[9,10] Furthermore, frailty and reduced physiologic reserve may blunt symptom reporting and physiologic responses, underscoring the importance of simple, reproducible bedside signs.[5-7]

Among bedside cues, anterior chest wall tenderness (ACWT) is an immediately available finding that plausibly correlates with underlying thoracic injury.[9,10] However, geriatric-specific evidence quantifying its diagnostic accuracy—and comparing its performance with other routine clinical data—remains limited.[9,10] In parallel, early-warning scores such as the National Early Warning Score (NEWS) and Modified Early Warning Score (MEWS) were designed to detect global clinical deterioration rather than specific anatomical injury, and their utility in identifying intrathoracic injury after low-energy trauma in older adults remains uncertain.[11,12]

Accordingly, we aimed to evaluate whether bedside findings—particularly focal chest tenderness findings, including ACWT and lateral compression tenderness—were associated with computed tomography (CT)-confirmed intrathoracic injury in older adults with low-energy blunt chest trauma. Secondary objectives were to explore associations with rib fracture and clinical disposition. We prespecified ACWT as the primary bedside variable of interest, while also evaluating lateral compression tenderness and chest pain as additional clinically relevant findings. We examined NEWS and MEWS as exploratory physiologic variables.

*Population Health Research Capsule*

What do we already know about this issue?
*In older adults with apparently minor blunt chest trauma, clinically important thoracic injuries may be missed on initial assessment.*

What was the research question?
*Do bedside findings—especially anterior chest-wall tenderness—predict computed tomography (CT)-confirmed intrathoracic injury?*

What was the major finding of the study?
*Anterior chest wall tenderness independently predicted injury (aOR 4.18, 95% CI, 1.85–9.44; P < .001).*

How does this improve population health?
*A simple bedside tenderness finding may help identify higher risk older adults who warrant selective chest CT and closer evaluation.*

## METHODS

### Study Design and Setting

We conducted this prospective, single-center study in a tertiary ED. Of patients 65 years of age and older presenting within 24 hours after low-energy blunt trauma, 136 were eligible for inclusion. (Figure). Written informed consent was obtained from all participants. The study protocol was approved by the Ankara University Ethics Committee (Decision No. i06-430-24; June 13, 2024).

### Participants

Consecutive adults 65 years of age and older presenting within 24 hours of low-energy blunt chest trauma were screened. Inclusion criteria included age 65 and older, blunt chest trauma from low-energy mechanisms that did not meet prespecified high-energy thresholds, and presentation within 24 hours. Exclusion criteria (*a priori*) were high-energy mechanisms (eg, motor vehicle collision ≥40 mph [64 km/hour], fall >2 m), penetrating trauma, multisystem major trauma requiring immediate operative or intensive care unit (ICU) resuscitation, transfer after prior imaging/management, inability to provide consent, or advanced cognitive impairment precluding study procedures without a surrogate. Screening logs were maintained.

### Variables and Data Collection

At triage and initial clinician assessment, we prospectively recorded demographics, comorbidities (including Charlson Comorbidity Index [CCI]), medications (antiplatelets/anticoagulants), mechanism of injury, symptoms (including chest pain and dyspnea), physical

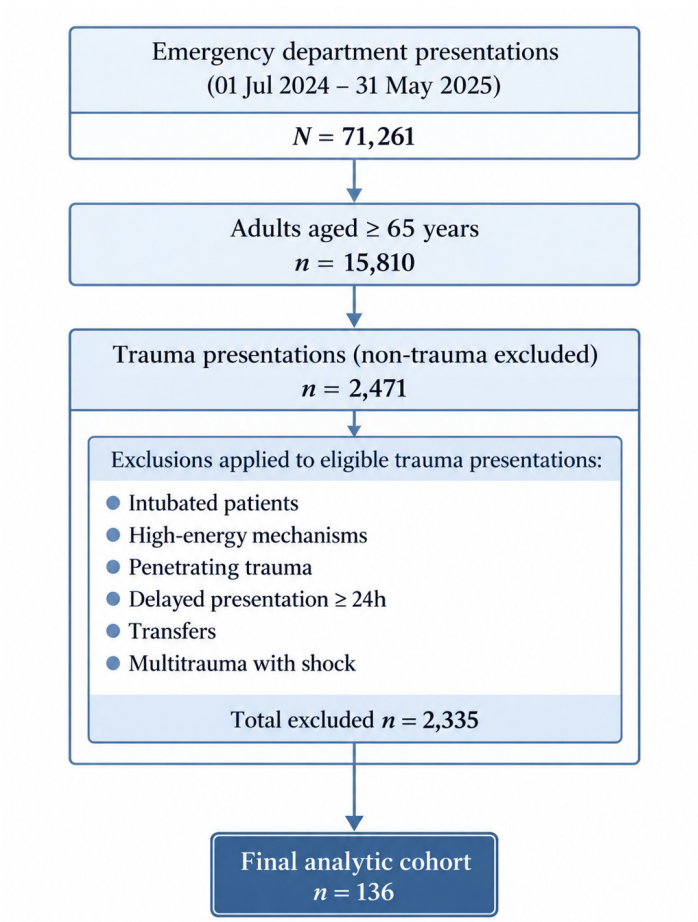


**Figure.** Study flow and cohort selection in a prospective single-center study of older adults (≥ 65 years) presenting to the emergency department within 24 hours of low-energy blunt chest trauma.
*h*, hours.

examination findings (including ACWT, lateral compression tenderness, thoracic spine tenderness, visible chest skin trauma, chest wall deformity, and auscultatory abnormalities), and vital signs. After calculating the EWSs from the first complete set of vital signs (NEWS and MEWS), they were analyzed as exploratory physiologic comparators. Routine laboratory testing at presentation included complete blood count, electrolytes, renal function, serum lactate, and arterial blood gas analysis.

Data capture followed routine clinical workflow: Treating clinicians documented variables contemporaneously at the bedside using a structured form; and research staff performed periodic completeness checks before database lock. We prespecified variable definitions and coding rules to minimize misclassification and support reproducibility. Only patients with complete data for prespecified study variables were included in the final analytic cohort; no imputation was performed for missing values.

### Imaging Strategy and Reference Standard

Imaging followed standard ED practice, informed by decision frameworks (eg, National Emergency X-Radiography Utilization Study [NEXUS] chest criteria), clinician judgment, and shared decision-making. Chest CT performed during the index visit served as the imaging reference standard for outcome ascertainment, with intravenous contrast use determined by clinical indication at the discretion of the treating team. Although NEXUS chest criteria informed routine imaging selection, it was not evaluated as a reference standard. Injury subtypes included rib fracture, pneumothorax, hemothorax, pulmonary contusion, and other clinically relevant thoracic injuries predefined in the protocol.

### Outcomes

The primary outcome was the presence of any intrathoracic pathology on chest CT during the index ED visit (pneumothorax, hemothorax, rib fracture, vascular injury, sternal fracture, diaphragmatic rupture, or pulmonary contusion). Secondary analyses examined associations between CT-confirmed intrathoracic pathology and bedside findings (history and physical examination, including chest pain, ACWT, lateral compression tenderness, thoracic spine tenderness, visible chest skin trauma, and auscultatory abnormalities), vital signs, laboratory results, and EWSs. Rib fracture and clinical disposition (ED discharge, ward admission, or ICU admission) were treated as prespecified exploratory analyses, and in hospital mortality was recorded descriptively.

### Sample Size Considerations

Given limited prior evidence, we calculated the sample size for multivariable logistic regression targeting detection of intrathoracic injury. Age was modeled as a continuous predictor, accounting for correlation among covariates ($R^2 \approx 0.17$). With $\alpha = .05$, 80% power, and events-per-variable principles applied, the required sample size was $n = 136$, which was achieved.

### Statistical Analysis

We summarized continuous variables as mean (standard deviation) or median (interquartile range), depending on distribution (assessed with the Shapiro–Wilk test). We presented categorical variables as counts and percentages. Between-group comparisons used $\chi^2$ or Fisher exact tests for categorical data, Student *t* tests for normally distributed continuous data, and the Mann–Whitney *U* test for nonnormal or ordinal data. When more than two groups were compared, we applied analysis of variance or Kruskal–Wallis.

To identify independent associations, we fitted multivariable logistic regression models for the primary endpoint of any intrathoracic pathology on CT and, as a prespecified exploratory subtype analysis, for rib fractures because they were the most frequent specific injury; other individual injury subtypes were not modeled separately because event counts were insufficient for stable multivariable

estimation. Candidate covariates were prespecified on clinical grounds and/or showed evidence of association in univariable analyses. Adjusted odds ratios (aOR) with 95% confidence intervals were reported. We assessed multicollinearity using variance inflation factors. Statistical significance was set at $P < .05$ (two-sided). For ACWT, we additionally calculated sensitivity, specificity, positive likelihood ratio (LR+), and negative likelihood ratio (LR−) to characterize diagnostic performance.

## RESULTS

### Cohort and Presentation

Among 136 patients, 60.3% were female, with a mean (SD) age of 78.9 (9.2) years. Approximately half of the cohort had a high comorbidity burden by CCI category. The most common comorbidities were coronary artery disease (30.9%) and diabetes mellitus (28.7%; Table 1). All injuries were low energy, most frequently due to ground-level falls (72.8%).

On examination, the most common findings were ACWT (25.0%) and lateral compression tenderness (21.3%); no chest wall deformity was observed. A complete panel of physical-examination findings—including thoracic spine tenderness, visible chest skin trauma, chest wall deformity, and auscultatory abnormalities—was documented so that focal tenderness findings could be interpreted within the context of the full examination panel. Early warning scores at presentation were predominantly low risk. The distribution of CT-confirmed intrathoracic injuries is presented in Table 2.

**Table 1.** Baseline demographic, clinical, and comorbidity characteristics of a prospective cohort of older adults (≥ 65 years) presenting to the emergency department within 24 hours in a study evaluating whether bedside findings of low-energy blunt chest trauma were associated with computed tomography-confirmed intrathoracic injury.

| Variable | *n* (%) or mean (SD) |
|---|---|
| Age, years | 78.9 (9.2) |
| Sex | |
| Male | 54 (39.7) |
| Female | 82 (60.3) |
| Charlson Comorbidity Index category | |
| Low | 11 (8.1) |
| Intermediate | 57 (41.9) |
| High | 68 (50.0) |
| Chronic medical conditions | |
| Chronic pulmonary disease | 11 (8.1) |
| Coronary artery disease | 42 (30.9) |
| Congestive heart failure | 16 (11.8) |
| Cerebrovascular disease | 14 (10.3) |
| Diabetes mellitus | 39 (28.7) |
| Antiplatelet use | 37 (27.2) |
| Anticoagulant use | 40 (29.4) |
| Symptoms at presentation | |
| Chest pain | 27 (19.9) |
| Dyspnea | 15 (11.0) |

Data are n (%) unless otherwise indicated. Age is presented as mean (SD).
*SD*, standard deviation.

### Laboratory Findings and Vital Signs

Vital signs, EWSs, and arterial blood gas parameters did not materially distinguish patients with and without intrathoracic injury.

### Predictors of Intrathoracic Pathology

On univariable analysis, chest pain (OR 3.83, 95% CI, 1.60–9.19; $P = .003$), ACWT (OR 4.18, 95% CI, 1.85–9.44; $P < .001$), and lateral chest-wall compression tenderness (OR 3.81, 95% CI, 1.62–8.94; $P = .002$) were associated with CT-confirmed intrathoracic injury (Table 3). In multivariable modeling, ACWT was the only independent bedside predictor of the primary outcome. Detailed univariable odds ratios with 95% confidence intervals and *P* values are presented in Table 3.

### Predictors of Rib Fracture

For rib fracture, ACWT (OR 5.20, 95% CI, 2.27–11.92; $P < .001$), chest pain (OR 4.64, 95% CI, 1.92–11.25; $P < .001$), and lateral compression tenderness (OR 4.65, 95% CI, 1.96–11.03; $P < .001$) were associated with CT-confirmed rib fracture on univariable analysis (Table 4).

### Diagnostic Performance

For intrathoracic injury, ACWT demonstrated modest sensitivity but useful specificity and a positive likelihood ratio,

**Table 2.** Distribution of computed tomography–confirmed intrathoracic injuries during the index emergency department visit in a prospective cohort of older adults with low-energy blunt chest trauma.

| Injury | *N* = 136<br>*n* (%) |
|---|---|
| Pneumothorax | 2 (1.4) |
| Hemothorax | 9 (6.6) |
| Rib fracture | 42 (30.8) |
| Vascular injury | 0 (0) |
| Sternal fracture | 0 (0) |
| Diaphragmatic rupture | 0 (0) |
| Pulmonary confusion | 12 (8.8) |

Data are expressed as number (percentage) unless otherwise indicated. All injuries were confirmed by computed tomography.

**Table 3.** Univariable logistic regression analyses examining associations between patient characteristics, bedside clinical findings, vital signs, arterial blood gas parameters, and routine laboratory values and the presence of any computed tomography–confirmed intrathoracic injury in older adults with low-energy blunt chest trauma.

| Variable | OR (95% CI) | *P* value |
|---|---|---|
| Sex (male) | 1.19 (0.57-2.47) | .640 |
| Age | 1.03 (0.99-1.07) | .175 |
| Charlson Comorbidity Index categories | | .741 |
| Low | Reference | - |
| Intermediate | 1.23 (0.29-5.19) | .777 |
| High | 1.55 (0.38-6.38) | .544 |
| Chest pain | 3.83 (1.60 -9.19) | **.003*** |
| Dyspnea | 2.50 (0.84-7.38) | .098 |
| Visible chest skin trauma | 0.54 (0.11-2.71) | .453 |
| Anterior chest wall tenderness on palpation | 4.18 (1.85-9.44) | **<.001*** |
| Tenderness on compression of the lateral chest wall | 3.81 (1.62 -8.94) | **.002*** |
| Tenderness over the thoracic vertebrae | 0.86 (0.25-2.95) | .807 |
| Abnormal auscultation findings | 2.02 (0.39-10.45) | .400 |
| pH | 0.77 (0.34-1.75) | .538 |
| $PaO_2$ (mm Hg) | 0.77 (0.34-1.73) | .531 |
| $PaCO_2$ (mm. Hg) | 0.73 (0.35-1.49) | .383 |
| Lactate (mmol/L) | 0.69 (0.28-1.71) | .425 |
| Base excess (mmol/L) | 0.98 (0.31-3.04) | .966 |

Note: Bold indicates statistical significance.
*mm Hg*, millimeters of mercury; mmol/L, millimoles per liter; *OR*, odds ratio; *pH*, potential of hydrogen; *$PaO_2$*, arterial partial pressure of oxygen; *$PaCO_2$*, arterial partial pressure of carbon dioxide.

supporting its role as a rule-in bedside cue rather than a stand-alone screening test. Lateral compression tenderness showed a similar directional association and may provide additional bedside support for suspicion of injury, particularly rib fracture. Thoracic spine tenderness, visible chest skin trauma, and abnormal auscultation did not discriminate injury. Detailed diagnostic performance estimates are presented in Table 5. Physical-examination findings, mechanism of injury, EWS categories, and oxygen support status are summarized in Table 6.

### Disposition and Downstream Care

Disposition reflected overall clinician judgment and downstream care needs rather than a prespecified thoracic-trauma admission rule; some patients were discharged from the ED, while others required ward admission, and a smaller subset required ICU care. In hospital mortality was rare. In adjusted analyses, serum lactate was associated with hospital admission; however, this should be interpreted cautiously because admission was not prospectively classified using prespecified thoracic-trauma criteria.

## DISCUSSION

### Principal Findings

In older adults with low-energy blunt chest trauma, ACWT was the only bedside finding independently associated with CT-confirmed intrathoracic injury and was strongly predictive of rib fracture. Sensitivity was modest, indicating that the absence of tenderness does not reliably exclude injury. However, the corresponding specificity and positive likelihood ratio support ACWT as a useful rule-in cue when clinical concern persists. Early warning scores at presentation showed limited discriminatory value for detecting intrathoracic injury. Serum lactate was associated with hospital admission; however, this association should be interpreted cautiously because admission was a heterogeneous, nonstandardized outcome.

**Table 4.** Univariable logistic regression analyses examining associations between patient characteristics, bedside clinical findings, physiological variables, and routine laboratory measures and computed tomography–confirmed rib fracture among older adults with low-energy blunt chest trauma.

| Variable | OR (95% CI) | *P* value |
|---|---|---|
| Sex (male) | 1.10 (0.52-2.33) | .798 |
| Age | 1.01 (0.97-1.05) | .522 |
| Charlson Comorbidity Index categories | | .920 |
| Low | Reference | - |
| Intermediate | 1.13 (0.27-4.80) | .865 |
| High | 1.27 (0.31-5.28) | .737 |
| Chest pain | 4.64 (1.92-11.25) | **< .001*** |
| Dyspnea | 2.92 (0.98-8.70) | .053 |
| Visible chest skin trauma | 0.62 (0.12-3.13) | .564 |
| Anterior chest-wall tenderness to palpation | 5.20 (2.27-11.91) | **< .001*** |
| Tenderness on lateral compression | 4.65 (1.96-11.03) | **< .001*** |
| Thoracic-spine tenderness | 0.99 (0.30-3.43) | .993 |
| Abnormal auscultation | 2.33 (0.45-12.07) | .312 |
| pH | 0.64 (0.27-1.52) | .314 |
| $PaO_2$ (mm Hg) | 0.91 (0.40-2.10) | .830 |
| $PaCO_2$ (mm Hg) | 0.65 (0.31-1.35) | .248 |
| Lactate (mmol/L) | 0.82 (0.33-2.03) | .665 |
| Base excess (mmol/L) | 1.14 (0.36-3.55) | .828 |

Note: Bold indicates statistical significance.
*mm Hg*, millimeters of mercury; mmol/L, millimoles per liter; *OR*, odds ratio; *pH*, potential of hydrogen; *$PaO_2$*, partial pressure of oxygen; *$PaCO_2$*, partial pressure of carbon dioxide.

**Table 5.** Diagnostic performance of anterior chest-wall tenderness for computed tomography–confirmed intrathoracic injury in a prospective cohort of older adults with low-energy blunt chest trauma.

| Measure | Estimate (95% CI) |
|---|---|
| Sensitivity | 47.6% (32.0–63.6) |
| Specificity | 85.1% (76.3–91.6) |
| Positive predictive value | 58.8% (44.5–71.8) |
| Negative predictive value | 78.4% (72.9–83.1) |
| Positive likelihood ratio | 3.2 (1.79–5.70) |
| Negative likelihood ratio | 0.62 (0.46–0.83) |

Diagnostic performance metrics are presented with 95% confidence intervals.

### Comparison with Previous Studies

Prior studies in older adults with low-energy trauma have shown that bedside examination alone has limited diagnostic yield for thoracic injury, a pattern reproduced in this cohort.[9,10] In a retrospective cohort of older adults with low-energy blunt trauma, Kania et al reported that physical examination findings had limited diagnostic utility for injury prediction.[10] In contrast, our prospective design captured predefined bedside findings and evaluated their association with CT-confirmed intrathoracic injury in a focused low-energy cohort undergoing chest CT. The findings also align with evidence that CT detects injuries frequently missed on radiography, including rib fractures, small pneumothoraces, hemothoraces, and early pulmonary contusions.[3,4]

In a multicenter prospective cohort of 5,912 patients with blunt chest trauma who underwent both chest radiography and chest CT, Langdorf et al reported that chest CT identified occult thoracic injuries in 71% of injured patients and in approximately one-quarter of all patients with blunt chest trauma, and that more than one third of these occult injuries prompted an intervention.[13] Although that cohort included patients of all ages and mixed mechanisms, our study focuses on older adults with low-energy trauma, a narrower clinical setting in which selective CT decisions may be particularly challenging.[13] Within this setting, focal tenderness findings remained clinically relevant: ACWT was the only independent bedside predictor of CT-confirmed intrathoracic injury, whereas lateral compression tenderness and chest pain were also associated with injury and remained independently associated with rib fracture. By contrast, EWSs were not designed to detect anatomic injury and did not provide useful discrimination in this cohort.[11,12]

We did not formally compare our findings with established rib-fracture severity or thoracic trauma scoring systems, because these tools are generally used for prognostication or disposition after established injury rather than for initial prediction of CT-confirmed injury; this remains an important area for future comparative study.

### Interpretation and Clinical Implications

Frailty, polypharmacy, and cognitive impairment in this population can blunt symptom reporting and physiological responses, increasing the relevance of simple, reproducible bedside signs.[5-7] In practice, focal tenderness findings—especially ACWT and lateral compression tenderness—may support a lower threshold for chest CT when interpreted alongside chest pain and the overall clinical picture. However, these findings should be treated as rule-in rather than rule-out cues, and their absence should not be used to exclude injury. In this cohort, NEWS and MEWS showed limited discriminatory value and should not be used in isolation as a trigger for chest imaging.[11,12]

These data support further study of geriatric-specific refinement of existing decision frameworks, particularly regarding how focal tenderness findings might be incorporated; external validation and impact evaluation are required before implementation.

### Operational Considerations

If externally validated, a selective CT approach informed by focused bedside assessment could be feasible to implement through standardized palpation for ACWT and lateral compression tenderness, consistent documentation of associated findings (including chest pain), and selective CT use when overall clinical concern remains elevated. A short checklist or electronic prompt may improve consistency of documentation, although the impact of such strategies remains untested.

### External Validity

Although conducted at a single center, the core elements of our study findings—mechanism, symptoms, focused palpation, and selective CT—are broadly applicable and likely generalizable to diverse ED settings. Case mix (eg, frailty and anticoagulant use) may alter absolute risks, but the use of concrete bedside cues to inform imaging decisions is expected to persist.

## STRENGTHS AND LIMITATIONS

Strengths include prospective enrollment, capture of a complete physical-examination panel, and use of chest CT as the reference standard. Limitations include the single-center setting, modest sample size, and limited precision for uncommon injuries. We also did not prospectively classify admissions by formal thoracic-trauma admission criteria, which limits interpretation of the disposition analysis. In addition, we did not formally compare our findings with established chest-trauma or rib-fracture scoring systems. Laboratory associations were exploratory and should not be interpreted as clinically definitive.

### Future Directions

Multicenter studies should externally validate these findings, quantify the independent contribution of ACWT, and

**Table 6.** Physical examination findings, mechanism of injury, National Early Warning Score, Modified Early Warning Score, and oxygen support status stratified by the presence or absence of computed tomography–confirmed intrathoracic injury in a prospective cohort of older adults with low-energy blunt chest trauma.

| Variable | n | Injury: Yes, *n* (%) | Injury: No, *n* (%) | *P* value |
|---|---|---|---|---|
| Physical examination finding | | | | |
| Visible chest skin trauma | 9 | 2 (22.2%) | 7 (77.8%) | .718 |
| Visible chest-wall deformity | 0 | 0 (0%) | 0 (0%) | - |
| Anterior chest-wall tenderness (on palpation) | 34 | 20 (58.8%) | 14 (41.2%) | < .001* |
| Lateral chest-wall compression tenderness | 29 | 17 (58.6%) | 12 (41.4%) | < .001* |
| Thoracic vertebral tenderness | 13 | 4 (30.8%) | 9 (69.2%) | 1.0 |
| Abnormal auscultation | 6 | 3 (50%) | 3 (50%) | .406 |
| Mechanism of trauma | | | | |
| Motor vehicle collision | 11 | 1 (9.1%) | 10 (90.9%) | |
| Motorcycle crash | 3 | 1 (33.3%) | 2 (66.7%) | |
| Pedestrian injury | 2 | 1 (50%) | 1 (50%) | |
| Same-level fall | 99 | 37 (37.4%) | 62 (62.6%) | |
| Other falls | 19 | 5 (26.3%) | 14 (73.7%) | |
| Blunt object injury | 2 | 1 (50%) | 1 (50%) | |
| NEWS score | | | | |
| Low-Intermediate risk | 132 | 46 (34.8%) | 86 (65.2%) | .300 |
| High risk | 4 | 0 (0%) | 4 (100%) | .300 |
| MEWS score | | | | |
| Low risk | 136 | 46 (33.8%) | 90 (66.2%) | NA |
| High risk | 0 | NA | NA | NA |
| $O_2$ support | 5 | 1 (20%) | 4 (80%) | .662 |

*MEWS,* Modified Early Warning Score; *NEWS,* National Early Warning Score; $O_2$, oxygen.

examine geriatric-specific calibration of existing decision frameworks. Comparative evaluations of selective, cue-informed CT strategies versus usual care should address missed-injury risk, downstream use, radiation exposure, time to diagnosis, and patient-centered outcomes.

Incorporating frailty measures and targeted physiologic variables may refine future models; however, any role for lactate in disposition assessment should be considered exploratory, especially because admissions were not prospectively categorized by formal thoracic-trauma criteria. Future research should also compare focal tenderness findings with established thoracic-trauma scoring systems in older adults.

## CONCLUSION

In older adults with low-energy blunt chest trauma, focal chest tenderness findings—especially ACWT, lateral compression tenderness, and chest pain—were associated with higher odds of CT-confirmed thoracic injury; however, anterior chest wall tenderness was the only independent bedside predictor of the primary outcome. These findings function as rule-in rather than rule-out cues, and their absence does not reliably exclude injury. When clinical concern persists, selective CT remains warranted. In this setting, early warning scores were not useful for anatomic injury detection, and laboratory- and disposition-related associations should be interpreted cautiously.

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# Rural-Urban Parity and Socioeconomic Gaps in Traumatic Brain Injury Outcomes

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**Background**: Traumatic brain injury (TBI) is a leading cause of death and disability in the United States. Rural residence and low community income are independently associated with poorer health outcomes, mediated by variations in injury mechanism and healthcare access. We evaluated the impact of geographic location on injury patterns and acute-care metrics in adults with TBI treated at Maryland's statewide Level I trauma center.

**Methods**: Adults (≥18 years of age) with radiographically confirmed TBI admitted between 2017 and 2021 were identified retrospectively from the institutional trauma registry. Rural residence was defined using Rural-Urban Commuting Area codes. This single-center study included only patients surviving to hospital admission. Primary outcomes included hospital length of stay (LOS) and discharge to hospice or death. Secondary outcomes included intensive care unit (ICU) and ventilator days and discharge disposition.

**Results**: Of 2,812 patients diagnosed with TBI during the study period, 267 (9.5%) resided in rural areas. Compared with nonrural patients, rural patients were older (median age 67 vs 60 years, $P < .001$) and lived in lower income communities. However, after adjustment for demographic and clinical covariates, rural residence was not associated with higher hospital LOS quartile category (adjusted odds ratio [aOR] 1.18; 95% CI, 0.91-1.53; $P = .20$), discharge to hospice or death (aOR 1.67; 95% CI, 0.95-2.94), or discharge to a nonhome setting (aOR 0.93; 95% CI, 0.66-1.31). Groups showed no significant differences in critical care use, including ICU and ventilator durations. Worse outcomes were associated primarily with injury severity, including lower Glasgow Coma Scale scores and higher Injury Severity Scores.

**Conclusion**: In a well-established regional trauma network, we found that among patients admitted with traumatic brain injury, residing in a rural area was not independently associated with worse in-hospital outcomes compared to patients who resided in nonrural (urban and suburban) communities. These findings suggest that a coordinated statewide trauma triage and access to tertiary neurotrauma care may help other systems similarly reduce rural disparities after severe head injury. [West J Emerg Med. 2026;27(5)1271–1279.]

## INTRODUCTION

Traumatic brain injury (TBI) accounts for millions of US emergency department visits annually and contributed to approximately 69,473 deaths in 2021 alone.[1] Growing evidence suggests that a patient's geographical location and socioeconomic status (SES) can substantially influence TBI outcomes.[2] Rural residents sustain proportionally more high-velocity mechanism injuries (eg, motor vehicle collisions) and often experience longer prehospital times and limited geographical access to Level I trauma centers.[3,4] Urban patients tend to be older, experience more fall-related injuries, and live in closer proximity to specialty care.[5] A recent systematic review of approximately 2.5 million patients found that patients who resided in rural areas had 28% higher odds of severe TBI (defined by Glasgow Coma Scale [GCS] ≤ 8) and were less likely to achieve optimal functional recovery compared to their urban counterparts.[5] Some studies also report higher TBI mortality in rural areas, potentially related to longer transport distances and fewer healthcare resources.[6,7]

Despite these disparities, the literature remains mixed. Several studies suggest that once rural patients reach tertiary centers within a well-organized trauma network, their outcomes may be similar to those of urban patients.[8,9] This raises the possibility that coordinated trauma system organization, such as standardized statewide triage protocols, rapid interfacility transfer pathways, and helicopter emergency medical services (HEMS) may mitigate rural disadvantages after severe injury.

To address these gaps, our study examined the association between rural residence, adult TBI injury patterns, hospital course, and discharge outcomes among adults with TBI treated at Maryland's statewide referral Level I trauma center. Because outcomes at a tertiary center are influenced by referral bias (thus capturing patients who survive initial injury and are triaged to high-level care), we sought to evaluate whether a regionalized model of coordinated field triage and HEMS is associated with rural-urban parity in hospital metrics, such as hospital length of stay (LOS), intensive care unit (ICU) use, ventilator use, and discharge disposition.

*Population Health Research Capsule*

What do we already know about this issue?
*Rural residents suffer from disproportionately higher traumatic brain injury (TBI) mortality rates due to prolonged transport times and limited local resources.*

What was the research question?
*Does an integrated regional trauma network eliminate rural-urban disparities in acute TBI outcomes?*

What was the major finding of the study?
*Rurality was not significantly associated with a higher length-of-stay quartile (adjusted odds ratio 1.18; 95% CI, 0.91-1.53; P = .20).*

How does this improve population health?
*Centralized neurotrauma hubs paired with coordinated regional field triage and aeromedical systems can potentially overcome rural-urban disparities.*

## METHODS

### Study Design and Setting

We performed a retrospective observational study of adult patients (≥18 years) treated for TBI at a statewide referral Level I trauma center. This study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The facility is an integrated, free-standing trauma center that serves as the state's Primary Adult Resource Center.[10] Field triage is coordinated through the Maryland Institute for EMS Systems, which uses unified triage criteria to transport severely injured patients. Direct process measures, such as individual helicopter flight times and scene-triage intervals, were not available in the registry and are addressed as a study limitation.

The study was approved by the institutional review board with a waiver of informed consent owing to its retrospective design.

### Maryland's Social Geography

Maryland is a small, topographically diverse state anchored by two major urban hubs (Baltimore and the Washington, DC, metropolitan area), and extensive rural or medically underserved pockets—the Eastern Shore across the Chesapeake Bay, the Appalachian panhandle in the far west, and numerous lower density counties between the urban corridors (Figure 1). These rural counties typically have lower median household incomes and higher rates of Health Professional Shortage Areas (HPSA) than the state average. The Shock Trauma Center catchment area includes both densely populated urban ZIP codes and dispersed rural communities with limited local trauma resources.

### Patient Identification

We queried the institution's prospectively maintained trauma registry, which captures more than 95% of admissions. We included patients admitted between January 1, 2017, and 31 December 31, 2021, with an isolated traumatic brain injury—defined as a head Abbreviated Injury Scale (AIS) score ≥ 3 and an AIS score. ≤ 2 in every other body region. Intracranial pathology was radiographically confirmed and

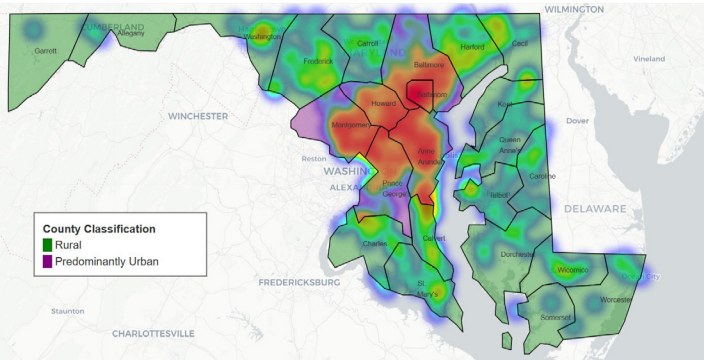


**Figure 1**. Patient density heatmap of the state of Maryland by rurality and home ZIP code in a study of traumatic brain injury outcomes at a regional Level I trauma center.

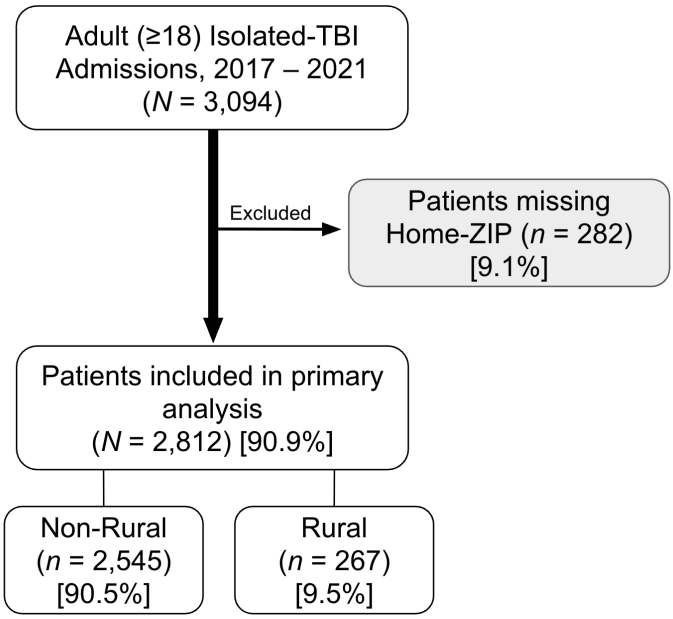


**Figure 2**. Flow diagram for patient selection in a study of traumatic brain injury outcomes at a regional Level I trauma center.
*TBI*, traumatic brain injury.

included subdural hematoma, epidural hematoma, and traumatic subarachnoid hemorrhage. We excluded records lacking a residential ZIP code (9.1%) because rurality depends on that field. We analyzed these excluded records and found no significant demographic differences compared to the included cohort, suggesting that missingness was at random rather than tied to factors such as homelessness; the final analytic cohort consisted of 2,812 patients (Figure 2).

### Variables and Data Sources

Data abstraction followed Worster and Bledsoe's guidelines. To ensure data quality, two trained abstractors independently reviewed a 10% random sample of records, achieving an interrater reliability ($\kappa$ = .92); any discrepancies were resolved by a third senior adjudicator. Direct process measures, such as individual helicopter flight times and scene-triage intervals, were not available in the registry and are addressed as a study limitation.[11]

### Rurality

We mapped home ZIP codes to counties and census tracts and classified "rural" according to the definition established by the Federal. Office of Rural Health Policy of the US Health Resources and Services Administration (HRSA). Under this definition, a location is rural if it meets any of the following criteria: (1) the county is nonmetropolitan; (2) the census tract lies in a metropolitan county but carries a Rural-Urban Commuting Area (RUCA) code 4-10; or (3) the tract is at least 400 square miles, a population density of 35 or fewer persons per square mile and has a RUCA code 2-3. All other ZIP codes were classified as nonrural based on the Maryland Rural-Urban Classification. We excluded patients with unknown ZIP codes in sensitivity analyses.

### Medically Underserved Areas

The HRSA database was queried by patient home address to identify HPSA and Medically Underserved Areas (MUA).[12] ZIP codes falling within a Maryland Health Enterprise Zone (MHEZ), which are census tracts designated as medically underserved by the Maryland Department of Health, were flagged to explore overlap between rurality, SES, and healthcare access.

### Outcomes

Hospital LOS, which is a patient-centered measure of morbidity and resource use that allows comparison across trauma populations, was designated a priori as the primary outcome and informed our sample-size calculation. Secondary outcomes examined both injury patterns and clinical courses. We compared (1) the distribution of intracranial injury types (subdural hematoma [SDH], subarachnoid hematoma [SAH], and epidural hematoma [EDH]; (2) initial injury severity by admission GCS score; (3) use of neurosurgical interventions (eg, craniotomy, craniectomy, external-ventricular–drain placement); (4) intensive-care metrics (ICU LOS and ventilator days); and (5) hospital discharge disposition (eg, home, short-term acute posthospital care, long-term subacute rehabilitation, death/hospice). Each outcome was analyzed uniformly across both independent variables: rurality; and community-income bracket.

### Sample Size Calculation

We based our sample size calculation for the primary outcome of hospital LOS according to Yue et al.[13] Their study reported a median hospital LOS for patients with TBI as three days (interquartile range [IQR] 2-8) or a mean of four days

(SD 2). Assuming a hospital LOS difference of one day between rural versus urban population, we calculated a sample size of 63 patients per group, or 126 total patients, to achieve a power of 80%, with statistical significance set at α = .05. While this analytical target was met for the primary outcome, the substantial baseline imbalance between the nonrural (*n* = 2,545) and rural (*n* = 267) cohorts inherently restricts the statistical power available for secondary clinical endpoints.

### Statistical Analysis

We conducted all statistical analyses using Minitab Statistical Software (Minitab, LLC, State College, PA). We used descriptive statistics to summarize patient characteristics by rurality, MHEZ, MUA, and HPSA status. Continuous variables were summarized as medians with IQR, and categorical variables as frequencies and percentages. Group comparisons were conducted using two-sample *t* tests or Mann-Whitney *U* tests for continuous variables and chi-square or Fisher exact tests for categorical variables, as appropriate.

Binary logistic regression models were then used to assess associations between independent variables and two binary outcomes: (1) discharge to death or hospice versus all other dispositions; and (2) discharge to a location other than home versus discharge home. An ordinal logistic regression was used to evaluate the primary outcome of LOS, which was categorized into quartiles: 0 = first quartile (≤ 1.07 days); 1 = second quartile (1.08-3.58 days); 2 = third quartile (3.59-8.84 days); and 3 = fourth quartile (> 8.84 days). All regression models were adjusted for demographic, clinical, and geographic covariates, including age, comorbidities, Injury Severity Score (ISS), rurality indicators, and ZIP code-level socioeconomic characteristics (Table 3). Variable inclusion was guided by clinical relevance and bivariate associations. Model outputs are provided in supplementary Appendices A-C.

**Table 3.** List of all variables used in the multivariable logistic and multivariable ordinal regressions in a study of traumatic brain injury outcomes at a regional Level I trauma center.

| Continuous variables | Categorical variables |
|---|---|
| Age | Sex |
| White blood cell count | Past medical history of hypertension |
| Mean arterial pressure | Past medical history of diabetes |
| Minute in trauma resuscitation unit | Past medical history of liver disease |
| Injury Severity Score | Past medical history of kidney disease |
| Trauma and Injury Severity Score | Past medical history of heart disease |
| GCS | Past medical history of neurological disease |
| ZIP code median income | Past medical history of drug/alcohol use |
| | Medical History of Past Surgeries |
| | Bacteremia |
| | Subdural Hematoma |
| | Subarachnoid Hemorrhage |
| | Epidural Hematoma |
| | Edema |
| | Race |
| | CT of Head |
| | Health Professional Shortage Area (HPSA) |
| | Medically Underserved Areas (MUA) |
| | Maryland Health Enterprise Zones (MHEZ) |
| | Rural Status |

*CT*, computed tomography; *GCS*, Glasgow Coma Scale.

## RESULTS

### Patient Characteristics

Between 2017 and 2021, 2,812 adults with isolated TBI were admitted, originating from diverse geographic areas of Maryland (Figure 1). Two-thirds were male, and the overall median age was 60 years. Only 267 patients (9.5 %) resided in rural ZIP codes. Rural patients were older (median 67 versus 60 years of age) and came from markedly lower-income communities (median annual ZIP code income: $71,600 vs $92,500) compared with nonrural peers; they were also more likely to be White (80 % vs 60 %) (Table 1).

### Injury Patterns

Subdural hematoma was the most common traumatic brain lesion, present in approximately 67% of all patients. The distribution of SDH and the need for neurosurgical procedures (craniotomy, craniectomy, external ventricular drain) did not significantly differ between rural and nonrural patients (all *P* > .20, Table 2).

### Hospital Course and Outcomes - Rural versus Nonrural

Unadjusted outcomes were largely equivalent (Table 2). Median hospital LOS was 3.6 days (1.1-9.0) for nonrural patients, and 3.3 days (0.84-7.8) for rural patients (*P* = .19). Use of ICU was similar, although rural patients had slightly longer total ICU time (median 0 [0-2.7] days versus 0 [0-3.3] days; *P* = .58) and comparable days spent on mechanical ventilation (0 days [0-2] for both groups, and *P* = .93). In-hospital mortality or hospice discharge trended higher among rural patients (15% versus 11%, *P* = .07) but did not reach significance (Table 2).

### Multivariable Analyses

After adjusting for demographics, comorbidities, and injury severity, rural residence was not associated with longer LOS (adjusted odds ratio [aOR] = 1.18; 95% CI, 0.91-1.53; *P*

**Table 1.** Rural versus nonrural baseline characteristics in a study of traumatic brain injury outcomes at a regional Level I trauma center.

| Variables | All Patients (*N* = 2,812) | Rurality | | | | |
|---|---|---|---|---|---|---|
| | | Nonrural (*n* = 2,545) | Rural (*n* = 267) | Diff | 95% CI | *P* |
| Demographics | | | | | | |
| Female (%) | 900 (32) | 808 (32) | 92 (34) | -0.03 | -0.09 to 0.03 | .38 |
| Male (%) | 1,911 (68) | 1,736 (68) | 175 (66) | 0.03 | -0.03 to 0.09 | .38 |
| Age, median [IQR] | 60.5 [40-77] | 60 [40-77] | 67 [47-81] | -5 | -7 to -2 | < .001 |
| Median household income [$] | 89,398 [61,572-112, 065] | 92,527 [61,572-114, 409] | 71,629 [59,135-87, 611] | 15,036 | 11,421-19,229 | < .001 |
| Race / Ethnicity (%) | | | | | | |
| White | 1,731 (62) | 1,518 (60) | 213 (80) | -0.2 | -0.25 to -0.15 | < .001 |
| Black | 842 (30) | 797 (31) | 45 (17) | 0.14 | 0.10-0.19 | < .001 |
| Asian | 59 (2) | 58 (2) | 1 (0.3) | 0.02 | 0.01-0.03 | .04 |
| Native Hawaiian / Pacific Isl. | 4 (0.1) | 4 (0.2) | 0 (0) | 0.002 | 0.0-0.003 | > .99 |
| American Indian / Alaskan Native | 6 (0.2) | 6 (0.2) | 0 (0) | 0.002 | 0.0004-0.004 | > .99 |
| Other / ≥2 races | 133 (5) | 126 (5) | 7 (3) | 0.02 | 0.002-0.04 | .03 |
| Comorbidities (%) | | | | | | |
| Hypertension | 1,298 (46) | 1,180 (46) | 118 (44) | 0.02 | -0.04 to 0.08 | .50 |
| Diabetes | 469 (17) | 429 (17) | 40 (15) | 0.02 | -0.03 to 0.06 | .42 |
| Liver disease | 125 (4) | 109 (4) | 16 (6) | -0.02 | -0.05 to 0.01 | .26 |
| Cardiac disease | 504 (18) | 454 (18) | 50 (19) | -0.01 | -0.06 to 0.04 | .72 |
| Kidney disease | 97 (3) | 91 (4) | 6 (2) | 0.01 | -0.006 to 0.03 | .37 |
| Neurological disorder | 744 (26) | 674 (26) | 70 (26) | 0.003 | -0.05 to 0.06 | .93 |
| Alcohol / drug use | 246 (9) | 217 (9) | 29 (11) | -0.02 | -0.06 to 0.02 | .24 |
| Prior surgery | 1,017 (36) | 923 (36) | 94 (35) | 0.01 | -0.05 to 0.07 | .73 |
| Top 5 Injury Mechanisms (%) | | | | | | |
| Fall | 1,777 (63) | 1,615 (63) | 162 (61) | 0.03 | -0.03 to 0.09 | .37 |
| ATV accident | 398 (14) | 354 (14) | 44 (16) | -0.03 | -0.07 to 0.02 | .28 |
| Assault | 329 (12) | 293 (12) | 36 (13) | -0.02 | -0.06 to 0.02 | .37 |
| Pedestrian accident | 101 (4) | 95 (4) | 6 (2) | 0.01 | -0.004 to 0.03 | .13 |
| Inanimate mechanical force | 63 (2) | 54 (2) | 9 (3) | -0.01 | -0.03 to 0.01 | .27 |

*ATV*, all-terrain vehicle; *Diff*, unadjusted absolute difference between the two comparison groups; *IQR*, interquartile range.

= .20), discharge to a non-home setting (aOR = 0.93; 95% CI, 0.66-1.31; *P* = .66), or death/hospice (aOR = 1.67; 95% CI, 0.95-2.94; *P* = .04) (Appendices A-C). In the multivariable ordinal logistic regression, diabetes (aOR = 1.33; 95% CI, 1.09-1.64; *P* = .01) and cerebral edema (aOR = 1.33; 95% CI, 1.01-1.76; *P* = .04), were associated with increased odds of belonging to a higher LOS quartile (Appendix A).

For discharge to death or hospice, significant associated factors included hypertension (aOR = 1.95; 95% CI, 1.30-2.90; *P* < .001); cardiac disease (aOR = 3.14; 95% CI, 2.11-4.70; *P* < .001)' SAH (aOR, 1.99; 95% CI, 1.39-2.85; *P* < .001); and cerebral edema (aOR = 1.74; 95% CI, 1.07-2.82; *P* = .03). Higher Injury Severity Score (ISS) (aOR = 1.07 per point; 95% CI, 1.04-1.10; *P* < .001) and lower admission GCS (aOR = 0.80; 95% CI, 0.77-0.84; *P* < .001) were also strongly associated with increased odds of death/hospice disposition (Appendix B).

For nonhome discharge, significant covariates included hypertension (aOR = 2.12; 95% CI, 1.72-2.63; *P* < .001); cardiac disease (aOR = 1.82; 95% CI, 1.40-2.36; *P* < .001); neurological disease (aOR = 1.52; 95% CI, 1.23-1.89; *P* < .001); bacteremia (aOR = 6.16; 95% CI, 2.50-15.19; *P* < .001); SDH (aOR = 1.27; 95% CI, 1.02-1.59; *P* = .03); SAH (aOR = 1.67; 95% CI, 1.37-2.04; *P* < .001); and cerebral edema (aOR = 1.58; 95% CI, 1.07-2.34; *P* = .02). Epidural hematoma was associated with lower odds of nonhome

**Table 2.** Clinical course and outcomes comparing rural versus nonrural patients in a study of traumatic brain injury outcomes at a regional Level I trauma center.

| | All Patients (*N* = 2,812) | Rurality | | | | |
|---|---|---|---|---|---|---|
| | | Nonrural (*n* = 2,545) | Rural (*n* = 267) | Diff | 95% CI | *P* |
| Injury (%) | | | | | | |
| Subdural hematoma | 1,885 (67) | 1,703 (67) | 182 (68) | -0.01 | -0.07 to 0.05 | .67 |
| Subarachnoid hemorrhage | 1,251 (44) | 1,134 (44) | 117 (44) | 0.007 | -0.05 to 0.07 | .82 |
| Epidural hematoma | 289 (10) | 267 (10) | 22 (8) | 0.02 | -0.01 to 0.06 | .21 |
| Edema | 239 (8) | 210 (8) | 29 (11) | -0.03 | -0.06 to 0.01 | .19 |
| Bacteremia | 88 (3) | 83 (3) | 5 (2) | 0.01 | -0.004 to 0.03 | .12 |
| Clinical Variables [IQR] | | | | | | |
| Length of stay (days) | 3.6 [1.1-8.8] | 3.6 [1.1-9.0] | 3.3 [0.84-7.8] | 0.21 | -0.10 to 0.61 | .19 |
| Ventilator days | 0 [0-2] | 0 [0-2] | 0 [0-2] | 0 | 0-0 | .93 |
| TRU minutes | 451 [281-765] | 451 [283-771] | 444 [255-700] | 23.5 | -16.7 to 64.4 | .25 |
| Total ICU Days | 0 [0-3.3] | 0 [0-3.3] | 0 [0-2.7] | 0 | 0-0 | .58 |
| Glasgow Coma Scale | 14 [11-15] | 14 [11-15] | 14 [9-15] | 0 | 0-0 | .54 |
| PTA GCS | 13 [7-15] | 13 [7-15] | 13 [7-14] | 0 | 0-1 | .17 |
| Injury Severity Score | 17 [10-25] | 17 [10-25] | 16 [10-25] | 0 | 0-0 | .50 |
| TRISS | 0.95 [0.88-0.98] | 0.95 [0.88-0.98] | 0.95 [0.87-0.98] | 0 | -0.002 to 0.005 | .68 |
| White Blood Cell Count (×1000 counts/μL) | 9.9 [7.5-13.4] | 9.9 [7.4-13.4] | 10.4 [7.8-13.2] | -0.2 | -0.7 to 0.3 | .47 |
| Admission SBP | 145 [130-169] | 145 [130-170] | 144 [129-166] | 2 | -2 to 5 | .30 |
| Admission DBP | 84 [74-94] | 84 [73-94] | 84 [73-94] | 0 | -2 to 3 | .65 |
| Procedures | | | | | | |
| Craniotomy | 118 (4) | 110 (4) | 8 (3) | 0.01 | -0.009 to 0.04 | .24 |
| Craniectomy | 17 (0.6) | 17 (0.6) | 0 (0) | 0.007 | 0.004-0.01 | .39 |
| Burr hole | 6 (0.2) | 4 (0.2) | 2 (0.7) | -0.006 | -0.02 to 0.004 | .10 |
| Cranioplasty | 12 (0.4) | 11 (0.4) | 1 (0.4) | 0.001 | -0.007 to 0.008 | > .99 |
| External ventricular drain | 65 (2) | 55 (2) | 10 (4) | -0.02 | -0.04 to 0.008 | .19 |
| CT Head | 2,546 (90) | 2,313 (91) | 233 (87) | 0.04 | -0.005 to 0.08 | .09 |
| Radiograph of Head | 13 (0.5) | 12 (0.5) | 1 (0.4) | 0.001 | -0.007 to 0.008 | > .99 |
| Discharge Disposition | | | | | | |
| Death / Hospice | 319 (11) | 279 (11) | 40 (15) | -0.04 | -0.08 to 0.004 | .07 |
| Nonhome | 1,420 (50) | 1,290 (51) | 130 (49) | 0.02 | -0.04 to 0.08 | .54 |
| Home | 1,357 (48) | 1,225 (48) | 132 (49) | -0.01 | -0.08 to 0.05 | .68 |
| Short-term acute posthospital care* | 683 (24) | 628 (25) | 55 (20) | 0.04 | -0.01 to 0.09 | .12 |
| Long-term subacute care** | 415 (15) | 380 (15) | 35 (13) | 0.02 | -0.02 to 0.06 | .40 |

*Short-term acute post-hospital care includes those discharged to acute care, inpatient units, inpatient rehabilitation facilities.
**Long-term subacute care includes those discharged to psychiatric facilities, residential facilities, specialty referral centers, subacute rehabilitation facilities.
*CT*, computed tomography; *DBP*, diastolic blood pressure; *Diff*, unadjusted absolute difference between the two comparison groups; *ICU*, intensive care unit; *IQR*, interquartile range; *PTA GCS*, pretransfer or prehospital Glasgow Coma Scale; *TRISS*, Trauma and Injury Severity Score; *SBP*, systolic blood pressure; *TRU*, trauma resuscitation unit.

discharge (aOR = 0.56; 95% CI, 0.40-0.80; $P < .001$). Higher ISS (aOR = 1.07 per point; 95% CI, 1.05-1.08; $P < .001$) and lower admission GCS (aOR = 0.77; 95% CI, 0.74-0.80; $P < .001$) also remained strongly associated with nonhome discharge (Appendix C).

Supplemental analyses examining HPSA, MUA, and MHEZ designations demonstrated substantial demographic and socioeconomic differences across groups but generally similar

short-term hospital outcomes (Supplementary Appendices D-F). Patients residing in MUAs demonstrated greater acute-care use, including longer trauma resuscitation unit times (466 versus 432 minutes, $P < .001$); increased ICU use (median, 0 [0-4.4] versus 0 [0-2.5] ICU days; $P = .03$); and higher craniotomy rates (5% versus 3%; $P = .02$), despite similar LOS and discharge disposition outcomes (Appendix D). Subgroup analyses of HPSA and MHEZ similarly showed minimal differences in major in-hospital outcomes (Appendix E, F).

Overall, within Maryland's coordinated trauma network, rural patients who survived to tertiary neurotrauma admission experienced care processes and short-term outcomes comparable to urban peers, despite older age and lower community income levels. Panels detailing MHEZ and MUA subanalyses are provided in the supplementary Appendices D-F.

## DISCUSSION

### Principal Findings

In a five-year, statewide cohort of 2,812 adults with isolated TBI, rural residence (9.5% of cases) was not associated with longer hospital or ICU stays, greater ventilator use, or increased odds of death or hospital discharge after adjustment. Rural patients were older and came from lower-income ZIP codes, yet their acute outcomes mirrored urban peers.

### Rural-Urban Parity: Potential Impact of an Inclusive Trauma System

In contrast to national trends, there were no significant rural-urban disparities in acute TBI outcomes. This finding is noteworthy given that, across the US, rural residents face substantially higher TBI-related mortality rates than their urban counterparts (27.5 versus 17.4 per 100,000 in 2017), with an estimated 23% higher fatality risk.[14] Prior studies attribute this rural disadvantage to longer prehospital transport times, limited access to trauma centers, and delays in definitive care[6,15]; each five-mile increase in distance from a trauma center increases odds of death by approximately 8%.[16]

We also examined whether differences in the type or severity of intracranial injury might account for rural-urban variation in presentation.[17] The distribution of SDH, SAH, and EPH, was nearly identical between rural and nonrural patients (all $P > .05$), and both median ISS and admission/pretransfer GCS were comparable (Table 2). These findings suggest that neurologic status at presentation is unlikely to be driven by systematically different injury patterns and may instead reflect other prehospital factors (eg, time from injury to intubation, hypotension, hypoxia) or baseline comorbidities.

Several features of Maryland's trauma system may have contributed to the absence of observed rural-urban differences in admitted patients. First, the statewide helicopter-based network operated by the Maryland Institute for EMS Systems[18] provides rapid scene or interfacility transport from any county to the Shock Trauma Center (Appendix G), or another designated trauma hospital, typically within the "golden hour."[19] This publicly funded HEMS program integrates first response through tertiary care, ensuring equitable access across the state. Second, direct admission to a high-volume Level I trauma center with 24/7 neurosurgical coverage standardizes definitive care.[20] Similar patterns have been reported elsewhere: when rural patients are air-lifted directly to Level I facilities, survival approximates (or exceeds) that of urban ground-transport patients.[21]

In our cohort, these system-level features appear to have neutralized geography-driven disadvantages, echoing smaller single-center reports that once rural patients reach a high-level facility, outcomes converge with urban norms, emphasizing the value of rapid aeromedical transport and centralized expertise.[22] Maryland's coordinated model—statewide HEMS, mandated field triage, and a single adult Level I hub (illustrated in Figure 3)—transports severely injured patients within 30 minutes and may serve as a model for other states seeking to eliminate rural-urban disparities in trauma outcomes.

In our cohort, where acute care protocols were uniform, these disparities likely stem from upstream factors such as community-level injury mechanisms, comorbidities, preinjury health, and downstream determinants such as access to rehabilitation and postacute navigation. Trauma systems alone cannot erase such gradients; community-level prevention, insurance expansion, and postacute navigation programs are needed.

### Implications for Rural Health Equity

1. System design matters. A coordinated statewide trauma network may substantially reduce in-hospital rural disparities after severe injury. States with large rural catchments may benefit from coordinated trauma-system elements, including publicly funded HEMS, standardized statewide EMS triage protocols, and designated neurotrauma hubs (Figure 3).
2. Equity requires dual focus. However, ensuring geographic access alone is unlikely to eliminate broader disparities in recovery. Community-level prevention, rehabilitation access, insurance coverage, and postacute care navigation likely remain important determinants of long-term rural TBI outcomes.

## LIMITATIONS

This retrospective, single-center study may not generalize to regions without Maryland's dense, publicly funded helicopter-based trauma network. Because the state is geographically compact and uses a unified state-operated aeromedical fleet, our findings likely represent a best-case rural scenario. Larger states, or those relying on fragmented, privatized EMS models, may face different logistical barriers. Analyses ended at hospital discharge; functional recovery,

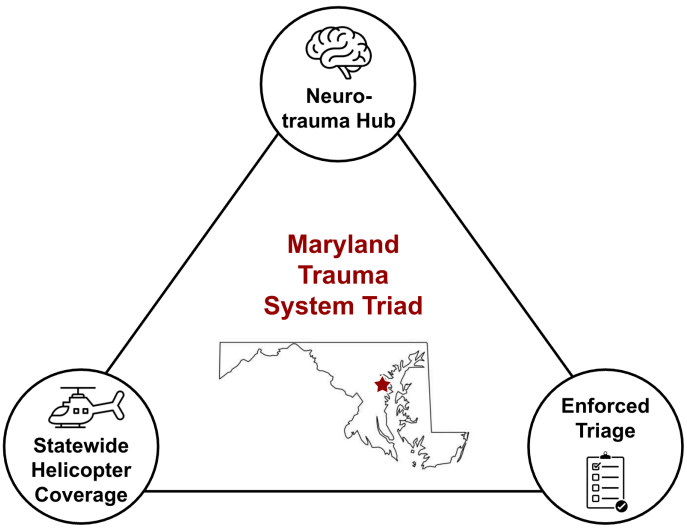


**Figure 3.** Maryland trauma system triad: neurotrauma hub; statewide helicopter coverage; and enforced field triage in a study of traumatic brain injury outcomes at a regional Level I trauma center. The three cornerstones of the Maryland's integrated trauma network are depicted as a hub-and-spoke triangle. The red star marks the location of the R. Adams Cowley Shock Trauma Center in Baltimore, the state's sole adult Level I trauma hub.

rehabilitation access, and long-term mortality were unavailable. Additionally, there are residual confounding variables—such as triage patterns, transport times, helicopter use, and transfer pathways inherent to retrospective studies—that may persist despite adjustment and influence outcomes.

Our study is constrained by a nearly 10-fold disparity in patient volume between cohorts (nonrural $n$ = 2,545 vs rural $n$ = 267). While the sample size was sufficient to demonstrate that statistical power was fully met for our primary metric (hospital LOS), this severe numerical imbalance leaves the study underpowered to detect subtle differences in low-incidence secondary endpoints. Specifically, these "rare outcomes" include low-frequency clinical complications and specialized surgical interventions, such as craniectomies ($n$ = 0 in the rural cohort), cranioplasties ($n$ = 1), or postinjury bacteremia ($n$ = 5), where absolute event counts are too minimal to draw definitive comparison conclusions. Furthermore, our database omits prehospital deaths, which could still disproportionately disadvantage remote communities. Similar tertiary hospital-level parity has been reported only sporadically (eg, in Saskatoon, Canada, where authors noted that excluding prehospital deaths may partly erase a rural gap).[22] Nevertheless, demonstrating parity among admitted patients provides a realistic benchmark for other regions aiming to close rural gaps through system design.

Additionally, our trauma registry output provided continuous critical care durations rather than categorical admission flags, preventing the calculation of the exact percentage of patients admitted to the ICU or requiring mechanical ventilation. Because our cohort included a high volume of mild-to-moderate TBIs (median admission GCS 14) that did not require critical care, the overall median for ICU and ventilator days was skewed to zero, limiting our ability to analyze critical care use as a binary outcome.

### Future Directions

Multicenter studies that integrate prehospital metrics, granular SES data, and long-term outcomes are needed to confirm whether the hospital-level parity observed here persists across diverse settings and throughout the continuum of recovery. Future work should replicate these findings in larger, more geographically diverse settings; quantify prehospital mortality to confirm complete rural equity; and test interventions (eg, targeted prevention campaigns in low-income communities and postacute navigation services) aimed at narrowing SES-related gaps.

## CONCLUSION

In this statewide cohort of adults with traumatic brain injury treated within a centralized Level I trauma system, rural residence was not independently associated with worse short-term in-hospital outcomes despite older age and lower community income among rural patients. These findings suggest that coordinated statewide trauma organization, including rapid aeromedical transport, standardized triage pathways, and centralized neurotrauma care, may help mitigate rural disparities once patients successfully access tertiary treatment. However, persistent differences in prehospital access, rehabilitation availability, and broader social determinants of health likely continue to influence long-term rural TBI outcomes beyond the acute hospitalization period.

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# Clinical and Financial Value of Cardiac Point-of-Care Ultrasound During Traumatic Cardiac Arrest

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**Introduction:** Traumatic cardiac arrest is associated with poor survival and significant consumption of hospital resources. Determining which patients have survivable injuries allows for judicious use of resources. Our aim was to determine whether cardiac activity on point-of-care ultrasound (POCUS) during traumatic cardiac arrest was associated with increased patient survival and the charges of continued resuscitation in patients that do have cardiac activity on POCUS.

**Methods:** We conducted this single-center retrospective study at an urban, Level I trauma center of consecutive patients arriving in traumatic cardiac arrest from August 2016–December 2023 who had a cardiac POCUS performed during the initial resuscitation efforts. Our primary outcome was to determine whether cardiac activity on POCUS during the arrest was associated with increased patient survival to neurologically intact hospital discharge. Secondary objectives included determining whether there was a correlation between cardiac activity on POCUS during traumatic cardiac arrest and survival to hospital admission. Additionally, we evaluated hospital charges and length of stay associated with continued resuscitation in patients who demonstrated cardiac activity on ultrasound.

**Results:** We identified 134 patients in traumatic cardiac arrest, of whom 74 (55.2%) had a cardiac POCUS performed and met inclusion criteria. A total of 17 patients had cardiac activity noted on the initial POCUS, with two (11%) surviving to hospital discharge (95% CI, 1.3-39.7). The two survivors initially categorized as being in traumatic cardiac arrest were ultimately found to have medical etiologies and not trauma. Of the 57 patients who had no cardiac activity noted on POCUS, none survived to hospital discharge (95% CI, 0-6.3%). More patients survived to hospital admission who had cardiac activity on their initial POCUS compared with those who had no cardiac activity (odds ratio [OR], 49.8; 95% CI, 5.5-446.9; P < .001). More patients survived to hospital discharge as well, but this was not statistically significant (OR, 18.6; 95% CI, 0.84-406.7, P = .06). Traumatic cardiac arrest patients who had present cardiac activity had longer code times prior to terminating efforts (26.6 vs 7.7 minutes, P < .001) and had higher overall charges per patient ($91,321 vs $10,032), P < .001).

**Conclusion:** The absence of cardiac activity on POCUS in patients with traumatic cardiac activity is likely to be fatal. The presence of cardiac activity was associated with increased resuscitation times, charges, and survival to hospital admission but not necessarily to hospital discharge. [West J Emerg Med. 2026;27(5)1280–1289.]

## INTRODUCTION

Traumatic cardiac arrest is one of the highest acuity conditions faced by both surgery and emergency physicians. Although both Advanced Cardiac Life Support (ACLS) and Advanced Trauma Life Support (ATLS) guidelines exist to aid management, outcomes are frequently poor, with only 5-12% of patients surviving to hospital discharge.[1,2] Significant resource use, both in terms of physicians' time and hospital consumables, occurs during these resuscitations and can lead to downstream issues with future patients.[3] It is therefore important that physicians have a way to differentiate which patients presenting in traumatic cardiac arrest have potentially survivable injuries and which do not.

Point-of-care ultrasound (POCUS) can rapidly assess multiple organ systems for traumatic injury at bedside. In nontraumatic cardiac arrest, POCUS is frequently used and accepted as a key clinical tool. Up to 91% of emergency physicians use ultrasound to assist in terminating resuscitation efforts, and presence of cardiac activity has a pooled odds ratio of 12.4 for return of spontaneous circulation (ROSC).[4,5] A 793-patient prospective study in nontraumatic cardiac arrest found that cardiac activity during initial resuscitation efforts was associated with increased survival to hospital admission (odds ratio [OR], 3.6; 95% CI, 2.2–5.9) and hospital discharge (OR, 5.7; 95% CI, 1.5–21.9) whereas only 0.6% (95% CI, 0.3–2.3) of patients with absent cardiac activity on initial POCUS survived to hospital discharge.[6-7] However, the optimal application of cardiac POCUS in traumatic cardiac arrest is less clear. There is some evidence suggesting that the absence of cardiac activity on POCUS is associated with nonsurvivable injury, with sensitivities ranging from 73%–91% and specificities ranging from 91–98% but with relatively heterogenous populations.[8-13]

### Outcomes

Our primary outcome was to determine whether cardiac activity on POCUS during traumatic cardiac arrest was associated with increased patient survival to neurologically intact hospital discharge. Secondary objectives included determining whether there was an association between cardiac activity on POCUS during traumatic cardiac arrest and survival to hospital admission, whether the absence of cardiac activity was associated with termination of resuscitative efforts, and the relative hospital-visit charges, both material and time-based, of continued resuscitation efforts in patients who do have cardiac activity on POCUS. Resuscitative procedures assessed included the following: airway; chest tube; central venous access; blood administration; and emergency department (ED) thoracotomies. We also compared hospital length of stay (LOS) in days for patients who were admitted. Our a priori hypothesis was that cardiac activity on POCUS during traumatic cardiac arrest would be associated with increased patient survival to hospital admission and neurologically intact discharge but at an increased charge.

*Population Health Research Capsule*

What do we already know about this issue?
*Traumatic cardiac arrest has poor survival and high resource use. Cardiac point-of-care ultrasound (POCUS) may identify patients with survivable injury during resuscitation.*

What was the research question?
*Is cardiac activity on POCUS associated with survival and charges in traumatic cardiac arrest?*

What was the major finding of the study?
*Cardiac activity on POCUS was associated with survival to hospital admission: 47% vs 1.8%; 95% CI, 5.5-446.9; P < .001.*

How does this improve population health?
*Early cardiac POCUS may guide traumatic cardiac arrest resuscitation, limiting futile care and conserving emergency department/trauma resources without missed survival.*

## METHODS

### Adherence to Methodologic Standards

The following optimal methodological standards were adhered to in this study.[14] All abstractors (DD, ZB, KD) were trained via a one-hour instructional session on data collection in the hospital's electronic health record (EHR) prior to collecting any data. The inclusion and exclusion criteria are explicitly defined below in the section on inclusion and exclusion criteria. Relevant variables are defined in the sections below. Data abstractors used a common data abstraction form. A separate investigator (TS) who was not part of the initial chart review then re-reviewed charts to ensure consistency and also reviewed overall data collection at regular intervals. All identified cardiac POCUS images were reviewed by an ultrasound fellowship-trained attending with experience performing and interpreting more than 1,000 cardiac POCUS examinations. Institutional review board approval at our local institution was obtained. Any missing data were noted, discussed with the abstractor and re-reviewer, and resolved by consensus.

### Setting

This was a single-center, retrospective study at an academic, tertiary care, urban Level I trauma center, with greater than 110,000 ED visits and approximately 20–25 traumatic cardiac arrest cases in approximately 550 full trauma responses a year. Point-of-care ultrasound

examinations are typically performed by an emergency medicine (EM) intern who has had a dedicated one-hour training session on cardiac POCUS with both a lecture and hands-on component. These exams are supervised by an EM fellow or attending. All ED attendings and fellows are globally credentialed to perform POCUS via the American Board of Emergency Medicine and receive training in POCUS as a condition for their board certification. Emergency department residents participate in 16 hours of dedicated ultrasound training during their first month and at least four weeks of dedicated POCUS training by the end of their second year, and they must perform a minimum of 500 POCUS examinations during their residency as a requirement for graduation. Occasionally, POCUS examinations are performed by a member of the trauma team: either a nurse practitioner, physician assistant, rotating EM or surgical resident, or the attending trauma surgeon.

Our ED has an active POCUS program with approximately 9,000 POCUS examinations performed annually, as well as an accredited three-year EM residency and a one-year emergency ultrasound fellowship. Point-of-care ultrasound was conducted with either a Sonosite Xporte (FUJIFILM Sonosite, Bothell, WA) or a Philips Sparq (Philips, Andover, MA). Quality assurance was performed by clinical ultrasound fellowship-trained faculty members. Cardiac POCUS was performed typically within the first 2–4 minutes during the first or second pulse check in all traumatic cardiac arrest resuscitation efforts. Subsequent POCUS, including the remaining views of the extended focused assessment for sonography in trauma (eFAST) exams, may have been obtained during subsequent pulse checks.

**Table 1.** Trauma activation criteria in a study analyzing the value of point-of-care ultrasound to determine cardiac activity and outcome in patients with traumatic cardiac arrest.

- GCS ≤ 12
- Systolic blood pressure < 90 mm Hg
- Respiratory rate < 10 or > 29, intubated or with threatened airway
- Any penetrating injury to the head, neck, torso, or extremities proximal to the elbows or knees
- MVC with patient ejected from vehicle
- Fall > 20 feet
- Major deep burns (20% body surface area)
- Chest wall instability
- Two or more proximal long bone fractures
- Suspected unstable pelvic fracture
- Open or depressed skull fracture
- Paralysis secondary to injury
- Amputation proximal to wrist or ankle
- Crushed, degloved, or mangled extremity at or proximal to elbows or knees
- Pregnant patient 20 weeks or greater with vaginal bleeding, abdominal tenderness, and/or injury
- Transfer patients receiving blood to maintain vital signs, positive FAST examination, or chest tube insertion
- Emergency physician's discretion

*FAST*, focused assessment for sonography in trauma; *GCS*, Glasgow Coma Scale; *MVC*, motor vehicle collision.

**Inclusion and Exclusion Criteria**

Our research team conducted a retrospective chart review to identify all traumatic cardiac arrest patients presenting to our ED from August 1, 2016–December 31, 2023. Patients were identified consecutively using *International Classification of Diseases, 10th. Revision,* (*ICD-10*) codes for cardiac arrest. Inclusion criteria were all patients at least 18 years of age who presented in traumatic cardiac arrest or who went into traumatic cardiac arrest in the ED who also had a cardiac POCUS conducted during the resuscitation. We accepted dedicated cardiac POCUS clips as well as cardiac POCUS clips that were in the context of an eFAST exam, provided that it was the first POCUS exam in the resuscitation. We defined cardiac arrest as a patient who had an absent palpable pulse and a cardiac rhythm requiring cardiopulmonary resuscitation or ACLS. The cardiac arrest was deemed to be traumatic if there was an external cause, blunt and penetrating, to the patient's presenting symptoms (such as a gunshot wound or motor vehicle collision). In some cases, determining the exact cause of cardiac arrest at the time of ED presentation was difficult; in these cases, we elected to include patients if the trauma surgery team was called to assist in resuscitation efforts based on our hospital's trauma activation guidelines (Table 1).

Patients were excluded if they had any of the following conditions: ROSC prior to ED arrival; a cardiac arrest after hospital admission; an advanced directive invoked during resuscitation. efforts; a nontraumatic cause for cardiac arrest (based on chart review); or lack of trauma team involvement in the patient's care.

A primary goal of POCUS in cardiac arrest is to assess for organized cardiac activity, which we defined as movement of the heart with sufficient cardiac output to sustain life, as defined in previous literature.[15] However, because there is no standard for the precise sonographic findings that constitute organized cardiac activity, we left this determination to the clinicians for each patient at the time of resuscitation. efforts, determined via physician documentation.[16] As there was no standardized POCUS workflow for much of the study period (our ED only obtained a dedicated POCUS workflow in October 2021), many cardiac POCUS images were lost to review by study investigators. Nevertheless, study investigators did attempt to locate all cardiac POCUS images associated with patients in this study by review of our institution's picture archiving and communication system

Survival to hospital admission was defined as having all three of the following: ROSC; admission orders placed; and transfer out of the ED. We included patients who went directly

to the operating room in the category of those who survived to hospital admission. Survival to hospital discharge was defined as a patient who survived to hospital admission and was then discharged to a definitive location (eg, rehab facility, home). We defined neurologically intact hospital discharge as a patient who met the criteria for survival to hospital discharge and who also had a Cerebral Performance Category score ≤ 2, as calculated by a member of the research team.[17] We evaluated resource utilization procedurally and financially by tracking the number of advanced airway procedures, central venous access placements, chest tube insertions, and thoracotomies performed, as well as total charges per hospital visit.

### Chart Review

After a joint discussion with all study members and a one-hour training session, study investigators manually reviewed the EHR within the study period to identify patients who had an *ICD-10* code consistent with cardiac arrest. A separate investigator who was not part of the initial chart review then re-reviewed approximately 10% of the charts to ensure consistency, and any errors discovered were corrected by re-review and consensus between the initial abstractors and the re-reviewer. The Cohen kappa (κ) was 0.89 between the initial reviewer and subsequent re-reviewer for all charted variables.

The study investigators reviewed each case of traumatic cardiac arrest as compiled in an existing database of the hospital's EHR based on *ICD-10* codes for cardiac arrest, which is kept for quality assurance purposes. Data was obtained from the initial patient encounter, patient records, emergency medical services records, and hospital billing data. Our team reviewed charts for demographics, comorbidities, medications administered, procedures performed, POCUS findings, and patient outcomes. Additional data such as comorbidities was obtained by chart review to obtain data points not available during the initial patient resuscitation.

### Statistical Analysis

Outcome data was reported as either discrete or continuous numerical data and were stored in Microsoft Excel 2017 (Microsoft Corporation, Redmond, WA). Tests of normality were conducted on all outcome data using the Shapiro-Wilk test. We subsequently analyzed normally distributed data with a two-tailed Student *t*-test, while nonnormally distributed data were analyzed with a Mann-Whitney *U* test. All analyses were conducted using SPSS version 28 (IBM Corporation, Armonk, NY). A $P$ value < .05 was considered statistically significant.

## RESULTS

A total of 134 patients with traumatic cardiac arrest were identified during the study period, of whom 79 (59.3%) had cardiac POCUS performed. Two patients had ROSC immediately upon ED arrival and were excluded. Three patients were excluded for incomplete ultrasound documentation, leaving a total of 74 patients in the final study analysis (Figure). The characteristics of the included and excluded patients are listed in Table 2.

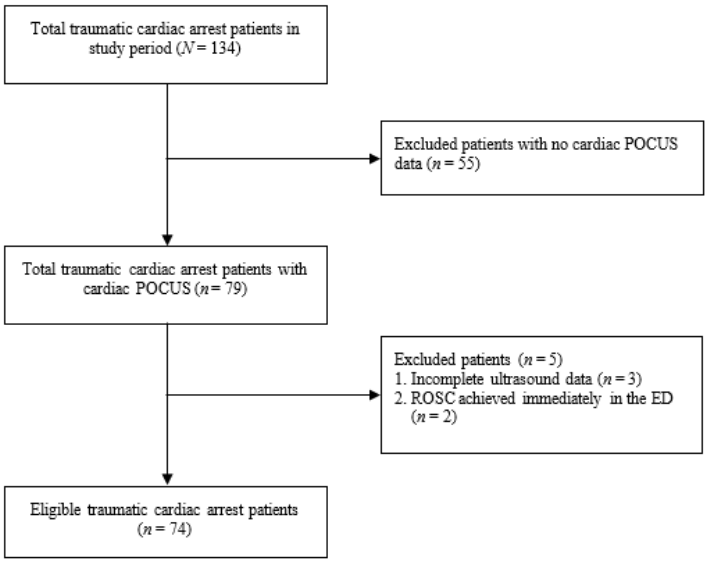


**Figure.** Diagram of included and excluded cases in a study of the value of point-of-care ultrasound to determine cardiac activity and outcome in traumatic cardiac arrest patients..
*ED*, emergency department; *POCUS*, point-of-care ultrasound; *ROSC*, return of spontaneous circulation.

The average age of included patients was 48.1 (standard deviation [SD] 22.0), 58 (73.4%) were male, 15 (20.3%) had penetrating trauma, and 59 (79.8%) blunt trauma.

A total of 17 patients (23.0%) had cardiac activity noted on the initial POCUS with 8 surviving to hospital admission (47% of group, 10.8% of study population) and 2 surviving to discharge (11.8% of group, 2.7% of study population, 95% CI, 0.24–7.22). Of the 57 patients (77.0%) who had no cardiac activity noted on POCUS, only one survived to hospital admission (1.8% of group, 1.4% of study population), and none survived to discharge (95% CI, 0-6.3%). Compared with those patients who had cardiac activity on their initial POCUS, those with no cardiac activity noted had higher rates of survival to hospital admission (47% compared with 1.8% absolute risk reduction [ARR]) and to hospital discharge [11.8% compared with 0% ARR]). The difference in survival to hospital admission was statistically significant (odds ratio [OR], 49.78; 95% CI, 5.54–446.92], $P$ < .001), and the difference in survival to hospital discharge was ultimately not statistically significant (OR, 18.55; 95% CI, 0.84–406.7, $P$ = .06). Of the patients with cardiac activity who survived to hospital admission, LOS on average was 8.37 days (SD 9.71). The single patient without cardiac activity on POCUS who survived to hospital admission died one day later.

Of the 74 included patients with a cardiac POCUS, only 13 (17.5%) had saved clips available to the study team for

**Table 2.** Characteristics of patients with traumatic cardiac arrest who had point-of-care ultrasound performed during resuscitation efforts compared with those that did not, in a study analyzing the value of ultrasound to determine cardiac activity and outcome.

| Traumatic Cardiac Arrest | POCUS Performed (*n* = 79) | No POCUS Performed (*n* = 55) | *P* value |
|---|---|---|---|
| Age | 46.9 years (SD 22.3) | 52.1 years (SD 22.6) | .53 |
| Sex | 61 males (77.2%) | 44 males (81.8%) | .29 |
| Blunt vs penetrating trauma | 63 blunt, 16 penetrating | 44 blunt, 11 penetrating | .91 |
| Airways in ED | 22 (27.8%) | 18 (32.7%) | .80 |
| Chest tube(s) | 33 | 18 | .02* |
| Central venous access | 18 | 19 | .88 |
| PRBCs administered per patient (pt) in the ED | 0.63/pt | 1.1/pt | .06 |
| Thoracotomies | 1 | 4 | .27 |
| Operating room from the ED | 1 | 5 | .01* |
| ED death | 66 (83.5%) | 23 (41.8%) | .001* |
| If death in ED, resuscitation length prior to termination | 18.44 min | 29.23 min | .04* |
| Survival to hospital admission | 12 (15.2%) | 32 (58.1%) | ≤ .001* |
| Survival to hospital discharge | 3 (3.8%) | 9 (16.4%) | ≤ .01* |
| Total length of hospital stay (days) | 88 (1.35/pt) | 166 (4.49/pt) | ≤ .01* |

*Significant differences ($P < .05$) between groups.
*ED*, emergency department; *POCUS*, point-of-care ultrasound; *PRBC*, packed red blood cells; *SD*, standard deviation.

review. On re-review of these images, 8 of the 13 patients had no cardiac activity documented by the clinical team, and the other 5 had cardiac activity documented. On image review, three of the eight patients who were documented to have absent cardiac activity actually had cardiac activity; all five patients who had cardiac activity did indeed have cardiac activity on review ($\kappa = 0.56$). In addition, two of the patients who had no cardiac activity were found to have a pericardial effusion. One patient had a small pericardial effusion (maximum diastolic diameter < 1.0 cm), and one patient had a moderate pericardial effusion (maximum diastolic diameter 1.0-2.0). Both patients presented with traumatic cardiac arrest secondary to penetrating trauma. Investigators could not assess for cardiac tamponade because complete cardiac standstill precluded evaluation for right ventricular collapse on ultrasound. Despite variability of POCUS findings on re-review, we opted to keep patients in their initial groups based on what the clinical team believed their POCUS findings to be during the initial resuscitation efforts.

There was a significant difference in the length of resuscitation efforts between patients with cardiac activity on POCUS (26.59 minutes) compared with those without cardiac activity on POCUS (7.67 minutes, $P < .001$). There was also a significant difference in charges, with patients with cardiac activity having an average total hospital charge of $91,321 (SD $133,402) per patient as compared to the patients without cardiac activity ($10,032 [$12,976]). Patients with cardiac activity had more blood products used on initial resuscitative effort, with 0.94 units of packed red blood cells (pRBC) compared with 0.44 pRBCs per patient without cardiac activity ($P = .01$). Patients with cardiac activity also underwent more total procedures, including central venous catheterizations and surgical interventions in the operating room (Table 3).

Additional analysis of hospital charges was conducted on the patients who died in the ED and those who survived to hospital admission (Table 4). Of the eight patients who survived to hospital admission with cardiac activity, the average charge of their total hospital stay was $180,991. The one person who survived to hospital admission with no cardiac activity had a total hospital stay charge of $69,805 ($P < .001$). The two patients who survived to hospital discharge had an average hospital charge of $346,329. Of the nine patients who died in the ED with cardiac activity on ultrasound, their hospital charge was significantly higher than the 56 patients who died in the ED with no cardiac activity ($27,024 vs $8,945, $P < .001$).

## DISCUSSION

### Interpretation and Comparison to Previous Studies

Despite ongoing medical improvements and advancements in ATLS care in both prehospital and in-hospital settings, patients with traumatic cardiac arrest still have a high mortality rate. Determining which may benefit from continued resuscitation efforts is a difficult decision dependent on multiple factors. Our data suggest that POCUS may assist in this decision, as the presence or absence of organized cardiac

**Table 3.** Characteristics of patients with traumatic cardiac arrest who had cardiac activity as assessed on point-of-care ultrasound in resuscitation compared with those who did not, in a study analyzing the value of ultrasound to determine cardiac activity and outcome.

| Traumatic Cardiac Arrest | No cardiac activity (*n* = 57) | Cardiac activity (*n* = 17) | *P* value |
|---|---|---|---|
| Age | 48.5 years (SD 17.8) | 47.1 years (SD 23.5) | .99 |
| Sex | 45 | 13 | .83 |
| Blunt vs penetrating Trauma | 45 Blunt, 12 Penetrating | 15 Blunt, 2 Penetrating | .39 |
| PRBCs administered per patient (pt) in the ED | 0.44/pt | 0.941/pt | .01 |
| Thoracotomies | 0 | 1 | .29 |
| Operating room from the ED | 0 | 1 | .29 |
| If death in ED, resuscitation length prior to termination | 7.67 min | 26.59 min | < .001 |
| Survival to hospital admission | 1 | 8 | < .001 |
| Survival to hospital discharge | 0 | 2 | .06 |
| Total length of hospital stay (days) | 1 (0.018/pt) | 67 (8.38/pt) | < .001 |

*ED*, emergency department; *PRBC*, packed red blood cells; *SD*, standard deviation.

activity on POCUS may serve as a prognostic sign of successful resuscitation. For traumatic cardiac arrest, poor outcomes have been associated with cardiac standstill in previous research, including a 0% survival rate in a single-center study of 187 traumatic cardiac arrest patients with standstill. Cardiac motion predicting survival to hospital admission was 86% sensitive and 91% specific in another single-center study of 162 traumatic cardiac arrest patients. A meta-analysis of 710 patients found negligible rates of survival to hospital discharge when cardiac standstill was present. Our study mirrors these findings, demonstrating dismal survival to hospital admission among patients presenting with cardiac standstill.

We report on the charges associated with the presence or absence of cardiac activity, which was documented less commonly in the literature. We noted one prior study of 37 traumatic cardiac arrest patients who saw decreased hospital costs with performance of POCUS in traumatic cardiac arrest ($1,871 in the POCUS group compared with $3,040 in the non-POCUS group); however, the study did not consider the findings on POCUS but rather only the actual performance of ultrasound. We found no suitable benchmark for hospital charges during traumatic cardiac arrest with which to compare our findings.

### Summary of Main Findings and Strengths

The 57 patients without cardiac activity on POCUS all died regardless of rhythm or resuscitative effort, consistent with previous studies. This finding was ultimately not statistically significant ($P = .06$). Although the absence of cardiac activity had a high odds ratio (18.55) for nonsurvivability, there was also a wide confidence interval associated with this analysis (95% CI, 0.84–406.7).[24] We therefore advocate for early performance of cardiac POCUS to determine the cardiac function of traumatic cardiac arrest patients. By doing so, significant resuscitative charges can be saved once the absence of cardiac activity is determined. By identifying the absence of cardiac activity on POCUS, approximately $18,000 in-hospital visit charges were saved per traumatic cardiac arrest patient, with likely no change in meaningful patient outcome.

One patient survived to hospital admission from this cohort—a 48-year-old female with a self-inflicted laceration to the left wrist who had significant anoxic brain injury as a sequela to injury. The family requested that no aggressive measures be taken in her care, and she died one day after hospital admission. Based on our findings, we suggest that if no cardiac movement is noted on POCUS during the initial traumatic cardiac arrest evaluation, further resuscitative efforts would likely be futile. Consideration should be given to terminating resuscitative efforts if no obvious reversible causes, such as pericardial tamponade, are noted on the primary and secondary survey.

We also found that the presence of cardiac activity on POCUS did not lead to a statistical increase in survival to hospital discharge (although a statistically significant increase in survival to hospital admission was noted). It is interesting to consider why traumatic cardiac arrest patients with cardiac activity on POCUS still have such poor outcomes. One possibility is that severe traumatic injuries carry a dismal prognosis and would have had poor outcomes regardless of the presence of cardiac activity on initial POCUS. Another possibility may be the lack of a formal definition of "cardiac activity." While we relied on the clinical team for the interpretation of the cardiac POCUS, there is a wide range of cardiac movement that can be considered cardiac activity.[16] For patients who survived to hospital admission, it remains unclear whether a specific acute event led to death or if it resulted from the inevitable progression of their pathophysiology.

**Table 4.** Hospital charges based on outcomes for patients broken down by those patients that had cardiac activity on point-of-care ultrasound compared with those patients that had no cardiac activity on ultrasound, in a study of the value of ultrasound to determine cardiac activity and outcome in traumatic cardiac arrest patients.

| Traumatic Cardiac Arrest | No cardiac activity (*n* = 57) | Cardiac activity (*n* = 17) | *P* value |
|---|---|---|---|
| Average charge of hospital visit | $10,032 (SD $12,976) | $91,321 (SD $133,402) | < .001 |
| Average charge of hospital visit for patients who ultimately died in the ED | $8,945 (SD $6,501) | $27,024 (SD $19,850) | < .001 |
| Average charge of hospital visit for patients who survived to hospital admission | $69,805 | $180,991 | < .001 |
| Average charge of hospital visit for patients who survived to hospital discharge | n/a | $346,329 | |

*ED*, emergency department; *SD*, standard deviation.

**Clinical Implications**

By using POCUS and terminating resuscitative efforts in traumatic cardiac arrest patients without cardiac activity, significant resources may be saved by the ED and the trauma team. Compared to those without cardiac activity, traumatic cardiac arrest patients with present cardiac activity experienced longer code times prior to terminating efforts (7.67 compared with 26.59 minutes, $P < .001$), had more units of red blood cells administered per patient (0.44 compared with 0.94, $P < .001$), and had more procedures performed ($P = .01$). Patients without cardiac activity incurred significantly lower charges than those with cardiac activity, both overall ($8,945 compared with $27,024; $P < .001$) and among those who died in the ED ($7,262 compared with $17,156; $P < .001$). We do not advocate for charge-sensitive care as a primary motivating factor for traumatic cardiac arrest resuscitation decisions, because these additional charges incurred for patients who had cardiac activity ultimately led to increased survivability.

**Research Implications**

Future prospective trials with larger samples sizes are required to validate these findings. Standardizing the definition of cardiac activity and ensuring the storage of ultrasound clips for retrospective review will improve data reproducibility. Furthermore, the study only evaluated cardiac POCUS findings and did not report data from other ultrasound views. Although the identification of a pneumothorax or hemoperitoneum may alter resuscitative decisions, the presence or absence of cardiac activity remains the most critical decision point during traumatic cardiac arrest resuscitation efforts.

## LIMITATIONS

We excluded a substantial cohort of patients with traumatic cardiac arrest because POCUS was not performed. This excluded population likely represented a less severely injured cohort, as evidenced by their significantly higher rates of survival to hospital admission and discharge (Table 1). In these cases, clinicians may have prioritized immediate definitive management over diagnostic bedside imaging. Neither did we review the actual ultrasound images; instead, we relied upon the resuscitation team's report and charting. Although POCUS is routinely used to assess cardiac function early in a resuscitation effort, the exact timing of the ultrasound evaluation was not recorded. Therefore, we could not determine whether POCUS findings served as the primary driver for continuing or terminating resuscitation efforts. Other components of the patient's presentation undoubtedly affected resuscitation decision-making, which would also have impacted the financial charges each patient accumulated. However, early POCUS use during cardiac arrest is standard protocol at our institution.

Only 13 patients (17.6%) of the 74 in the cohort had saved images available for retrospective analysis. On image review, three of the eight patients documented as having absent cardiac activity demonstrated subtle yet definitive cardiac motion. It is unclear whether this subtle cardiac activity that was initially missed by clinicians would have resulted in a meaningful change in resuscitation but suggests that ultrasound interpretation was not perfect by the treating physicians. Extrapolating to our entire population, there likely were more cases of misinterpreted POCUS that may have impacted resuscitative decision-making. However, since decision-making is not solely reliant on POCUS in cases of traumatic cardiac arrest, the clinical outcomes may have been similar even if physicians had been aware of the correct POCUS interpretation. Nevertheless, this is a notable limitation of our study.

Pericardial effusions and cardiac tamponade can also be diagnosed with cardiac POCUS and represent a reversible cause of traumatic cardiac arrest that can be acted upon by the medical team. No clinically significant pericardial effusions were noted on chart review; however, upon review of available images by investigators, two pericardial effusions

were identified. Both were in the setting of penetrating trauma_one small and one moderate_and in both cases, they were accompanied by cardiac standstill. Because both patients were in standstill, it is difficult to ascertain whether cardiac tamponade was the direct cause of mortality in either case. However, it is likely that more pericardial effusions may have been present in our study cohort, which is another notable limitation.

The classification of "traumatic" cardiac arrest can be difficult because preceding medical events may lead to subsequent traumatic events, and assessing which event is the larger contributor to cardiac arrest is often not possible. We elected to include all cardiac arrests with trauma team activation, even if no traumatic injuries were subsequently noted, because there is a detailed set of guidelines dictating such activations, including the ability for the initial clinical team to request or cancel a trauma team activation. Only two patients in our study cohort survived to hospital discharge. The first was a 55-year-old man in a low-speed motor vehicle collision. After he was resuscitated in the ED, he was found to have rib fractures and small apical pneumothoraxes thought to be secondary to chest compressions rather than an initial traumatic injury. During his hospitalization, the patient admitted to recreational polysubstance use, which the clinician then attributed to his cardiac arrest. He was discharged to a rehabilitation facility with a Cerebral Performance Category (CPC) score of 2. The second patient who survived to hospital discharge was a 54-year-old man who fell off a ladder and was found to be in cardiac arrest. He received bilateral needle decompressions in the field. In the ED, ROSC was achieved, and subsequent electrocardiogram revealed an ST-elevation myocardial infarction and a 100% occlusion in his circumflex artery. He was eventually discharged home with a CPC score of 1.

We suspect that the cardiac arrest in both patients was unlikely secondary to a traumatic cause. Because the trauma team was called to aid in the initial resuscitation and because the lack of initial traumatic injuries was not known until after ROSC was obtained, we chose to include these two patients in our cohort. Conversely, our research team did not review each individual case of nontraumatic cardiac arrest to determine whether there may have been a traumatic cause of injury. Therefore, it is likely that some of our nontraumatic cardiac arrests likely were indeed traumatic in nature, a determination that could not have been made by chart review alone.

Additionally, our study focused on a single center; other hospitals may have different trauma activation criteria leading to a potentially higher catchment for traumatic cardiac arrest. Because our trauma center does not mandate cardiac POCUS in every cardiac arrest, a significant number of traumatic cardiac arrest patients did not receive cardiac ultrasound. It is unclear why. Perhaps it may have been clinician comfort, or there was an identified nonsurvivable injury or other unfavorable characteristics of the resuscitation effort that led to termination, or even that ROSC was achieved prior to the ultrasound. Knowing the reasoning behind the lack of POCUS in our traumatic cardiac arrest populations would have helped strengthen our research. Because our chart reviewers were also authors, they were not blinded to the original study hypotheses, which may have introduced bias.

Our POCUS workflow during the study timeframe was an order-based system; consequently, we were able to determine only the physician who ordered the POCUS and not the one who actually performed the exam. Although the ED intern typically is assigned to perform the POCUS as part of their resuscitation duties, we were unable to verify whether the intern in fact performed the exam. In the setting of traumatic cardiac arrest, a more senior resident or attending will often dictate management of ultrasound. In addition, our nurse practitioners and physician assistants, as well as the trauma service clinicians, are not subject to the same formal credentialing guidelines as our ED residents, fellows, and attendings, which means they may have had varying levels of training if they were the ones who performed or supervised the POCUS.

We report medical charge data, which may approximate cost but does not represent true cost. Actual cost data are more difficult to obtain because of bundled payment structures and variation in reimbursement across patients and insurance plans. In addition, there was opportunity cost from the trauma team, which was not accounted for in our charge data.

It would be interesting in future research to determine differences between study groups in critical care or intensive care unit (ICU) LOS. Unfortunately, our dataset does not readily allow us to distinguish ICU LOS from stepdown or floor LOS, because our EHR does not provide a reliable way to determine exactly when patients were formally transferred from the ICU to stepdown or floor status. Perhaps, this topic can be more formally addressed in the future

Some of our conclusions are clearly limited by a low sample size, given the single-center nature of our study. A recent meta-analysis of trauma centers that had patients with traumatic cardiac arrest showed varying patient volumes, including 88 patients over a three-year period in three hospitals in France; 588 patients in a six-year period in a single hospital in New Orleans, LA; 463 patients in a four-year period in five hospitals in Taiwan and 284 patients in a 10-year study period in a single hospital in Sweden.[25-29] We had 134 patients with traumatic cardiac arrest over an approximate 6.5-year study timeframe, which represented a slightly lower annual average per hospital. However, as previously noted, the number of traumatic cardiac arrests per trauma center can vary significantly. In addition, the actual frequency of use of cardiac POCUS in these patients can also vary significantly. Although literature exists on the use of cardiac POCUS in traumatic cardiac arrests, the frequency with which cardiac POCUS is performed has not been well studied.[30] Although the number of patients in our center with

traumatic cardiac arrest is reflective of a busy, urban Level I trauma center, more patients and more centers would help confirm the validity of our findings.

The average age in our patient population was 48 years, which is generally an older population compared to other studies. We noted 35 patients who were at least 65, each of whom presented with blunt trauma. The two most common inciting traumatic incidents in this population were motor vehicle collision and fall. Just as in our two patients who survived to hospital discharge, it is not clear whether there was a preceding medical incident that led to the traumatic injury in these patients because autopsy data was not available to us, and many patients' families did not desire definitive autopsies. Again, to maintain consistency, we elected to enroll any patient who had a trauma activation with trauma surgery consult. Lastly, despite analyzing almost seven years' worth of data, we found only 79 traumatic cardiac arrest cases with POCUS. We selected our study window to coincide with the implementation of our current. EHR.

## CONCLUSION

The absence of cardiac activity on ultrasound in traumatic cardiac arrest patients was associated with nonsurvivability and reduced hospital visit charges in the ED and in hospital. The ability of ED and trauma teams to ascertain the presence or absence of cardiac activity so rapidly at bedside with POCUS is an excellent reason to consider ultrasound early in resuscitation efforts. Further research, including prospective studies and those with larger sample sizes, are needed to best elucidate the best practices for cardiac point-of-care ultrasound in patients with traumatic cardiac arrest.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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# Traumatic Extremity Amputations in Children: Causes and Outcomes Based on a Regional Experience

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**Introduction:** Pediatric traumatic extremity or digit amputations are preventable causes of morbidity. The object of this study was to evaluate the etiology and outcomes of these injuries in our region. We used the Childhood Opportunity Index to explore the role of social determinants of health.

**Methods:** We performed a retrospective cohort study at an academic children's hospital on all pediatric patients younger than 18 years who presented with a traumatic digit or extremity amputation between January 1, 2014, to July 31, 2024. Metrics such as patient demographics, injury severity, prehospital course, hospital events and follow-up were abstracted. The Childhood Opportunity Index assigns a 0-100 composite score of region-based childhood opportunity determined from home ZIP codes. Our primary outcome measure was mechanism of injury. Secondary outcomes included length of stay, need for initial surgical intervention, subsequent operations, or unplanned readmissions.

**Results:** A total of 73 patients presented with a traumatic amputation of a digit or extremity. The median age was 12.7. The top three causes of amputations were all-terrain vehicle (ATV) crashes, fireworks, and entrapment in an object. All-terrain vehicle crashes were the most common cause in all age groups from 5-17, while caught in an object was the most common for ages 0-4. The median Injury Severity Score was 5 (IQR 7). The three most common sites of amputation were right index finger (21), right long finger (17), and left long finger (15). Thirty-three children (45.2%) had more than one amputation. The highest number of amputations in a single patient was 10. All patients underwent a surgical intervention, and there were no mortalities. The median Childhood Opportunity Index score of the cohort was low at 19 (IQR 33), with 73% (n = 53) of the cohort originating from a very low (n = 37) or low (n = 16) index region. A rising index score was weakly associated with a decrease in total number of amputations ($\rho$ = -0.25 [CI, -0.45 to -0.02, $P$ = .04]).

**Conclusion:** A. total of 73 children in our region suffered a traumatic digit or extremity amputation, mostly due to ATV crashes and fireworks. Most patients originated from a neighborhood of very low or low Childhood Opportunity Index scores. Increased public awareness regarding the danger of ATVs in regions with lower index scores may prevent these injuries. Clear, targeted policies toward ATV usage in childhood are needed. [West J Emerg Med. 2026;27(5)1290–1297.]

## INTRODUCTION

Traumatic amputations in children are a devastating source of morbidity and are assumed to be caused by preventable events. In a recent review of the National Electronic Injury Surveillance System from 2012 to 2021, it was estimated that the most common age demographic to suffer from a near or complete traumatic amputation was the 0-5 year-old age group.[1] Of all the estimated pediatric patents included, fingers were the most common body part affected, and doors were the most common consumer product to cause injury in children.[1] However, there has been recent concern that not all amputation injuries in children should be presumed to be accidental. A review of the New York Statewide Planning and Research Cooperative System from 2004 to 2013 suggested that pediatric patients presenting with diagnostic code for abuse were significantly more likely to have a fingertip injury than those who did not.[2]

The cost of an amputation in a child involves more than just the physical losses and has reverberations in healthcare costs and family dynamics. Vakhshori et al found that, in the United States, there was a total national healthcare use cost of $166 million for 6,130 pediatric traumatic upper extremity injuries from 1997 to 2012.[3] Furthermore, in a survey of caregivers of children with limb loss, there was a notable increase in missed school for the child, and half of caregivers needed to adjust their work participation due to the injury.[4]

This study was prompted by a perceived increase in the case burden of these devastating injuries presenting to our hospital and a desire to understand the cause of these events. Our primary aim was to evaluate the mechanism of these events by age group, with secondary aims including understanding overall injury severity in this population and analyzing the relationship of social determinants of health via the Childhood Opportunity Index with these injuries. The Childhood Opportunity Index is a composite indicator revealing the impact of a child's neighborhood on their overall opportunities in life; it encompasses numerous metrics including economic resources, environmental impact, and community social capital.[5] This indicator has been used in previous trauma literature as a surrogate marker of social determinants of health to evaluate the impact of a child's home origin on trauma outcomes.[6] A lower Childhood Opportunity Index has been shown to be associated with violent mechanisms of injury, but further research is needed in other geographical regions to continue to validate its role in addressing unmet health-related social needs.[7]

We hypothesized that the primary cause of traumatic extremity or digit amputations in children in our region would be due to motor vehicle collisions (MVC) and that most patients would come from a background with a lower Childhood Opportunity Index. Our children's hospital is located next to a major interstate freeway and is surrounded by a region with poor public transport systems. This, coupled with a high burden of MVCs presenting to our children's hospital, prompted our hypothesis. The objective of this study was to determine the number, mechanism, and clinical impact of traumatic extremity and digit injury amputations to our Level I pediatric trauma center over time.

*Population Health Research Capsule*

What do we already know about this issue?
*Traumatic amputations in children cause devastating morbidity and high healthcare costs.*

What was the research question?
*Our goal was to understand the rates, severity, and causes of traumatic extremity and digit amputations in southeast California.*

What was the major finding of the study?
*Seventy-three children suffered a traumatic extremity/digit amputation with nearly 1/3 caused by all-terrain vehicle crashes.*

How does this improve population health?
*Causes of preventable injury need to be delineated to improve awareness and advocacy.*

## METHODS

### Study Design and Patient Population

After institutional review board (IRB) approval (#5240372), a retrospective cohort study was initiated. We performed a review of the trauma registry at an academic children's hospital with Level I pediatric and adult trauma designation. The institutional trauma database includes all patients with a traumatic injury who were admitted or received a trauma team activation. It does not capture patients who were treated and discharged from the emergency department (ED) without a trauma team activation. Inclusion criteria of the study included all patients younger than 18 years who presented with a traumatic digit or extremity amputation between January 1, 2014, to July 31, 2024. Amputations were initially identified by *International Classification of Diseases*, 9th and. 10th revisions, (ICD 9 and 10) codes provided in the trauma registry. Exclusion criteria included any patient over 18 years of age and the diagnosis of an incomplete amputation or an amputation of a nonextremity body part.

Data abstracted from the trauma database included patient origin, demographics, injury mechanism, outside hospital course, ED course and discharge details. Additional

information was abstracted from the institutional electronic health record including location of amputation, operative details, hospital course, complications, and follow=up. Amputations were classified by location. Any severing amputation involving a hand or foot phalangeal joint, distal metacarpal or distal metatarsal were considered digit amputations. Amputations proximal to the metacarpal or metatarsal joints, or through the wrist, upper extremity, mid foot or lower extremity were considered extremity amputations. A total of 73 children were identified during the study period.

### Use of Childhood Opportunity Index

The Childhood Opportunity Index version 3.0 is a composite index of 44 indicators that provides a ZIP code or US Census-based numerical assignment to describe the overall access to opportunities that a child residing in that neighborhood has.[8] In version 3.0, numerical assignments are given based on quintiles from 1-100.[8] Additionally, in version 3.0, scores were derived for years 2012 to 2021.[8] In this analysis, scores were assigned based on ZIP code of patient's home address and corresponded to year of injury, except for years 2022 to 2024, which were based on the scores from 2021 due to lack of Childhood Opportunity Index data from those years at time of research study. Then, patients were assigned into the opportunity categories. For a subanalysis, we combined moderate, high and very high into one category.

### Statistical Analysis and Method Criterion

We used descriptive statistics for analyzing demographics and clinical characteristics using Excel (Microsoft Corporation). Additional analyses were conducted to assess correlation or differences between demographic and clinical covariates and three Childhood Opportunity Index subgroups, including the Spearman correlation and Wilcoxon rank-sum test. Statistical significance was denoted by $P$ value < .05. We used SAS for analysis (SAS Institute, Inc). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for cohort studies was used to ensure proper information reporting. We followed the method criteria outlined by Worster and Bledsoe: abstractor training; defined case selection criteria; defined variables; consistent abstraction form; monitored performance; interobserver reliability discussion; medical record identification; described sampling method; and IRB approval.[9]

## RESULTS

### Demographics, Childhood Opportunity Index, and Interventions

Of the 73 children identified in the study, the median age was 12.7 years (range 1.2 to 17.9 years). Most patients injured were male (71%) and identified as Hispanic (59%). In 2021, 58.2% of children in our institution's county identified as Hispanic or Latino.[10] The median body mass index (BMI) for the entire cohort was 19.7 (IQR 8.5). The median Childhood Opportunity Index of the cohort was low at 19 (IQR 33). When the cohort was divided into five Childhood Opportunity Index categories, just over half the cohort was shown to live in ZIP codes identified as very low opportunity neighborhoods (51%). Most patients originated from a neighborhood of very low or low opportunity (73%) while the minority (27%) of patients lived in a ZIP code identified as providing moderate, high, or very high opportunity. These results are relatively similar to the overall trauma population presenting to our institution. In 2021, 75.5% of pediatric patients presented from a neighborhood of very low (46.6%) or low opportunity (28.9%) and 24.5% from a neighborhood of moderate (14.6%), high (6.8%) or very high (3.1%) opportunity.

All patients required a surgical intervention, and 14% of patients were fitted or planned to be fitted for a prosthesis after surgical intervention. Nonextremity surgical interventions were required in 11% of patients. Demographics of the cohort are summarized in Table 1.

### Severity and Rates of Injuries

The overall rate of injury presentation has fluctuated over time with an overall positive trajectory, ranging from four to nine patients per year. The number of patients treated during

**Table 1.** Demographics of 73 pediatric patients with traumatic extremity or digit amputations in a study evaluating the etiology and outcomes of these injuries using the Childhood Opportunity Index to explore the role of social determinants of health.

| | | |
|---|---|---|
| Age, median [IQR], years | 12.7 | [8.4] |
| Male Sex, n (%) | 52 | (71) |
| Race, n (%) | | |
| Hispanic | 43 | (59) |
| White | 23 | (32) |
| Black | 3 | (4) |
| Asian | 1 | (1) |
| Other | 3 | (4) |
| Body mass index, median [IQR] | 19.7 | [8.5] |
| Childhood Opportunity Index score, median [IQR] | 19 | [33] |
| Childhood Opportunity Index categories, n (%) | | |
| Very Low | 37 | (51) |
| Low | 16 | (22) |
| Moderate | 9 | (13) |
| High | 5 | (7) |
| Very High | 5 | (7) |
| Injury Severity Score, median [IQR] | 5 | [7] |
| Nonextremity surgical intervention, n (%) | 8 | (11) |
| Prosthesis planned or fitted, n [IQR] | 10 | [14] |

*IQR,* interquartile range.

the first half of 2024 (n = 8) nearly met the highest rate overall rate of injured patients seen in 2018 (n = 9). For the overall cohort, the median Injury Severity Score (ISS) was 5 (IQR 7). Median length of stay (LOS) for the cohort was 2.9 days. The average LOS was 7.3 days, likely skewed by one patient with a maximum stay of 129.9 days. During our study period, 9,657 pediatric patients with a traumatic injury were admitted or received a trauma team activation. The percentage of traumatic amputations in this cohort was rare at 0.76%.

**Mechanism of Injury**

The most common mechanism of a traumatic amputation in this cohort was all-terrain vehicle (ATV) crash (or four-wheeler crash), followed by fireworks and an appendage being entrapped or caught in an object such as a door or fence. The next most common causes were power tool accidents (eg, table or chop saw), falling objects, industrialized machinery equipment accidents (eg, a hydraulic wood splitter or conveyor belt) and landscaping equipment (eg, a hedge trimmer or clippers). Less common causes were due to bicycle, motorcycle or dirt bike accidents, boating, rodeo roping competition, or animal bite. Surprisingly, MVC was tied for the seventh most common cause of injury. Figure 1 outlines all mechanisms of traumatic amputations in our cohort.

**Injury Mechanism by Age Group**

To better understand specific risk factors of these injuries, the cohort was split by age groups. The injury causes by age group were surprisingly similar. For patients in age group 0-4, an appendage becoming entrapped in an object was the most common cause. However, for all three additional age groups (5-9, 10-13 and 14-17) the most common cause of amputation was due to ATV crashes, with fireworks tying for first in the 10-13 age group. Fireworks were also the second leading cause in age groups 5-9 and 14-17. The distribution of mechanism of injury by age group is displayed in Figure 2.

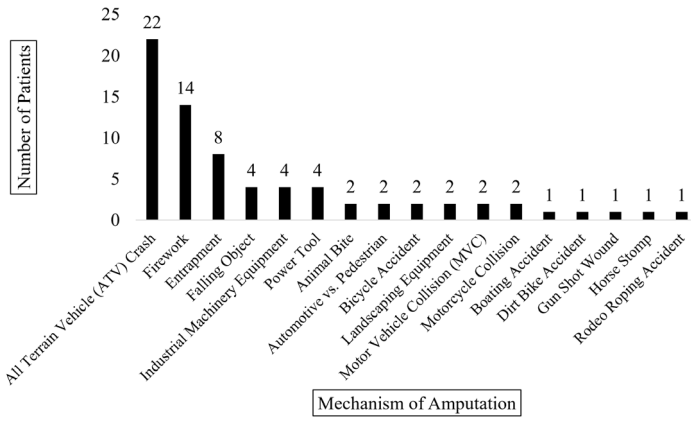


**Figure 1.** All mechanisms of traumatic extremity or digit amputations in pediatric cohort at single children's hospital.

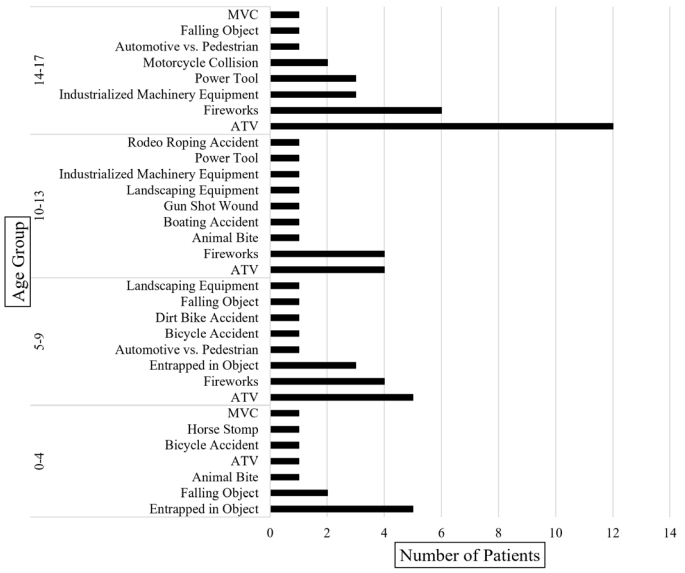


**Figure 2.** All mechanisms of traumatic extremity or digit amputations divided by age groups at a single children's hospital. *ATV*, all-terrain vehicle Crash; *MVC*, motor vehicle collision.

**Sites of Amputation**

Site of amputation was determined by chart review to ascertain the approximate location of amputation, and each appendage lost was counted separately. Most injuries occurred in the hands, with fingers being the most affected. The five most frequently amputated appendages were right index finger (n = 21), right long finger (n = 17), left long finger (n = 15), left ring finger (n = 14), and left small finger (n = 11). Patient handedness was not consistently reported. Figure 3 outlines the number of amputations by site of amputation. Thirty-three patients had more than one site of amputation. The highest number of amputation sites was 10 in a patient who lost all fingers due to their injury. Fifteen extremities were lost ranging from the wrist to the upper leg at the femur. The mechanisms of complete extremity amputations were ATV crashes (n = 5), fireworks (n = 4), automotive versus pedestrian accidents (n = 3), motor vehicle collision (n = 1), motorcycle collision (n = 1) and animal bite (n = 1). The total number of amputated digits and extremities for the cohort were 146.

**Impact of Childhood Opportunity Index on Cohort Amputation Rates and Outcomes**

To understand whether a child's Childhood Opportunity Index impacted the severity, rate, or outcome of a traumatic amputation, we conducted a subanalysis (Table 2). Due to a low number of total patients in the moderate opportunity, high

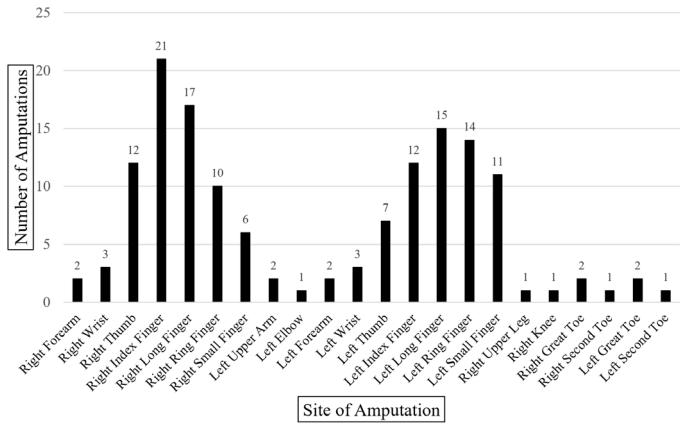


**Figure 3.** Number and site of extremity or digit amputation of entire pediatric cohort at a single children's hospital.

opportunity and very high opportunity cohorts, these three were combined into one group in the analysis (n = 19). One patient was from outside the country and did not have an assigned Childhood Opportunity Index and was excluded from this analysis. The only relationships that showed statistical significance was that rising Childhood Opportunity Index (increased opportunities) was weakly and negatively correlated with the total number amputations a patient suffered ($\rho = -0.25$; $P = .04$). There was no correlation between Childhood Opportunity Index and ISS, requiring nonextremity surgery for traumatic injuries, LOS in days, whether a prosthetic was planned or fitted, the need for a second surgery, unplanned readmission, unplanned ED visit, or amputation-related surgical complications.

## DISCUSSION

Traumatic extremity and digit amputations in children in our region were primarily caused by ATV crashes and fireworks in nearly all age groups. The causes of these injuries in our cohort are preventable. Educating parents on recreational vehicle safety and avoiding celebratory explosive devices is crucial to preventing these devastating injuries. In the United States, traumatic amputations in children have been associated with lawnmower accidents, specifically riding motors instead of push mowers, farming accidents, and animal encounters.[11-13] Internationally, documented causes have included household meat grinders in Turkey, MVCs in England, or doors in Greece.[14-16] study from Bertani et al describes their experience with 89 children who suffered war-related extremity injuries in Afghanistan.[17] Explosive devices were the highest cause of injuries (79%), and nearly 5% of their cohort died from the injuries received.[17]

A large review conducted in 2010 of 956 U.S.-based cases noted that digit amputations accounted for the majority of amputations (64%), similar to our patient population.[18] In 2017, a review of the National Trauma Data bank (NTDB) from 2007 to 2011 was conducted, analyzing 2,238 pediatric patients for trends in causes of amputations.[19] The authors reported that common amputation locations were fingers (54%) and toes (20%) with most amputations occurring in patients younger than 5 years and older than 15 years.[19] The former national review concluded that pediatric traumatic amputations created a large healthcare cost burden and prevention efforts should be prioritized to reduce these injuries and their associated healthcare costs.[18] The latter review noted that despite perceived increases in public awareness regarding the impact of specific causes such as lawnmowers current prevention efforts were inadequate.[19] Landscaping equipment was not a major cause of amputation in our region, potentially signaling that in the past decade, targeted prevention strategies for lawnmowers was successful, but this will need verification from larger national studies. The NTDB review noted that injuries were more common in younger and older children, but our cohort was skewed toward increased teenage population (14-17 years old).[19] It is possible that this was impacted by our regional referral pattern with severe injuries transferred in and less severe injuries managed locally.

In Vakhshori et al's review of the Healthcare Cost and Utilization Project (HCUP) Kids' Inpatient Database from 1997 to 2012, the most common causes of traumatic upper extremity amputations, if known, were lawn mower/machinery accidents and being caught in an object, with fireworks rounding out the top five mechanisms.[3] There is no description of ATV crashes, but MVCs were one of the main causes of major amputations above the elbow, with increasing rates over the study period while most other causes decreased in incidence.[3] Our patient cohort reflected overall similar mechanisms but a differing distribution of primary causes. This national sample had a similar overall median age of 12.1 compared to 12.7 in our cohort, signaling that the burden of this risk of amputation is in older elementary school children (aged 9–11 years).[3] The large cohort had an average LOS of 3.4 days, compared to our study's average of 7.3 days.[3] Our median LOS was 2.9 days, reflecting that our average was skewed by multiple high outliers demonstrating the range of impact that these injuries can have on healthcare burden. Although we did not review cost of treatment in our population, the mean hospital charge for the HCUP cohort was nearly $29,000 and increased with age.[3] This may reflect the higher burden of injury in older patients.

In our patient population, we were surprised to find that our three main regional culprits were ATV crashes, fireworks, and a digit being caught in an object, the latter a similar cause as found in the Greek cohort. We hypothesized that the cause of amputations would be primarily due to MVCs due to our proximity with multiple major interstate highways and our location in an urban environment with a rural catchment area. Two patients suffered from a traumatic amputation due to

**Table 2.** Analysis of Childhood Opportunity Index of pediatric cohort demonstrating no correlation between lower index score and Injury Severity Score or intervention required.

| | Very Low (n = 37) | Low (n = 16) | Moderate to Very High (n = 19) | *P* value | ρ [CI] |
|---|---|---|---|---|---|
| ISS, median [IQR] | 5 [6] | 8 [6.5] | 5 [8] | .66^ | 0.05 [-0.18 to 0.28] |
| Total number of amputations, median | 2 | 2 | 1 | **.04^** | -0.25 [-0.45 to -0.02] |
| Non-extremity surgical intervention, n (%) | 5 (13.5%) | 1 (6.3%) | 2 (10.5%) | .62^ | |
| Length of stay, median days | 3.7 | 2.1 | 2.6 | .27^ | -0.13 [-0.35 to 0.10] |
| Second operation, n (%) | 16 (43.2%) | 8 (50%) | 7 (36.8%) | .78* | |
| Unplanned readmission, n (%) | 3 (8.1%) | 1 (6.3%) | 1 (5.3%) | .69* | |
| Unplanned ED visit, n (%) | 4 (10.8%) | 2 (12.5%) | 0 | .25* | |
| Surgical complications from amputation, n (%) | 9 (34.2%) | 3 (17.8%) | 3 (15.8%) | .44* | |
| Prosthetic planned or fitted, n (%) | 7 (18.9%) | 2 (12.5%) | 1 (5.3%) | .17* | |

^Spearman correlation.
*Wilcoxon rank-sum test.
*ED,* emergency department; *IQR,* interquartile range; *ISS,* Injury Severity Score.

MVC, but ATV crashes were the clear cause of amputation-related injuries, spanning multiple age groups. Recent studies are raising the alarm of the danger of these recreational vehicles in children. Willis et al reported nearly 500 cases of ATV-related injuries at their Level I pediatric trauma center, calling for increased prevention education.[20] Concerns regarding the impact of off-road vehicle (ORV) crashes in our region are rising. Recent work from Kenney et al described the patterns of injuries and impact of social vulnerability on ORV crashes in the adult trauma population in our region.[21] Over a six-year period, 574 adult patients were treated at our institution for ORV crashes with the majority originating from a region of high social vulnerability.[21] It is possible that future analyses of pediatric ORV crashes in our region will demonstrate a similar pattern of higher vulnerability groups being disproportionally impacted.

The primary causes of traumatic extremity and digit amputations are accidental, as demonstrated in our study, but nonaccidental trauma should be considered by clinicians caring for these patients.[2] The management of these injuries may vary depending on location of care. In a review of the HCUP Project Kids' Inpatient Database from 2000 to 2006 regarding pediatric finger injuries, Squitieri et al found that most children were treated at nonchildren's hospitals but that there were notable disparities in the attempted reimplantation rates for Black, Hispanic, or uninsured patients.[22] A similar paper using the same database queried it from 2000 to 2012 to understand disparities in those who underwent reimplantation for thumb and finger amputations finding that most were younger, female, and had private insurance.[23]

Our cohort did not have any documented nonaccidental trauma concerns. However, 50% of the cohort resided in a neighborhood with very low opportunity. Only 27% lived in a neighborhood that was considered to have moderate, high or very high childhood opportunity. In our subanalysis, we found that although this was a striking difference, the only outcome that correlated with the Childhood Opportunity Index grouping was a small increase in total number of amputation injuries. All other differences in ISS, LOS, unplanned readmissions, unplanned ED visits, or amputation-related surgical complications were not statistically significant between the groups. However, due to the strains linked to residing in a lower opportunity neighborhood, long-term outcomes including rehabilitation attendance should be assessed to identify areas in which these families can better be supported. Buncke et al noted in their review of pediatric mutilating hand injuries that conscientious, advocative, and consistent parental support was key for fostering the best rehabilitation outcomes.[24]

Targeted public health interventions are needed to address the causes of traumatic amputations in children in our region, particularly due to ATV crashes and fireworks. Awareness regarding the significant morbidity caused by recreational vehicles and fireworks is a first step.

## LIMITATIONS

There are limitations to this study due to its retrospective nature and regional referral patterns. Our trauma database

does not include traumatic injuries that were exclusively treated in the ED without a trauma activation or admission; therefore, minor injuries may have been missed. There are some missing data points in the electronic health record, and multiple patients were lost to long-term follow-up, precluding the ability to analyze the long-term effects of these injuries. We were unable to ascertain handedness in most patients from medical records, limiting inferences based on side of injured upper extremity. Although our hospital receives many pediatric transfers for pediatric trauma continuation or pediatric hand specialization consultation, our regional sample is likely missing patients cared for primarily by rural hospitals, thus limiting our overall cohort size. Additionally, we do not have complete injury patterns of all trauma mechanisms, limiting the evaluation of incidence of these injuries. Furthermore, at the time of study, Childhood Opportunity Index data was not available for years 2022 to 2024; therefore, the index level assignments were extrapolated from 2021 data, which may impact the accuracy of comparisons of groups. The Childhood Opportunity Index category comparisons were exploratory in nature and not prescriptive. Further studies are needed to target the long-term implications of these injuries when obtained during childhood.

## CONCLUSION

A total of 73 children in our region suffered a traumatic digit or extremity amputation over 9.5 years. The two most common causes were ATV (or four-wheeler) crashes and fireworks. The most common location of amputation was the right index finger, right long finger, and left long finger. Most patients lived in a neighborhood with very low or low Childhood Opportunity Index scores. Increased targeted public awareness of the growing danger of ATV crashes and fireworks in our community may inform prevention of these life-altering injuries.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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# Impact of a Rapid Assessment Zone on Patient Throughput in an Urban Pediatric Emergency Department

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**Introduction:** The rapid assessment zone is a newer model for optimizing emergency department (ED) throughput. Similar models implemented in adult ED settings have shown improvements in throughput parameters. However, few studies have taken place in the pediatric ED setting. Our study objective was to assess the impact of implementing a rapid assessment zone on throughput in an urban pediatric ED. We hypothesized that length of stay (LOS), time to bed placement, and time to see a clinician would decrease after the intervention and remain sustainable over long-term follow-up.

**Methods:** This retrospective study assessed the effect of rapid implementation from May 2012–April 2018 on LOS for ED visits for three two-year time periods: pre- and post-rapid assessment zone and post-follow-up. Our primary outcome measures were LOS, time from registration to bed, and time from registration to first clinician evaluation. Secondary outcome measures were how LOS differed between high- and low-acuity visits. We analyzed data using Kruskal-Wallis for comparison of medians and Wilcoxon rank-sum tests with Bonferroni correction for pairwise comparisons.

**Results:** There were 304,318 unique ED visits from May 1, 2012–April 30, 2018, with an increase in volume over time (92,551 visits pre-rapid assessment zone and 106,530 visits post-follow-up). Overall median LOS decreased from pre- rapid assessment zone, post- rapid assessment zone, and post-follow-up, respectively (110 minutes versus 101 minutes vs 94 minutes; $P < .001$). When stratified by acuity level, low-acuity visit LOS decreased from pre- rapid assessment zone to post-rapid assessment zone to post-follow-up (85 min vs 77 min vs 70 min; $P < .001$), whereas LOS for higher-acuity levels was, on average, unchanged (144 min vs 149 min vs 143 min for pre-RAZ, post- rapid assessment zone, and post-follow-up, respectively; $P < .001$). The overall registration to clinician time decreased from 15 minutes to 13 minutes ($P < .001$) between pre-rapid assessment zone and postfollow-up, which is statistically but not clinically significant.

**Conclusion:** Implementation of a rapid assessment zone significantly decreased overall length of stay in our pediatric ED despite increased patient volume, especially for lower acuity patients. The rapid assessment zone model can be effective in preventing crowding in a pediatric ED with a large proportion of low-acuity visits. [West J Emerg Med. 2026;27(5)1298–1304.]

## INTRODUCTION

Optimization of emergency department (ED) front-end operations has become a crucial area of focus for quality improvement because crowding has been associated with negative effects on patient health and well-being.[1–5] Examples of front-end–focused methods that have been shown to be effective include physician-led triage and split-flow models, including fast-tracking lower acuity patients.[6] One specific model for optimizing throughput is the rapid assessment zone, which streamlines lower-acuity patients to designated areas ("zones") for joint assessment and disposition by ED nurses and clinicians. While lower acuity visits typically require minimal care, they disproportionately contribute to ED crowding, which impacts the care of all patients.[7]

Rapid assessment zones or related models have been implemented and studied in adult EDs, with most showing modest improvement in time-related patient outcomes.[8–12] However, there are few reported studies of the impact of rapid assessment zones, or similar throughput modification, on similar outcomes in pediatric EDs (PED).[13–16] Pediatric EDs experience higher rates of low-acuity visits due to a low threshold for ED visits for childhood illness, despite having a primary care physician.[17] This results in longer wait times, delayed assessment and disposition processes, and high rates of left without being seen. Therefore, efficiency in managing low-acuity visits is vital for reducing crowding and improving patient outcomes for PED visits of all acuity levels.

*Population Health Research Capsule*

What do we already know about this issue?
*Front-end focused methods of optimizing emergency department (ED) throughput are effective in adult EDs. Pediatric EDs experience crowding due to their high volume of low-acuity visits.*

What was the research question?
*Does throughput in an urban pediatric ED improve with the implementation of a rapid assessment zone?*

What was the major finding of the study?
*Median length of stay decreased 16 minutes (15%; 110 min to 94 min; P < .001) and 18% for low-acuity visits.*

How does this improve population health?
*Optimizing pediatric ED throughput with front-end facing methods like rapid assessment zones promotes improved quality of care and the ability to care for more patients.*

At the time, our study was the first to describe the implementation of a rapid assessment zone in an urban PED and its effect on time-related outcomes. Prior to the implementation of the. rapid assessment zone, patients were equally divided on arrival into one of two ED zones regardless of acuity or concern, except for patients requiring resuscitation. The new model, however, allows for 60% of visits to be streamlined to the rapid assessment zone for efficient evaluation and improved movement through the ED. When operating at full capacity, the rapid assessment zone has 15 beds, with five to seven focused on initial assessment of the patient. Staffing changes throughout the day to account for patient arrival volumes. The area is staffed by one attending physician, one to two nurse practitioners or physician assistants, one to two resident physicians, and two to four nurses, with maximum staffing during peak arrival times.

In this model, patients who present to the ED are initially triaged by nurses who determine patient allocation based on acuity and anticipated length of time needed for patient care. Low-acuity patients with anticipated LOS of < 60 minutes are sent to the rapid assessment zone, with further distribution based on expected diagnostic and therapeutic needs. Moderate- and high-acuity patients, or those with anticipated high-resource use with LOS > 60 minutes are sent to the traditional ED track. A list of inclusion and exclusion criteria is available for triage nurses to aid in determining the disposition of the patient (Table 1). Rapid assessment zone allocation is followed by joint assessment and disposition by a physician and nurse, expediting assessment and diagnosis in this new process. The rapid assessment zone inclusion and exclusion criteria have been modified since their implementation. Originally, inclusion criteria were limited to quick disposition and short LOS. However, this practice overwhelmed the other patient care areas due to few patients meeting criteria, and due to lack of objective parameters for rapid assessment zone allocation. Over time, additional complaints such as specific types of abdominal pain, chest pain in noncardiac patients, or nonpetechial rashes can be considered for the rapid assessment zone (Table 1). Additional details of the model, including its development and implementation, are published elsewhere.[18]

The aim of this study is to add to the paucity of literature on the impact of rapid assessment zone implementation on PED throughput. Improved throughput with rapid assessment zone implementation is expected due to the accelerated triage care, elimination of upfront registration tasks, immediate placement in ED beds, and joint physician/nurse assessment, all of which streamline movement through the ED. We hypothesize that the LOS, time to bed placement, and time to see a clinician will decrease post- rapid assessment zone implementation and will sustain post-follow-up. Furthermore,

**Table 1.** Rapid assessment zone inclusion and exclusion criteria for triage disposition.

| Inclusion criteria | Exclusion criteria |
|---|---|
| Abdominal pain | < 60 days old with fever/low temperature |
| Cellulitis | Asthma score > 5 |
| Chest pain (non-cardiac patient) | Amputations |
| Congestion | Bilious emesis |
| Constipation | C-collar and backboard |
| Cough | Ingestion |
| CPS/CSA | Limping with fever |
| Croup without stridor | Medically complex patients |
| Dental complaints | Nail bed injuries |
| Diarrhea (non-bloody) | Obvious incision and drainage needed |
| Difficulty breathing | Open fractures |
| Dysuria | Petechial rash |
| Ear pain | Pre-arrival from specialty clinics |
| Extremity pain without deformity (swelling OK) | Pregnant patients |
| Eye drainage | Retractions or respiratory distress |
| Fever | Sedation |
| Foreign body (ingested or nose/ear) | Swallowed magnet or battery |
| Headache | |
| Head injury | |
| Lacerations (simple, must visualize) | |
| Nosebleeds | |
| Rashes (not petechial) | |
| Simple febrile seizure (< 1 in 24 hours, < 20 minutes duration) | |
| Sore throat | |
| STI check | |
| Syncope (no cardiac history) | |
| Testicular pain | |
| Vomiting | |

*CPS*, child protective services; *CSA*, child sexual assault; *RAZ*, rapid assessment zone; *STI*, sexually transmitted infections.

we expect that this change will improve LOS for lower acuity visits, without worsening LOS for moderate- and high-acuity visits.

## METHODS

This retrospective, before-and-after study assessed the effect of rapid assessment zone implementation on an urban PED throughput. Consecutive patient visits were collected from the electronic health record (EHR) for a 6-year period and then separated into 2-year time periods to compare throughput outcomes from before implementation of a rapid assessment zone to the two years after, and the following two years for sustained effect. Visits were collected from May 1, 2012–April 30, 2018. Data were then divided into three groups based on 2-year time frames: pre- rapid assessment zone (May 1, 2012–April 30, 2014); immediately post-rapid assessment zone (May 1, 2014–April 30, 2016); and post-follow-up (May 1, 2016–April 30, 2018). Time-related outcome data exported from the EHR included precalculated time from arrival registration to seeing a clinician (registration to clinician), time from registration to placement in a bed (registration to bed), and time from registration to discharge ie, ED LOS. We excluded the visits where the data were missing, partial, or not logical, such as no acuity documented; multiple dates/times; LOS < 0 minutes or > 5 days; time from registration to bed or clinician greater than LOS; left without being seen and saw a clinician; and time from registration to clinician or bed being < 0 minutes.

The main outcomes assessed were ED LOS, time from registration to placement in a bed, and time from registration to seeing a clinician. To examine how rapid assessment zone implementation affected these ED throughput parameters, we assessed for trends in LOS over the study period as well as comparing averages in LOS, registration to bed, and registration to clinician, between the three time periods (pre- and immediately post-rapid assessment zone, and post-follow-up). Additionally, we examined how overall LOS differed between high-to-moderate acuity (levels 1-3) and low-acuity (levels 4 and 5) visits over the study period.

All time-related outcomes were in terms of minutes and treated as continuous variables. Data were not normally distributed and, therefore, were thus analyzed with Kruskal-Wallis for nonparametric comparisons of statistical difference and reported as median (interquartile range [IQR]: 25$^{th}$, 75$^{th}$ percentile). If the medians were significantly different across the three time periods, we used Wilcoxon rank-sum tests for pairwise comparisons with Bonferroni correction for reducing type 1 error. All analyses were conducted using SAS software v9.3 (SAS Institute Inc, Cary, NC). $P$ values < 0.05 were considered significant.

Our methods adhered to most of the Worster and Bledsoe (2005) methodologic standards in medical record review. Specifically, data abstractors were trained and used an abstractor form, sampling methods were described (which included using medical records), and case selection criteria were developed with specific variable definitions.[19] We did not, however, blind the abstractor to the details of the study or discuss interobserver reliability. Missing data were simply excluded and not managed statistically. This study was considered exempt by the institutional review board.

## RESULTS

There were 304,318 unique ED visits from May 1, 2012–April 30, 2018, after excluding 5,147 visits. Visits were divided into pre- rapid assessment zone (May 1, 2012–April 30, 2014; n = 92,551), post-rapid assessment zone (May 1, 2014–April 30, 2016; n = 105,237), and post-follow-up (May 1, 2016–April 30, 2018; n = 106,530) (Figure 1). Volume increased over time (92,551 visits pre-rapid assessment zone to 106,530 visits post-follow-up). High-to-moderate acuity

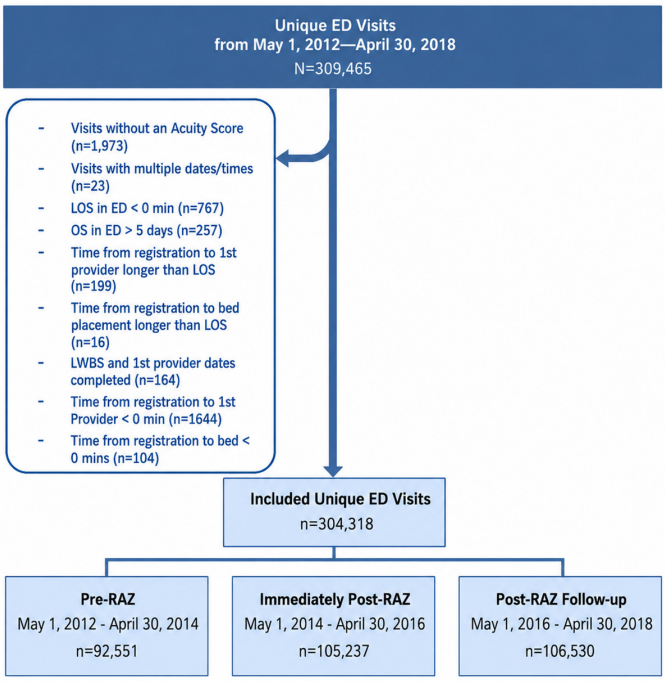


**Figure 1.** Inclusion and exclusion study criteria for ED visits in a retrospective cohort study of rapid assessment zone implementation in a pediatric emergency department. *ED*, emergency department; *LOS*, length of stay; *LWBS*, left without being seen; *RAZ*, rapid assessment zone.

level visits were more prevalent in the pre- rapid assessment zone rapid assessment zone time as compared to post-rapid assessment zone and post-follow-up (51.8% versus 42.4% versus 42.8%).

Overall median ED LOS decreased by 14.5%; from 110 minutes (IQR 72-165) pre-rapid assessment. zone to 101 minutes (64-156] post-rapid assessment zone, and to 94 minutes (59-148) post-follow-up ($P < .001$). We did not find clinically significant differences in length of time from registration to bed after the implementation of rapid assessment zone. Time from registration to clinician contact decreased from 15 minutes pre-rapid. assessment zone to 13 minutes post-follow-up ($P < .001$); however, this difference of 2 minutes is likely not clinically significant (Table 2).

When stratified by acuity level, we found that median ED LOS (minutes) for low-acuity visits significantly decreased over the study periods from pre-rapid assessment zone, to post-rapid assessment zone, and then to post-follow-up (85 versus 77 vs 70; $P < .001$). This corresponds to a 17.5% reduction in average LOS for lower acuity visits from pre-rapid assessment zone to post-follow-up. For high-to-moderate-acuity level visits, LOS was, on average, unchanged (144 min vs 149 min vs 143 min for pre-rapid assessment zone, post-rapid assessment zone, and post-follow-up, respectively; $P < .001$) (Figure 2).

When LOS was stratified by month for evaluation of seasonal variation, peaks in visit time varied by month and year, and these changes were similar between low- and higher acuity groups (ie, both acuity groups reflected a similar magnitude of increase in LOS when an increase was observed) (Figure 3). From January to March in 2013, 2015, and 2018, more dramatic increases in LOS were seen. Despite seasonal upticks in LOS, lower acuity visits still trended downward while higher acuity visits remained minimally changed.

## DISCUSSION

We found that the implementation of a rapid assessment zone improved throughput in an urban PED. We noticed a significantly decreased median LOS after rapid assessment zone implementation by 16 minutes (14.5%; $P < .001$). While performed in adult EDs, studies conducted at other institutions have shown data consistent with these findings.[7–12] A 2005 study found that average monthly wait times decreased by 24 minutes (95% CI, 10-38), and overall ED LOS decreased by 31 minutes (95% CI, 6-57) after implementing their rapid

**Table 2.** Changes in throughput-related outcomes length of stay, registration to bed, and registration to first clinician contact) over study periods during pre-rapid assessment. zone, post-rapid assessment zone, and post-follow-up study periods in a pediatric emergency department.

| | Study Period | | | |
|---|---|---|---|---|
| Outcome | Pre-RAZ n=92,551 | Post-RAZ n=105,237 | Post-follow-up n=106,530 | *P* value |
| LOS (minutes) | 110 [72, 165] | 101 [64, 156] | 94 [59, 148] | < .001 |
| Registration to bed (minutes) | 5 [3, 10] | 6 [3, 16] | 5 [3, 11] | < .001 |
| Registration to first clinician contact (minutes) | 15 [8, 30] | 15 [8, 31] | 13 [7, 27] | < .001 |

Data are reported as median [25th percentile, 75th percentile]. *P* values are based on Kruskal-Wallis comparison of medians and Wilcoxon rank-aum test with Bonferroni correction for pairwise comparisons.
*LOS*, length of stay; *RAZ*, rapid assessment zone.

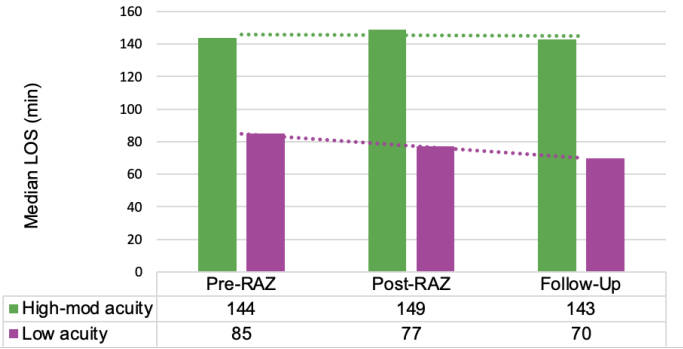


**Figure 2.** Length of stay by acuity level over study periods in a retrospective cohort study of rapid assessment zone implementation in a pediatric emergency department.
*ED*, emergency department; *LOS*, length of stay; *min*, minute; *mod*, moderate; *RAZ*, rapid assessment zone.

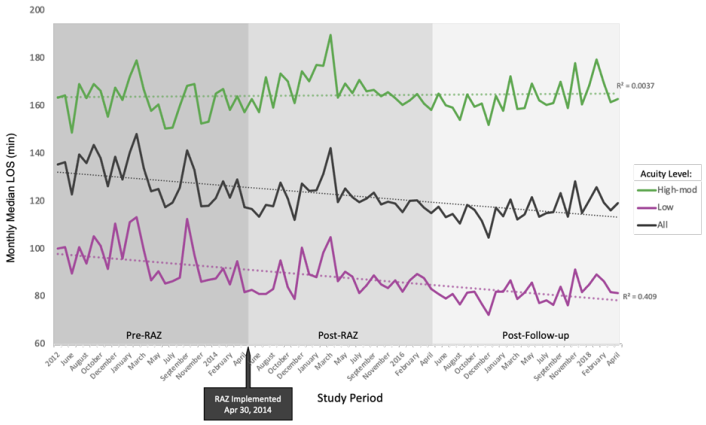


**Figure 3.** Length of emergency department stays by month and acuity during pre-rapid assessment zone, post-rapid assessment zone, and post-follow-up rapid assessment zone study periods in a retrospective cohort study of rapid assessment zone implementation in a pediatric emergency department.
*LOS*, length of stay; *min*, minute; *RAZ*, rapid assessment zone.

triage model.[10] Similarly, White et al (2012) implemented a "supplemented triage and rapid treatment" model resulting in decreased overall LOS by 29 minutes (from 361 minutes to 332 minutes; $P < .001$).[8] A more recent study by Anderson et al (2020) also found that implementation of a rapid assessment zone rapid assessment zone reduced median LOS by 31 minutes (15.8%), and also time from arrival to clinician contact decreased by 15 minutes (53.6%).[12] Differences in results may be due to a lack of a standard outcome, differences between pediatric and adult EDs in staffing, patient volume and relative acuity, and registration needs.[20]

Few have studied the effect of a rapid assessment zone or other throughput optimization models on outcomes in PEDs. However, a study quite similar to ours was very recently published and reflected the same findings, including a decreased LOS of 15.7 minutes ($P < .001$) compared to our 16 minutes.[21] The main differences between the studies are that we placed a focus on stratifying our data by acuity, whereas they placed a focus on the rate of left without being seen, which was excluded from our study. In general, a recent technical report by the American Academy of Pediatrics summarizes the available evidence and suggests guidelines to improve PED crowding.[17] Throughput-related solutions included staffing and room allocation models such as fast tracks or streaming, rapid assessment zone, and clinician in triage. However, given the lack of available data, most of the cited studies were conducted in adult EDs; therefore, the results may vary when compared with PEDs as seen in our study and Ramirez et al.[21] A systematic review by Morley et al also provides a comprehensive summary on the different interventions aimed at optimizing ED throughput and their associated outcomes.[6] This includes not only front-end methods such as a rapid assessment zone but also other effective strategies, such as bed management and point-of-care testing.

We also found that the overall reduction in LOS differed by patient acuity, with those at lower levels of acuity benefiting the most with a more sustained and larger decrease in LOS over time. This trend was observed despite seasonal LOS upticks during upper respiratory illness months. This finding was expected given the nature of lower acuity concerns necessitating fewer tests and less complex or time-consuming interventions. The overall reduction in LOS was likely due to increased bed availability/turnover and, therefore, shorter wait times for all patients. One study similarly found that their intervention decreased LOS among lower acuity visits with no significant change in LOS for high- to moderate-acuity visits. The same group then published another paper, detailing how they further modified their model to successfully improve LOS specifically for high-acuity patients.[22] Importantly, the modifications were cost-neutral (ie, they did not require additional clinicians, space, or resources). These results, albeit conducted in an adult ED, are promising and may represent a future of iterative improvements in throughput optimization models to suit the unique needs of PEDs and benefit all acuity patients.

We expected this benefit in LOS for lower acuity visits, but questioned whether LOS would change for higher acuity visits. We observed no clinically significant change or worsening in LOS over time for high-acuity visits, although the volume of high-acuity visits decreased approximately 10% over the study period, which may have affected the results. This finding is, however, consistent with available literature, which has demonstrated that throughput models similar to the rapid assessment zone have not had a negative impact on high-acuity visit LOS or delay in first point of contact with a physician.[23] Further modification to the rapid assessment zone protocol, similar to the work of Chartier et al could be

conducted in an attempt to decrease LOS among high- to moderate-acuity visits, as well.

The consistency in data among multiple institutions of varying settings, patient populations, and ages—including data from our PED—aids in bridging the gap in generalizability that was previously present in the data pool. The improvement in LOS as shown in our study can potentially improve patient satisfaction, bed availability in times of patient surges, bed availability to critically ill and injured patients, and staff utilization. Joint assessment with the physician and nursing staff is not only time effective but also aids in collaboration with the multiple members of the care team. This collaboration can improve patient care, communication, and satisfaction. Other secondary outcomes, such as patient satisfaction, have been shown to improve with rapid assessment zone implementation in multiple studies conducted in adult EDs.[1,24,25] While we did not assess patient satisfaction with our data collection, we recognize the importance of considering the up- and down-stream effects of rapid assessment zone implementation on all patients. Future research is warranted to identify and examine the negative and positive externalities associated with implementing such models and how to mitigate or accentuate those effects.

The effect of implementing a rapid assessment zone on ED throughput may differ in larger cities or more rural areas with different patient populations and, therefore, acuity. In 2018, over 55% of visits to our high-volume PED were lower acuity (Emergency Severity Index level 4 or 5), with approximately 55,000 annual visits and an admission rate of 8.4%.[17] This compares to a national PED median number of annual visits of approximately 25,000, with 46.4% being lower acuity, and an average admission rate of 15 %.[20] Our PED had overall higher volumes, a higher percentage of lower acuity visits, and lower admission rates compared to the other PEDs. The high proportion of lower acuity patients seen in our ED is due to poor access to pediatric urgent care in the area and limited pediatrician office hours. Therefore, by decreasing the burden of these lower acuity visits on wait times in the ED, there is an impact on overall LOS and potentially on the quality of care provided to all our patients, especially those of higher acuity. We hypothesize that rapid assessment zone implementation in similar settings (high volume, high proportion of low-acuity patients) would prove to be the most effective, as is demonstrated with our PED.

We did not look at the impact of the COVID-19 pandemic on our ED throughput. In general, there were fewer pediatric ED visits nationally during the pandemic; LOS was prolonged compared to pre-pandemic times.[26–31] This corresponded with a greater proportion of high-acuity visits, as well as increased sanitation measures, staffing shortages, requirements for use of personal protective equipment, and other factors that increased the time needed to deliver safe and effective care. Given the generally low acuity of COVID-19 symptoms in pediatric populations, many COVID-19–related visits were likely allocated to a rapid assessment zone. Therefore, further research is needed to assess the effect of the pandemic on LOS and post-pandemic recovery in PEDs with and without a rapid assessment zone. Additional research may be done to assess the impact of improved ED throughput on rates of nosocomial transmission.

## LIMITATIONS

One limitation of this study is the inability to control for residual confounding factors that may have influenced ED throughput. Factors that may have changed over the course of the study period, which were not explicitly tracked, include staffing volume, charting procedures, or general ED operations. Moreover, increases in patient volume and changes in the type of acuity over this six-year period may have also influenced results. Other limitations of note include being a single-site study, and we did not collect data on multiple other outcomes assessed in the literature for ED throughput, such as rates of leaving without being seen or leaving before treatment completion. Further studies may choose to include these additional parameters to encompass a broader scope of ED throughput analysis.

## CONCLUSION

In this retrospective operational study, implementing a rapid assessment zone in an urban pediatric emergency department significantly decreased overall length of stay. This change differed by visit acuity, with those with the lowest levels of acuity benefiting the most with a more sustained and larger decrease in LOS over time. In emergency departments with high volumes of low-acuity visits, we believe that implementation of a rapid assessment zone model is potentially useful in improving ED throughput. However, further research is needed to assess the effect of the COVID-19 pandemic on LOS and post-pandemic recovery in our pediatric. ED.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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# Nurse and Physician Stakeholder Guidance on Improving Sexually Transmitted Infection Care in a Pediatric Emergency Department

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**Introduction:** Pediatric emergency departments (PEDs) and general EDs in the United States (U.S.) do not consistently deliver sexually transmitted infection (STI) care that aligns with clinical guidelines. To inform the development of an implementation strategy plan aimed to improve STI care in a PED, we interviewed PED nurse and physician stakeholders to identify challenges and corresponding potential solutions aimed to improve STI care in a PED.

**Methods:** We conducted semi-structured interviews with 27 stakeholders consisting of emergency medicine (EM) residents, pediatrics residents, pediatric EM (PEM) fellows, attending pediatric emergency physicians, and PED nurses at an academic urban PED. Using the Tailored Implementation in Chronic Diseases (TICD) framework, we prepared semi-structured interview guides specific to stakeholder roles structured according to the usual six successive workflow stages of STI care in the PED (triage, history-taking, physical examination, testing, treatment, and follow-up). Questions concerned current practices on providing STI care, challenges encountered, and potential solutions. Interviews were transcribed and analyzed using rapid content analysis. Responses were coded independently by two reviewers and categorized by TICD determinant domain.

**Results:** Participants identified multilevel implementation challenges across the stages of STI care in the PED. Structural challenges included lack of privacy and limited private exam rooms, inadequate STI-related workflows, and inadequate waiting areas. Procedural challenges included the following: nonstandardized triage protocols; unclear role delineation; confusing sample collection procedures; insufficient training in STI examination, testing, and treatment procedures; variable documentation practices; and difficulty ensuring follow-up. Suggested solutions included development of role-specific STI protocols, smart phrases for documentation, improved sample-labeling procedures, prepackaged medications for empiric treatment, and embedded referral pathways to an adolescent care clinic.

**Conclusion:** Using the TICD framework, this study identified key challenges, such as gaps in training, protocols and transition of care, and corresponding stakeholder-informed solutions to improve adolescent care for STIs in a pediatric ED setting. These findings can guide efforts to implement evidence-based STI practice guidelines in PEDs and general EDs. [West J Emerg Med. 2026;27(5)1305–1316.]

## INTRODUCTION

Adolescents and young adults 15 to 24 years of age accounted for almost half of new sexually transmitted infection (STI) cases diagnosed in the United States (U.S.) in 2023.[1] Although the U.S. Centers for Disease Control and Prevention (CDC) has promulgated guidelines on STI evaluation and treatment, there have been reports of poor compliance with recommended practice in U.S. pediatric emergency departments (PEDs) and general EDs.[2] Despite often being the initial care clinicians for adolescents and young adults with possible STIs, PEDs and general EDs have demonstrated deficiencies in STI evaluation and treatment, including the following: absent or incomplete documentation of sexual histories with differences by sex; incomplete physical examinations; lack of or incomplete STI testing (including lack of HIV testing) with differences by sex; lack of pregnancy testing; disparate documentation and performance of STI or pregnancy testing by race; STI treatment provision not in accordance with guidelines; disparate STI treatment by sex, Hispanic ethnicity, or race; incomplete or missing STI-related discharge instructions with differences by sex; and lack of referral to outpatient follow-up care.[3-25] Understanding the challenges that prevent healthcare professionals from providing STI care to adolescents and young adults according to CDC guidelines is a necessary first step in the pathway to improve STI care among adolescents and young adults.

We sought to develop, deploy, and evaluate an implementation strategy plan designed to improve the delivery of STI care at a U.S. urban academic center PED. The evidenced-based practices we implemented were the 2021 CDC STI Treatment Guidelines.[2] To inform this implementation strategy plan, we interviewed key nursing and physician stakeholders involved in the care of PED patients with possible STIs. The goal was to identify challenges and suggested solutions related to conducting six key steps in ED STI care (triage and initial assessment, medical history taking and documentation, physical examination and documentation, STI testing, empiric treatment, and follow-up arrangements) in accordance with CDC guidelines. This formative qualitative study was guided by this research question: What barriers and stakeholder-informed solutions do PED nursing and physician staff identify during each of the six stages of STI care delivery? The objective of this study was to elucidate and characterize the challenges and accompanying suggested solutions to overcome those challenges in delivering STI guideline-concordant care in this PED, as reported by PED nursing and physician staff. Our ultimate objective was to use the findings to inform the development of an implementation strategy plan to improve delivery of guideline-concordant STI care in the PED.

*Population Health Research Capsule*

What do we already know about this issue?
*Pediatric emergency departments (PEDs) and general EDs do not consistently deliver sexually transmitted infection (STI) care that aligns with clinical guidelines.*

What was the research question?
*What do PED nurses and physicians identify as the challenges and solutions to providing guideline-concordant care for patients with a possible STI?*

What was the major finding of the study?
*Nurses and physicians offered actionable solutions to address impediments to providing care to STI patients.*

How does this improve population health?
*Suggested solutions to challenges in providing STI care in the PED that could assist in reducing the spread and morbidity of these infections.*

## METHODS

### Study Design, Setting, and Research Team

This investigation was conducted as part of a three-phase (formative, implementation and evaluation phases) larger implementation project designed to improve STI care in a U.S. PED. The larger project aimed to develop, deploy, and evaluate an implementation strategy plan to increase the delivery of STI care in the PED concordant with the 2021 CDC STI Treatment Guidelines. The evidence-based practices targeted for implementation in this plan were these guidelines. This paper reports only the formative qualitative phase of the project, which involved semi-structured interviews with PED nursing and physician stakeholders to identify challenges, facilitators, and suggested solutions related to guideline-concordant STI care delivery in the PED.

The qualitative research design was a case study of the STI care processes in this PED, in reference to the 2021 CDC STI Treatment Guidelines.[2] The qualitative research paradigm was pragmatic, such that although the interviews were designed to address Tailored Implementation in Chronic Diseases (TICD) implementation determinants, the semi-structured interviews were flexible to permit new information to be explored as it arose. The study was informed by the TICD framework and organized according to the six sequential workflow stages of ED STI care: triage and initial assessment; history-taking; physical examination; testing; treatment; and follow-up.[26]

The PED for this project was situated at the Mount Sinai Hospital, a quaternary care, urban, academic center in New York City that hosts emergency medicine (EM), pediatrics, and

family medicine residencies, as well as a pediatric emergency medicine (PEM) fellowship. The PED clinical team is composed of nine PEM attending physicians, three PEM fellows, and 26 full- and part-time nurses. Emergency medicine (EM) residents from two separate residency programs, pediatrics residents from one residency program, and family medicine residents from one residency program (all of which are affiliated with the medical school) provide additional medical staff coverage. The study was approved by the medical school's institutional review board. We followed the Standards for Reporting Qualitative Research checklist to ensure transparency and rigor in reporting.[27] The research team was comprised of three emergency physicians (including a PEM-fellowship trained PEM physician and two adult emergency physicians trained in implementation science methodology), an adolescent health physician, and a survey methodologist.

**Determinants Framework and Interview Guide Development**

To identify the relevant determinants of implementing improved processes for STI care, we employed the TICD framework for this project. The research team reviewed all TICD domains and selected those most applicable to the delivery of evidence-based STI care in the PED. Each selected determinant was prioritized by the research team based on its importance and feasibility. The resultant list of prioritized determinants was paired with an exploration process—research reviews, expert consultations (eg, with pharmacists or information technologists (IT)), or stakeholder interviews. This paper reports the work from the stakeholder interviews.

For the stakeholder interviews, we developed interview guides to explore the prioritized TICD determinants in context of the goals of the project. We created the semi-structured interview scripts for this investigation, which included open-ended questions and prompts to elaborate on the responses. The guides were structured around the usual six successive workflow stages of STI care in the PED: 1) triage and initial assessment; 2) obtaining the patient history; 3) conducting the physical examination; 4) testing; 5) treatment; and 6) arranging follow-up. Questions were designed to elicit responses about standard practices, barriers, facilitators, and potential solutions to improve STI care. Separate guides were developed for physicians and nurses. Interview scripts are available in the Supplement 1 (nurses) and Supplement 2 (physicians).

**Participant Recruitment and Interview Procedures**

Using stratified purposive sampling, we recruited stakeholders targeting at least five participants per stratum (eg, attending physicians, residents, nurses) in accordance with qualitative research best practices to achieve saturation.[28] Residents were eligible only if they had completed at least one month of PED service. At least one resident from each postgraduate year was recruited to permit a range of perspectives based on years of experience. Family medicine residents were not included in the interviews because they perform few clinical shifts in the PED, in contrast to EM and pediatrics residents. The final stakeholder group was comprised of six EM residents, six pediatrics residents, six PEM faculty, three PEM fellows (the entire complement), and six PED nurses. Interviewed EM and pediatrics residents range between first year residents to chief residents, who had completed at least one month of PED service. Interviewed faculty members completed a PEM fellowship, and had been with the department for at least three years. The final stakeholder group had 19 females, eight males; 21 identified as White, five identified as Asian, one identified as Hispanic.

Participants were recruited via email and announcements at staff meetings. Because recruitment occurred through a combination of direct outreach and open staff-meeting announcements, the total number of eligible individuals who received or viewed recruitment information was not systematically tracked. Therefore, a response rate could not be calculated. We continued recruitment until the targeted clinical roles were represented. All interviews were conducted virtually by the principal investigator and project manager. Participants confirmed their consent to be included in the study at the start of each interview. The interview guides were semi-structured and included open-ended questions and prompts. Interviews were purposely iterative; when participants raised new workflow issues or suggested solutions relevant to subsequent interviews, the interviewer added or modified probes to explore those topics with later participants. The core interview domains remained consistent across interviews. Interviews were audio recorded and transcribed verbatim. Participants received a gift card.

**Interview Transcript Analyses**

Transcripts were analyzed using rapid content analysis. Two physician coders not involved in the interviews nor the creation of the interview guide independently summarized responses by stakeholder type. They met afterward and prepared a combined summary of responses categorized by topic, subtopic and sub-subtopic, which is provided in Supplement 3. Discrepancies were resolved through consensus. Challenges and solutions were categorized by TICD determinants and arranged according to the framework of the six stages of the usual flow of patients through the PED for a visit for a possible STI. Responses were summarized by stakeholder type rather than quantified by individual participant frequency. Therefore, stakeholder abbreviations in the supplemental results table indicate that at least one participant from that stakeholder group identified the corresponding challenge or suggested solution.

## RESULTS

The PED nursing and physician staff reported largely structural and process-related challenges when providing STI care. Table 1 summarizes these challenges, along with their

**Table 1.** Summary of nurse- and physician-reported suggested solutions to the challenges in providing sexually transmitted infection care in the pediatric emergency department

| | | | | Participant group which reported challenges and/or suggested solutions to the challenges | | | | |
|---|---|---|---|---|---|---|---|---|
| **Stage of PED STI care** | **TICD determinant domain** | **Challenges** | **Solutions** | **Nurse** | **Pediatrics resident** | **Emergency medicine resident** | **Pediatric emergency medicine fellow** | **Attending physician** |
| Triage and initial assessment | Workflow, policy, and role clarity | STI screening questions not standardized | Create triage protocol for STI patients | C/S | | | | |
| | | STI risk not assessed at triage | Add STI risk assessment to triage workflow | S | | | C | |
| | Resources; patient privacy and engagement | Patient privacy limited during triage | Enhance privacy during rooming and assessment | C/S | | | | |
| | | Patient preparation and communication are difficult | Improve communication and patient preparation workflow | C/S | | | | |
| History taking and documentation | Resources; patient privacy and engagement | Lack of privacy during sexual history taking | Enhance privacy during history taking | | C/S | C/S | C/S | C/S |
| | Resources; workflow efficiency | Limited time and long waits interfere with history taking | Expand workforce; consider fast-track pathway | | C/S | C/S | | C |
| | Patient engagement; communication | Communication problems affect history taking | Enhance communication strategies | | | C | C | C/S |
| | EHR/ documentation; patient engagement | Self-administered or nonverbal history options underused | Add electronic or paper sexual history tools | | | | | C/S |
| | Workflow, policy, and role clarity | Age-related privacy laws create uncertainty | Clarify adolescent confidentiality policies | | | | | C |
| | EHR and documentation | Documentation problems | Standardize documentation process; improve EHR | | C/S | C/S | C/S | C/S |
| | Clinician knowledge, skills, and comfort | Clinicians forget sexual health questions | Add prompts or structured interview guide | | S | C/S | C | S |
| | | Stigma affects STI conversations | Normalize and destigmatize STI care | S | S | | | C |
| | Team processes and care coordination | Repetitive questioning by multiple clinicians | Clarify roles; coordinate workflow; reduce redundancy | | C/S | C/S | | C/S |

suggested solutions to address them. Challenges and solutions are denoted by stakeholder type: nursing staff; pediatrics residents; EM residents; PEM fellows; and PEM attending physicians. The narrative below explains each challenge and corresponding solution, organized primarily by the clinical stage of care, with relevant TICD determinants highlighted.

**Table 1.** Continued

| Stage of PED STI care | TICD determinant domain | Challenges | Solutions | Participant group which reported challenges and/or suggested solutions to the challenges | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Nurse | Pediatrics resident | Emergency medicine resident | Pediatric emergency medicine fellow | Attending physician |
| Physical examination and documentation | Team processes and care coordination | Repetitive patient evaluation across clinicians | Clarify roles and handoffs | | | S | | C/S |
| | Workflow, policy, and role clarity | Chaperone expectations unclear | Clarify chaperone guidelines | C | C | C | | C |
| | Clinician knowledge, skills, and comfort | Limited clinician experience with GU exam/sample collection | Standardize exam process; train residents | | S | C/S | S | |
| | Resources; patient privacy and engagement | Lack of privacy during examination | Enhance privacy during examination | | C/S | C/S | C/S | C/S |
| | Resources: space, equipment, supplies, and time | Equipment or supplies unavailable/ nonfunctional | Improve equipment and supply availability | | C/S | C/S | C/S | C/S |
| | Resources; workflow efficiency | Delays occur during STI-related examination or care | Decrease delays; improve workflow and staffing | C | C/S | C/S | C/S | C/S |
| | Team communication | Communication problems affect examination process | Improve team communication during exam workflow | | | | C | |
| | EHR and documentation | Documentation problems | Standardize exam documentation; add EHR reminders | | C/S | C/S | C/S | C/S |
| | EHR and documentation; confidentiality policy | Uncertainty about EHR privacy for adolescents | Train clinicians on adolescent EHR privacy | | | C/S | C/S | C |
| | Patient privacy, preferences, and engagement | Patient reluctance to undergo physical examination | Use patient-centered, trauma-informed examination approach | C | | | | C |

Representative quotes are included throughout to help illustrate participant viewpoints.

### Triage and Initial Assessment

*Capacity for Organizational Change: Regulations, Rules, and Policies*

Nurses noted that there is no PED policy on triaging procedures for possible STI concerns. They also reported difficulties accurately identifying patients presenting with STI-related complaints at triage. Pediatric EM fellows specifically noted the absence of routine triage screening for STI risk, contributing to overlooked cases early in the visit.

### Incentives and Resources: Availability of Necessary Resources

A central issue identified was insufficient patient privacy. Nurses frequently described challenges maintaining patient confidentiality due to limited private examination spaces and difficulty separating patients from family members. As one nurse explained, it can be "difficult when parents don't want to leave the room" during sensitive conversations. Another nurse

**Table 1.** Continued

| Stage of PED STI care | TICD determinant domain | Challenges | Solutions | Participant group which reported challenges and/or suggested solutions to the challenges | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Nurse | Pediatrics resident | Emergency medicine resident | Pediatric emergency medicine fellow | Attending physician |
| STI testing | Clinician knowledge, skills, and comfort | Uncertainty about appropriate test selection | Create standardized STI testing algorithm; train clinicians | | C/S | C/S | C | C |
| | | Trichomonas testing inconsistent | Include trichomonas guidance in testing protocol | | C | C | C | C |
| | | Sample collection technique varies | Standardize collection procedures | | C | C/S | | |
| | Patient privacy and communication | STI testing discussions lack discretion in open areas | Protect privacy during testing discussions | | C/S | | | |
| | Workflow, policy, and role clarity | Sample handling process unclear | Standardize sample handling, labeling, and drop-off | C | C | C/S | C | |
| | | Sample collection problems | Create sample collection workflow and instructions | C/S | C | C | | C/S |
| | | Legal concerns about GU documentation | Clarify medicolegal documentation guidance | | | | | C/S |
| | Resources: equipment, supplies, and EHR support | Testing supplies unavailable | Improve testing supply availability | S | S | C/S | | C/S |
| | Resources; EHR and documentation | STI test label-printing delays | Fix label-printing workflow/EHR process | S | | C | C | C |
| | Resources; follow-up/results workflow | Extended wait for STI test results | Improve results workflow and follow-up process | | C | | C | C |
| | Resources; lab/testing workflow | Test processing problems | Coordinate with laboratory/testing workflow | C | | | | |

pointed out the current practice of "using the gynecology (GYN) room for non-GYN complaints," which limits access for adolescent patients needing private exams. Both nurses and physicians expressed frustration with inadequate sound-isolated spaces equipped for gynecologic examinations.

**Patient factors: Behavior, Motivation, and Preferences**

Nurses described adolescent embarrassment and reluctance to openly discuss sensitive concerns at triage. Medical staff have also noted that patients hesitate to speak about their sexual concerns particularly when seated near younger children who could overhear conversations.

**Suggested Solutions**

Pediatrics and EM residents, along with attending physicians, recommended triage protocols to assign private rooms immediately to patients suspected of having an STI. Nurses suggested creating dedicated private spaces specifically

**Table 1.** Continued

| Stage of PED STI care | TICD determinant domain | Challenges | Solutions | Participant group which reported challenges and/or suggested solutions to the challenges | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Nurse | Pediatrics resident | Emergency medicine resident | Pediatric emergency medicine fellow | Attending physician |
| Empiric treatment | Clinician awareness and familiarity with recommendations | Abstinence counseling unclear | Add abstinence counseling to treatment guide | | | | C/S | |
| | | Trichomonas undertreatment | Include trichomonas treatment in guidance | | | | | C/S |
| | | Persistent symptoms management unclear | Add persistent symptoms pathway | | | | | C/S |
| | | Empiric treatment indications unclear | Create empiric treatment algorithm | | | | C/S | |
| | | Medication regimen selection varies | Standardize recommended regimens | | | | C/S | |
| | Patient engagement; adherence | Treatment adherence challenging | Provide patient-centered treatment education | | C | C | C/S | C |
| | Patient engagement; follow-up systems | Unable to track adherence after discharge | Improve postdischarge tracking/follow-up | | C | C | | |
| | Patient engagement; partner management | Partner treatment difficult to ensure | Strengthen partner treatment/EPT pathway | | C/S | S | S | C/S |
| | Patient privacy, preferences, and engagement | Privacy concerns during treatment | Protect privacy during treatment counseling | | C | S | C | C/S |
| | Resources: medication administration and access | Medication access and administration barriers | Coordinate with pharmacy and insurance; revise medication workflow | C/S | S | | S | C/S |

for adolescent STI concerns. Attending physicians supported establishing separate waiting areas for guardians. Nurses and pediatrics residents emphasized the importance of considering patient age when assigning rooms to prevent adolescents from feeling uncomfortable around younger children.

**Medical History Taking and Documentation**

*Incentives and Resources: Availability of Necessary Resources*

Many participants shared that the lack of private, closed patient examination rooms and thus reliance on curtained rooms significantly hindered privacy, negatively affecting adolescents' comfort in sharing truthful medical histories. Lack of in-room computer workstations were also reported as hindering physicians from documenting while taking the patient's medical history; thus, completion of patient records is often delayed and lacks precision. Residents and fellows also mentioned the lack of standardized interview templates tailored to sexual health concerns available within the electronic health record (EHR), resulting in documentation practices that varied across physicians.

*Incentives and Resources: Information System and Capacity for Organizational Change: Regulations, Rules, and Policies*

Participants expressed confusion over documentation

**Table 1.** Continued

| Stage of PED STI care | TICD determinant domain | Challenges | Solutions | Participant group which reported challenges and/or suggested solutions to the challenges | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Nurse | Pediatrics resident | Emergency medicine resident | Pediatric emergency medicine fellow | Attending physician |
| Follow-up arrangements | Follow-up systems and EHR tracking | Unable to track follow-up after discharge | Streamline follow-up process | | C/S | C/S | C | C/S |
| | Referral processes and interdisciplinary care | Outpatient pediatricians may be uncomfortable treating STIs | Develop interdisciplinary follow-up team | | | S | | C/S |
| | Referral processes and communication | Referral and communication processes inconsistent | Standardize referral and communication process | | | C/S | C/S | C/S |
| | Follow-up systems and referral support | Physicians face barriers making follow-up arrangements | Create systems to support follow-up arrangements | | C/S | C | C/S | C |
| | Patient access and engagement | Patients face barriers arranging follow-up | Assist with appointment scheduling; offer phone follow-up | S | C/S | C/S | C | C/S |
| | Patient privacy and confidentiality | Follow-up privacy concerns | Use confidential contact and disclosure procedures | | C | | | C |
| | Follow-up communication and results disclosure | Results disclosure after discharge challenging | Standardize results disclosure workflow | | | | | C/S |
| | EHR and follow-up contact information | Contact information incomplete or inaccurate | Verify contact information in EHR | | | | | C/S |

*C,* challenges; *EHR*, electronic health record; *GU*, genitourinary; *PED,* pediatric emergency department; *S,* solutions; *STI*, sexually transmitted infection; *TICD*, Tailored Implementation in Chronic Diseases.

standards and privacy laws, specifically regarding confidentiality and Health Insurance Portability and Accountability Act (HIPAA) compliance for minors, causing reluctance to document sensitive details. One pediatrics resident explained concerns over documentation: "If I were seeing a 14-year-old and I didn't know what was appropriate to document in the chart…I might be hesitant to document those things fully."

*Individual Health Professional Factors: Skills Needed*

Participants across stakeholder roles cited barriers to sexual history taking due to discomfort with asking these questions, particularly when related to patient-physician/nurse gender discordance. Emergency medicine residents specifically described challenges due to inadequate privacy, noting that "perceived inconsistencies in patient sexual histories" were often secondary to variations in physician interview methods, a point corroborated by attending physicians. Pediatric EM Fellows and residents also mentioned difficulty remembering to ask pertinent questions about sexual health and difficulty remembering details provided by the patients.

*Professional Interactions: Team Processes*

Pediatrics and EM residents and attending physicians noted inefficiencies and patient inconvenience resulting from

multiple nurses and physicians conducting similar evaluations sequentially.

*Suggested Solutions*

In addition to the recommendation of placing patients with STI-related complaints in a dedicated room, physicians also proposed routinely reassuring adolescents and guardians that interviewing privately is standard practice. To improve EHR documentation, physicians suggested standardized smart phrases, templates, and checklists. Attending physicians recommended patient self-administered surveys for sexual history taking. Residents suggested hiring scribes and increasing in-room computer availability to aid in timely completion of EHR records, while fellows recommended privacy restrictions within the EHR to protect sensitive patient information from parents/guardians.

**Conducting and Documenting the Physical Examination**

*Capacity for Organizational Change: Regulations, Rules, and Policies*

Attending physicians voiced concerns about redundant and repetitive physical examinations being performed by multiple physicians for the same patient (eg, resident, fellow, attending). Knowledge about institutional policies regarding chaperone guidelines also differed among the physicians. Residents expressed that the responsibilities of residents and nurses overlap, thus creating confusion on who will complete a certain task.

*Individual Health Professional Factors: Skills Needed*

Residents voiced concerns regarding their ability to accurately identify findings, such as cervical motion tenderness. Emergency medicine residents expressed that they do not have sufficient experience in performing a physical examination on a patient with a potential STI. Attendings highlighted anxieties around the legal implications of performing and documenting the results from genitourinary examinations for these patients.

*Incentives and Resources: Availability of Necessary Resources*

Physicians emphasized privacy issues during physical examinations, notably due to curtained exam areas. One EM resident noted discomfort: "I feel like if I was in that situation, (as a patient) I'd be uncomfortable knowing that there was just a curtain or even kind of like a screen." Participants universally described inadequate equipment, specifically the limited availability of gynecologic beds and examination stirrups. Physicians additionally noted logistical issues, notably delayed patient room assignment and difficulties with promptly finding chaperones.

*Incentives and Resources: Information System*

Patient information privacy concerns were also expressed in this section. Most physicians also voiced uncertainty on guardian access to adolescent patients' EHR. Physicians described the challenges of delayed documentation postexamination, uncertainty regarding patient information privacy, and parent/guardian access to the patient's EHR.

*Suggested Solutions*

Participants recommended creating at least one dedicated private examination room in the PED exclusively equipped for genitourinary examinations, along with convertible beds and stirrups. Clear assignment of chaperone duties and improved coordination among medical staff were suggested to streamline care. For documentation improvements, attendings recommended using EHR templates and smart phrases with automated flags. One attending physician noted: "If you use one of those templates... it will give you a flag before you send that chart."

**Sexually Transmitted Infection Testing**

*Individual Health Professional Factors: Skills Needed*

Pediatrics and EM residents said that they receive insufficient training on genitourinary sample collection. All physicians reported uncertainty in selecting the appropriate testing kit for certain specimen sources. They also expressed inadequate familiarity with STI testing protocols, particularly trichomonas testing. An EM resident confessed, "I don't think I've ever tested for trich (trichomonas), which is unfortunate, but I also don't know how we do it."

*Capacity for Organizational Change: Regulations, Rules, and Policies*

Fellows emphasized that trichomonas was notably absent from standard STI order sets. Nurses said that the urine sample handling process was unclear, which led to cancelled tests.

*Incentives and Resources: Availability of Resources*

Participants described significant delays locating testing supplies and printing patient labels for specimens. Nurses specifically noted confusion about the required sample types (urine, cervical, etc) since they were not displayed clearly in the EHR, and they highlighted challenges scanning patient labels on specimens before laboratory submission. Emergency medicine residents indicated higher risk of sample mislabeling due to limited nurse-only access to label printing. Most participants cited long waits for laboratory results as problematic, requiring patient follow-up after discharge and creating risks related to patient contact and confidentiality.

*Suggested Solutions*

All participants requested additional training on sample collection. They recommended easily accessible "tip sheets" outlining STI test procedures, automating label printing immediately after orders, and clearly indicating sample types in the EHR. They also proposed routine collection of urine samples at triage for adolescents, and saving urine samples for some time in case a new test needed to be performed.

Emergency medicine residents suggested standardized methods for conveying STI results (primarily by telephone), verifying patient contact details during PED visits, and documenting clearly whether contact numbers belonged to patients or guardians.

**Sexually Transmitted Infection Empiric Treatment**

*Individual Health Professional Factors: Awareness and Familiarity with the Recommendation*

Some physicians described uncertainty on management guidelines for empiric treatment and persistent symptoms despite usual treatment. Nurses specifically highlighted discomfort and unfamiliarity with diluting and administering ceftriaxone with lidocaine.

*Patient Factors: Behavior, Motivation, and Preferences*

Physicians expressed concerns about patient adherence with a 7-day doxycycline course versus single-dose azithromycin, as well as delayed or inability to obtain prescription medications due to patient affordability concerns. Physicians and nurses described adolescent reluctance to accept intramuscular medications, such as ceftriaxone, due to injection-related pain, and patient hesitancy notifying their sexual partners of their STI diagnosis.

*Suggested Solutions*

Physicians recommended creation of easily accessible instructional documents that describe treatment guidelines. Participants proposed training nurses on alternative ceftriaxone administration methods (intravenous or intramuscular mixed with lidocaine). To address medication dispensation challenges, proposed solutions included providing prepackaged medication kits for patients and their partners in the PED and designating a social worker or health educator to assist patients in obtaining outpatient medications from the hospital pharmacy while the patient was in the PED. To encourage partner treatment, attending physicians proposed enabling STI medications to be prescribed through processes not tied to the patient's EHR.

**Arrangement of Follow-Up Visits**

*Individual Health Professional Factors: Knowledge About Own Practice*

Physicians reported that they typically arrange follow-up visits for patients before discharge, but that it is difficult to do so if the patient is discharged outside outpatient clinic hours or if the PED shift is very hectic. If the follow-up visits were not arranged prior to discharge, physicians noted that they were unsure whether the patients would eventually be scheduled for a follow-up visit or had successfully retrieved their medications from their outpatient pharmacy.

*Incentives and Resources: Information System*

Nurses and physicians highlighted inadequate follow-up systems, difficulty contacting patients after discharge, and challenges coordinating care with external primary care physicians. One attending physician stated, "I don't know if the patients follow up…universally it would be nice to link our patients directly." Fellows emphasized patient-related barriers such as low health literacy, language issues, and limited support for appointment scheduling. Participants reported that inaccurate patient contact details frequently impeded postdischarge communication. Emergency medicine residents expressed uncertainty whether the referral order was being received by the appropriate outpatient clinic or patients were being contacted for a follow-up visit.

*Suggested Solutions*

Participants suggested reserving follow-up appointments in advance and scheduling visits before patient discharge. Increased use of EHR dot-phrases, business cards, quick response codes, and interdisciplinary team notifications was also proposed. A pediatric EM fellow described a successful approach at another hospital: "They had an appointment scheduler...they would also change the color of the patient on the ED track board, so then we knew that the appointment had been made." Fellows also stressed the importance of verifying accurate patient phone numbers at the time STI testing was performed.

## DISCUSSION

This investigation identified stage-specific, stakeholder-reported barriers to delivering guideline-concordant STI care for adolescents and young adults in the PED, as well as practical solutions to inform development of a targeted implementation strategy. The challenges were predominantly structural or procedural, encompassing nurse and physician knowledge gaps; physical resource and setting limitations; deficits in information gathering and sharing; system-level barriers to documentation, communication, and follow-up; lack of privacy; and inefficient and unclear workflows and procedures. Such challenges are likely commonly faced at other PEDs and general EDs. However, they were not considered unsurmountable by stakeholders. Pediatric emergency physician and nurse stakeholders were able to suggest numerous valuable solutions that could lead to better STI care. These solutions likely also could be applied to other PEDs and general EDs, with site-specific adaptations. From this work, we were able to develop an implementation strategy plan designed to improve STI care at our PED so that it was concordant with CDC STI treatment guidelines.[29] We are evaluating the implementation and desired outcomes from the plan's deployment, which will be shared in a future publication.

Other quality improvement efforts on STI care conducted at other EDs and PEDs have explored several potential solutions thath have demonstrated impact and were echoed in our participants' proposed solutions. These efforts include the following: enhanced clinician education on STI screening,

especially among asymptomatic patients; the use of computerized screening tools (which have been found to double the rate of STI testing among adolescents); self-collection of samples; scheduling follow-up appointments at ED discharge; and sending text message reminders to schedule and attend a follow-up visit.[30-34] System-level interventions, such as improved documentation of confidential adolescent contact information, similarly have facilitated more effective follow-up and communication of test results.[35] As implemented in some inpatient settings, interventions aimed at normalizing sexual history taking in the ED setting have also led to increased STI screening rates.[36] Advancing these solutions into deployable implementation strategy plans and assessing their effectiveness is a necessary subsequent step in guiding best practices for STI care in PEDs and general EDs.

## LIMITATIONS

One limitation of this investigation was that it was conducted only at a single teaching hospital, which could limit the external validity of the results to other hospitals. Because this investigation was a qualitative study using purposive sampling, the findings are not intended to estimate the prevalence of these challenges in this PED or across PEDs or general EDs. However, several challenges identified by participants—including limited privacy, lack of standardized workflows, EHR documentation barriers, testing and sample-handling challenges, and difficulty arranging follow-up—are likely applicable to other emergency care settings that provide STI care to adolescents and young adults. Recall and social desirability biases may have influenced participant responses, and inherent biases of the interviewers and analysts could have impacted the results. Strengths of the study include the use of the TICD framework; a structured interview guide based on STI care workflow in the PED; and independence of the data coders and analyzers from the conduct of the interviews and creation of the interview guide.[26] In addition, the participant sample included a range of clinical roles (nurses, residents, fellows, attendings), thereby enhancing the ability to gain multiple perspectives from those who evaluate and treat patients with a possible STI.

## CONCLUSION

This investigation identified several challenges that disrupt timely, confidential, and guideline-concordant STI care for adolescents and young adults in the pediatric ED, including limited privacy, lack of standardized workflows, unclear team roles, gaps in STI-specific training, variable documentation practices, testing and sample-handling barriers, challenges with empiric treatment and partner management, and difficulty arranging follow-up after discharge. Organizing findings by clinical stage and TICD domain enabled a structured understanding of specific challenges and corresponding solutions, such as EHR modifications, staff training, triage protocols, and workflow redesign, which should be addressed to improve STI care.

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# Respiratory Viral Positivity Is Associated with Decreased Risk of Serious Bacterial Infections in Febrile Infants

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**Introduction:** Febrile infants ≤ 60 days of age are at increased risk for serious bacterial infections (SBIs), often necessitating extensive diagnostic evaluation and hospitalization. Although respiratory viral infections are common in this population and may influence the likelihood of concurrent bacterial infection, the relationship between respiratory viral panel (RVP) results and SBI risk remains an important consideration in clinical decision-making. The objective of this study was to evaluate the association between RVP results and the occurrence of SBIs among febrile infants ≤ 60 days of age.

**Methods:** In this single-center, retrospective study we analyzed data from infants ≤ 60 days of age who presented to the emergency department with fever (temperature > 100.4 °F/38 °C) between September 2020–May 2024. Infants were divided into two subgroups based on RVP results: positive or negative for any viral infections via a multiplex polymerase chain reaction panel. The overall rate of SBI, and the rates of individual SBIs (urinary tract infection [UTI], bacteremia, and bacterial meningitis), were compared between groups. The primary outcome was the rate of SBIs among infants with any positive RVP compared to those with a negative RVP.

**Results:** We analyzed 1,986 charts of febrile infants ≤ 60 days of age, of whom 485 (24.4%) met criteria. Of these, 309 (63.7%) had a positive RVP for at least one pathogen while 176 (36.3%) were all negative. Overall, the rate of serious bacterial infection in the RVP negative group was 35.8% (95% CI, 29%-43.1%) compared to 6.5% (95% CI, 4.1%-9.6%) in the RVP positive group ($P < .001$). Infants with a positive RVP had a significantly lower prevalence of serious bacterial infection (7.4%) and UTI (5.5%) compared to those with a negative RVP ($P < .001$). In the RVP positive group, 17 patients (5.5% [95% CI, 3.4%-8.5%]) had a UTI compared to 46 (26.1% [95% CI, 20.1%-33%]) in the RVP negative group. Notably, there were four cases of bacteremia (1.3% [95% CI, 0.4%-3%]) in the positive RVP group compared to 20 (11.4% [95% CI, 7.3%-16.7%]) in the negative RVP group. In the positive RVP group, there were 0 cases of meningitis (0% [95% CI, 0%-0.9%]) compared to 5 (2.8% [95% CI, 3.4%-85%]) in the RVP-negative group. The differences in bacteremia and meningitis rates between the two groups were statistically significant ($P < .001$).

**Conclusion:** Febrile infants ≤ 60 days of age with a positive RVP are associated with a significantly lower risk for SBI compared to those with a negative RVP, a 64% relative risk reduction. If validated with a prospective study, these findings could help guide clinical decision-making, potentially allowing for a more nuanced approach to the management and disposition of febrile infants, particularly the need for invasive workup and hospitalization. [West J Emerg Med. 2026;27(5)1317–1320.]

## INTRODUCTION

The evaluation of febrile infants, particularly those under two months of age, remains a subject of ongoing controversy in pediatric emergency medicine. Febrile illness is among the most common reasons for emergency department visits in infants < 60 days of age. Fever raises clinical concern for serious bacterial infections such as meningitis, bacteremia, or urinary tract infections (UTI).[6] These infections can result in significant morbidity if not promptly diagnosed and treated.

Distinguishing between viral and bacterial etiologies in febrile infants in inherently challenging due to overlapping clinical presentations. To address this, the American Academy of Pediatrics (AAP) developed widely adopted guidelines for the evaluation and management of febrile infants.[9] These guidelines have played a crucial role in improving clinical outcomes, thereby reducing the use of unnecessary invasive procedures in this vulnerable population. However, a notable limitation of these guidelines is the omission of respiratory viral panel (RVP) testing. The RVP is a diagnostic tool that can identify a wide range of viral pathogens, including influenza, parainfluenza, coronavirus, adenovirus, human metapneumovirus, human rhinovirus/enterovirus, and respiratory syncytial virus.[2] Viral etiologies may decrease the likelihood of a concurrent serious bacterial infection; consequently, identifying them may reduce reliance on invasive diagnostic testing and empiric broad-spectrum antibiotics. Incorporating RVP testing into the evaluation of febrile infants has the potential to enhance diagnostic precision, improve patient outcomes, and optimize the use of healthcare resources.

*Population Health Research Capsule*

What do we already know about this issue?
*Febrile infants ≤ 60 days are at risk for serious bacterial infections, but the role of respiratory viral testing in risk stratification remains unclear.*

What was the research question?
*Does a positive respiratory viral panel reduce serious bacterial infection risk in febrile infants ≤ 60 days old?*

What was the major finding of the study?
*A positive respiratory viral panel was associated with a 64% lower serious bacterial infection risk (RR 0.34).*

How does this improve population health?
*Respiratory viral testing testing may improve risk stratification, reducing unnecessary invasive testing, antibiotics, and hospitalizations in this population.*

## METHODS

This retrospective cohort study included febrile infants ≤ 60 days of age who presented to the pediatric emergency department (PED) from September 2020–May 2024. We used stratified sampling to derive data.[15] Fever was defined as any documented temperature ≥ 100.4 °F in the PED, a prior healthcare setting, or at home within the preceding 24 hours. We identified eligible patients through the electronic health record (EHR) including all infants ≤ 60 days of age with a RVP collected. The exclusion criteria were as follows: preterm infants (< 37 weeks' gestation); infants < 14 days of age whose perinatal course was complicated by maternal fever, infection, and/or antimicrobial use; febrile infants with high suspicion of herpes simplex virus infection (eg, infants with vesicles); infants with a focal bacterial infection (eg, cellulitis, omphalitis, septic arthritis, osteomyelitis); infants with documented or suspected immunodeficiency; infants whose neonatal course was complicated by surgery or infection; infants with congenital or chromosomal abnormalities; medically fragile infants who required some form of technology or ongoing therapeutic intervention to sustain life; and infants who had received immunizations within the prior 48 hours. Additionally, patients were excluded if they had not undergone both RVP testing and culture collection (urine, blood, and/or cerebral spinal fluid).

Variables collected included demographics, chief complaint, presenting symptoms, maximum temperature, ED disposition, diagnostic codes, antibiotic use, and hospital length of stay (if admitted). Laboratory data included white blood cell count, absolute neutrophil count, C-reactive protein, procalcitonin, urinalysis, urine culture, blood culture, cerebrospinal fluid culture, and RVP results. The RVP test used was the BioFire Respiratory 2.1 Panel (BioFire Diagnostics LLC, Salt Lake City, UT), which detects 21 respiratory pathogens (adenovirus, coronavirus HKU1, coronavirus NL63, coronavirus 229E, coronavirus OC43, human metapneumovirus, human rhinovirus, and enterovirus). We collected the data from the EHR and stored it using Microsoft Excel (Microsoft Corp, Redmond, WA). The primary outcome was the presence of serious bacterial infection, defined as a UTI, bacteremia, or bacterial meningitis. A UTI was defined as a urine culture positive with at least 50,000 colonies/mL of a single organism obtained via sterile catheterization. Meningitis and bacteremia were defined as growth of a single pathogen on either cerebrospinal fluid or blood culture. Enteritis was not included as part of a serious bacterial infection as we do not routinely perform stool cultures at our institution.

We categorized patients based on RVP results (positive versus negative) and compared the overall rate of serious

**Table 1.** Baseline characteristics of patients by respiratory viral panel (RVP) status in a study examining the rate of serious bacterial infections among febrile infants with a positive RVP.

| | RVP Negative (n = 176) | RVP Positive (n = 309) | *P*-value |
|---|---|---|---|
| Age (days) | 27 (24 - 29) | 35 (33 - 37) | <.001 |
| Sex | | | |
| Male | 108 (38.6%) | 172 (61.4%) | .26 |
| Female | 68 (33.2%) | 137 (66.8% | .26 |
| Race | | | |
| Asian | 37 (56.1%) | 29 (43.9%) | < .001 |
| Black | 3 (60%) | 2 (40%) | .36 |
| Hispanic | 26 (46.4%) | 30 (53.6%) | .13 |
| White | 86 (30.9%) | 192 (69.1%) | .01 |
| Other | 19 (27.9%) | 49 (72.1%) | .16 |
| Maximum Temperature (ºF) | 101.5 (101.4 - 101.7) | 101.3 (101.2 - 101.4) | <.001 |
| White blood cell count (x103/UL) | 12.58 (11.44 - 13.72) | 10.76 (10.26 - 11.26) | <.001 |

*RVP,* respiratory viral panel.

**Table 2.** Prevalence of serious bacterial infection, urinary tract infection, bacteremia, and meningitis by respiratory viral panel status, in a study of febrile infants.

| | | RVP negative | RVP positive | *P*-value |
|---|---|---|---|---|
| Total | 485 | 176 (36%) | 309 (64%) | <.001 |
| SBI | 83 | 63 (76%) | 20 (24%) | <.001 |
| UTI | 63 | 46 (73%) | 17 (27%) | <.001 |
| Bacteremia | 24 | 20 (83%) | 4 (17%) | <.001 |
| Meningitis | 5 | 5 (100%) | 0 | .003 |

*RVP,* respiratory viral panel; *SBI,* serious bacterial infection; *UTI,* urinary tract infection.

bacterial infections between the groups. Continuous variables were summarized with medians and interquartile ranges**.** Categorical variables were summarized with frequencies and percentages. When comparing categorical variables, we used the Fisher exact test and chi-square test. All statistical analysis was carried out with SPSS statistical software (IBM Corporation. Armonk, NY) with a significance threshold of 0.05. The study was approved by the institutional review board at Maimonides Medical Center.

## RESULTS

A total of 485 (24.4%) patients met inclusion criteria after we analyzed the charts of 1,986 febrile infants who presented to the ED from September 2020–May 2024. All patients had at least one culture collected (urine, blood, and/or cerebrospinal fluid). All patients but 12 (2.5%) had an extended RVP collected. The rate of serious bacterial infection in the RVP negative group was 35.8 % (95% CI, 29%-43.1%) compared to 6.5 % (4.1%-9.6%) in the RVP positive group ($P < .001$). Of the serious bacterial infection in the RVP negative group, 46 patients had a UTI, 20 had bacteremia, and five had bacterial meningitis. A statistical significance was observed for serious bacterial infection in the RVP-positive group when compared to the RVP-negative group (Table 2). In the RV-positive group, four patients had bacteremia, and zero had meningitis. Of the patients with bacteremia, three were > 29 days and one < 28 days of age. The organisms involved in the cases of bacteremia include *Escherichia coli* (two), *Acinetobacter ursingii*, and *Streptococcus lutetiensis*. Of the four patients with bacteremia, the ones with *E coli* were likely true bacteremia; however, the patients with *A ursingii, and S lutetiensis* may have been secondary to contamination.

## DISCUSSION

The utility of RVP testing in the risk stratification of febrile infants ≤ 60 days old has been a subject of ongoing clinical debate. Given the vulnerability of this population to serious bacterial infections, the diagnostic evaluation frequently involves invasive tests and empiric antibiotics. The development of the AAP guidelines has resulted in improved risk stratification and contributed to a reduction of invasive and antibiotics for febrile infants. Prior studies have shown that patients with influenza, respiratory syncytial virus, or severe acute respiratory syndrome coronavirus 2 are at lower risk for serious bacterial infection. Our study builds upon this body of evidence by evaluating whether a positive RVP result is associated with a decreased likelihood of serious bacterial infections compared with infants who test RVP negative.

Our findings indicate that a positive RVP result is significantly associated with a lower risk for serious bacterial infection. Notably, no cases of bacterial meningitis were identified in the RVP-positive group, further supporting the potential protective nature of viral detection. Although the AAP guidelines have provided a structured approach to the evaluation of febrile infants, they do not currently incorporate RVP testing as a factor in clinical decision-making. The presents study supports the growing body of evidence suggesting that a positive RVP test may be a protective factor against serious bacterial infection in febrile infants and could help minimize invasive testing and of broad-spectrum antibiotics in this vulnerable population.

## LIMITATIONS

This study has several limitations. First, it was conducted at a single center, thereby limiting generalizability. Moreover, because not all hospitals have access to rapid RVP testing

there is a limit to the utility of the test in real-time clinical decision-making. Secondly, the retrospective design is inherently subject to biases such as incomplete documentation and unmeasured cofounding factors. In addition, the sample size was small, making it less likely to discern differences in rare outcomes such as bacterial meningitis and bacteremia. These limitations underscore the need for larger, prospective multicenter studies to evaluate the role of RVP testing more precisely in the risk stratification of febrile infants, especially in the context of coexisting viral infections.

## CONCLUSION

Febrile infants ≤ 60 days old with a positive respiratory viral panel are associated with a significantly lower risk for serious bacterial infections compared to those with negative RVP results, corresponding to a 64% relative risk reduction (0.34). These findings support the potential utility of RVP testing in guiding clinical decision-making, potentially allowing for a more nuanced approach to the testing, management, and disposition of febrile infants.

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# Prehospital Flumazenil: Five-Year Review of Use, Indications, Outcomes, and Adverse Events in Suspected Benzodiazepine Overdose

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**Introduction:** Historically, flumazenil was employed as both a diagnostic aid in unresponsive patients and as an antidote for suspected benzodiazepine overdose in both emergency departments and out-of-hospital settings. However, its prehospital application has been historically constrained by long-standing concerns regarding adverse events, leading many emergency medical service (EMS) systems to restrict or avoid its use. The use of flumazenil in the prehospital setting remains underreported in the literature, despite its inclusion in the treatment protocols of various EMS agencies. We conducted a descriptive analysis of the use of flumazenil by EMS in the out-of-hospital setting across the state of Kansas over a five-year period. We characterize the frequency, indications, patient outcomes, and associated adverse events of flumazenil administration, thereby contributing to a better understanding of its role, safety, and clinical relevance in prehospital care.

**Methods:** We performed a retrospective observational cohort design to evaluate the use of flumazenil by EMS clinicians in the state of Kansas from January 2015–August 2020. Patient care reports documenting prehospital administration of flumazenil were obtained from the Kansas Board of EMS. Data extracted included demographics, indications, initial and subsequent Glasgow Coma Scale (GCS) scores when available, clinical response, and the occurrence of adverse events. Our primary outcome measure was GCS improvement following administration, with secondary outcome measures including patterns and outcomes with flumazenil use in the prehospital setting, clinical response, and occurrence of adverse side effects.

**Results:** A total of 80 cases involving EMS administration of flumazenil were identified with 69 cases meeting inclusion criteria. No seizures or adverse events were associated with flumazenil use (0/69; 95% CI, 0–4.3%), even in administrations with possible contraindications. Of the 69 cases analyzed, 24 cases documented suspected benzodiazepine overdose, all of which documented neurologic improvement (24/24; 95% CI, 87.5–100%), with 17 receiving flumazenil alone and 7 with naloxone coadministration.

**Conclusion:** In this small sample, no adverse events were noted with flumazenil administration in the prehospital setting. Flumazenil administration was commonly associated with documented improvement in GCS in suspected benzodiazepine overdose. These findings suggest that exclusion in EMS protocols based solely on concern for adverse events in the prehospital setting can be reconsidered. Further research is needed to better define its safety, efficacy, and clinical utility in this setting. [West J Emerg Med. 2026;27(5)1321–1326.]

## INTRODUCTION

Flumazenil is an imidazobenzodiazepine and a selective $GABA_A$ receptor antagonist that acts through competitive inhibition at the benzodiazepine binding site. It is approved by the U.S. Food and Drug Administration (FDA) for the reversal of benzodiazepine-induced sedation during procedural sedation and general anesthesia in both adult and pediatric patients. It is also indicated for the treatment of benzodiazepine overdose in adults. Flumazenil can be administered through multiple routes, including intravenous, intramuscular, and intranasal delivery. It provides rapid and consistent reversal of the pharmacologic effects of benzodiazepines.[1] In addition to reversing the effects of benzodiazepines, flumazenil can also antagonize the sedative effects of certain nonbenzodiazepine agents that act on the same benzodiazepine binding site of the $GABA_A$ receptor. This includes drugs such as zolpidem, a nonbenzodiazepine hypnotic commonly used for the treatment of insomnia, which shares similar receptor-binding characteristics despite structural dissimilarity.[2] Due to its rapid onset and relatively short duration of action, flumazenil was initially regarded as an ideal antidote for benzodiazepine overdose. It was considered safe, lacking intrinsic agonist activity, and was recommended both for reversing benzodiazepine-induced coma and as a diagnostic agent to identify benzodiazepine involvement in comatose patients, both in emergency departments (ED) and out-of-hospital settings.[3,4]

However, concerns soon emerged in the medical literature regarding the potential for flumazenil to precipitate acute benzodiazepine withdrawal and provoke seizures. The actual incidence and clinical significance of these adverse effects remain a topic of debate. Notably, flumazenil has also been investigated as a therapeutic option for managing benzodiazepine withdrawal; most seizure cases associated with its use have been reported in the context of polydrug ingestions rather than isolated benzodiazepine exposure.[5-7] Widespread concerns about the risk of precipitating seizures and benzodiazepine withdrawal led to numerous warnings and clinical cautions against the use of flumazenil, particularly in patients with a history of seizure disorders, chronic benzodiazepine use, or suspected polydrug ingestion.[8,9]

Despite the shift toward more conservative use, flumazenil continues to be administered in hospital settings, EDs, and emergency medical service (EMS) systems, with reports supporting both its effectiveness and safety.[10-12] However, its role in the prehospital environment remains underexplored, with very few studies published specifically addressing flumazenil use in out-of-hospital care.[13] This question has become more pertinent due to increasing abuse of benzodiazepines.[14] In this descriptive study we aimed to characterize the use of flumazenil by state-wide EMS clinicians. The primary outcomes were adverse reactions after administration and clinical effect when given for suspected benzodiazepine overdoses.

*Population Health Research Capsule*

What do we already know about this issue?
*Flumazenil reverses benzodiazepines but is rarely used prehospital due to seizure risk concerns, with limited emergency medical services (EMS) data on safety and outcomes.*

What was the research question?
*What are flumazenil use patterns by EMS, Glasgow Coma Scale (GCS) outcomes, and adverse event rates in prehospital care?*

What was the major finding of the study?
*There were 0/69 adverse events (95% CI, 0–4.3%); GCS improved in 24/24 suspected benzodiazepine overdoses (95% CI, 87.5–100%).*

How does this improve population health?
*These findings support safe EMS flumazenil use, enabling faster reversal of benzodiazepine overdose, improved consciousness, and potentially reduced morbidity.*

## METHODS

### Design

This retrospective observational cohort study evaluated flumazenil administration by EMS clinicians across the state of Kansas from January 1, 2015–August 31, 2020.The study objective, population, and inclusion and exclusion criteria were defined a priori. We obtained data from the Kansas EMS Information System (KEMSIS), a statewide National EMS Information System version 3–compliant repository managed by the Kansas Board of EMS. This database captures EMS response data statewide from 2015 onward and, as of October 1, 2019, included approximately 98% of total EMS call volume in Kansas. Deidentified, redacted EMS patient care reports were provided by the Kansas Board of EMS upon request.

This study was designed and reported in accordance with methodological recommendations for emergency medicine chart review studies as described by Worster and Bledsoe. Data elements and outcomes were specified a priori. All data were abstracted from standardized EMS patient care reports using predefined variables, and the study cohort was constructed with transparent accounting of exclusions. We excluded cases for documentation errors or if flumazenil administration occurred outside the prehospital setting.

Extracted variables included patient demographics, documented indication for flumazenil use, pre- and

postadministration Glasgow Coma Scale (GCS) scores, narrative clinical response (eg, improvement in GCS, seizure-like activity), vital signs, dose and route of administration, relevant medical history, and reported adverse events. Contraindications to flumazenil use were defined as the presence of focal neurologic deficits, seizure-like activity, or suspected ingestion of nonbenzodiazepine substances, including tricyclic antidepressants, other seizurogenic medications, or polysubstance exposures.

We defined adverse events as development of any new symptom following administration or worsening of any preexisting symptoms. Improvement in GCS was defined as an increase of GCS by at least one point based on explicit documentation or through narrative interpretation. Proportions are presented with 95% confidence intervals calculated using the exact Clopper–Pearson method for binomial data, given the small sample sizes and presence of proportions near 0% and 100%.

### Subjects Selection Criteria

*Inclusion Criteria*

We included all EMS patient care reports from participating agencies documenting the administration of flumazenil by EMS clinicians.

*Exclusion Criteria*

We excluded cases in which flumazenil was administered outside the out-of-hospital environment, including those occurring within hospital facilities or during interfacility transfers not classified as prehospital care (ie, given by an EMS clinician while physically located at the sending or receiving facility, or given by a non-EMS clinician) were excluded. Additional exclusion criteria included age < 18, cases with missing data (ie, no initial GCS, missing indication, etc).

*Sample Size*

A total of 80 EMS patient care reports documented flumazenil administrations. Of these, 11 cases were excluded based on the exclusion criteria above including the following: nine interfacility transfers where flumazenil was administered at the sending facility prior to EMS involvement; one case of administration by an ambulatory surgery clinic before EMS arrival; and one case excluded due to a documentation error where fentanyl administration was incorrectly recorded as flumazenil. The final study sample included 69 patients.

## RESULTS

After applying exclusion criteria, 69 cases involving the administration of flumazenil by EMS personnel in the out-of-hospital setting were identified from the available patient care reports. These cases included interfacility transfers classified as prehospital care, suspected or possible nonbenzodiazepine overdose (ie, suspected opioid overdose, or type of overdose not specified), suspected benzodiazepine overdose (as specified in the patient care report), altered mental status of unknown etiology, and cardiac arrest (Table).

Of the 69 total prehospital flumazenil administrations analyzed, no patients who received flumazenil developed any new or worsening symptoms (0/69; 95% CI, 0–4.3%). Crucially, this also includes several administrations in cases with possible contraindications including one patient with focal neurologic deficits; two with seizure-like activity; two with tricyclic antidepressant coingestion, three with known anticholinergic overdose, and 14 other polydrug ingestions.

Of the 24 cases that documented suspected benzodiazepine overdose, all patients demonstrated clinical improvement following flumazenil administration (24/24; 95% CI, 87.5–100%). Improvement was observed in all patients receiving flumazenil alone (17/17; 95% CI, 82.4–100%) and in those receiving flumazenil with naloxone (7/7; 95% CI, 57.1–100%).

Of the seven cases in which GCS improvement was reported after coadministration of flumazenil and naloxone, two of these documented specifically no response to naloxone but improvement following flumazenil (2/7; 95% CI, 3.7–71.0%). Among the 17 cases attributed to flumazenil alone, 13 involved patients with an initial GCS < 8 who experienced documented improvement postadministration by at least one point. The remaining four cases had documented GCS scores > 8 prior to flumazenil administration and saw improvement by at least one point following administration (Figure).

These findings suggest that when EMS clinicians suspected benzodiazepine overdose in the prehospital setting, flumazenil administration were more frequently associated with clinical improvement. Among the remaining EMS-administered flumazenil cases (those documenting suspected nonbenzodiazepine overdose, altered mental status of unknown etiology, cardiac arrest, and interfacility transfers classified as prehospital care), several yielded notable outcomes. Two patients with "altered mental status of unknown origin" experienced improved GCS post-administration (2/16; 95% CI, 1.6–38.3%). One administration was given for cardiac arrest, resulting in the return of spontaneous circulation postadministration (1/10; 95% CI, 0.3–44.5%). In three cases with contraindications, including

**Table.** Characteristics of emergency medical services flumazenil administrations (n = 69) in a study evaluating the use of flumazenil by emergency medical services clinicians.

| Category | n | % |
|---|---|---|
| Interfacility transfers classified as prehospital care | 5 | 7% |
| Suspected/possible non-benzodiazepine overdoses | 14 | 20% |
| Suspected benzodiazepine overdoses (documented) | 24 | 35% |
| Altered mental status of unknown etiology | 16 | 23% |
| Cardiac arrest | 10 | 14% |
| Return of spontaneous circulation achieved | 1 | 0.01% |

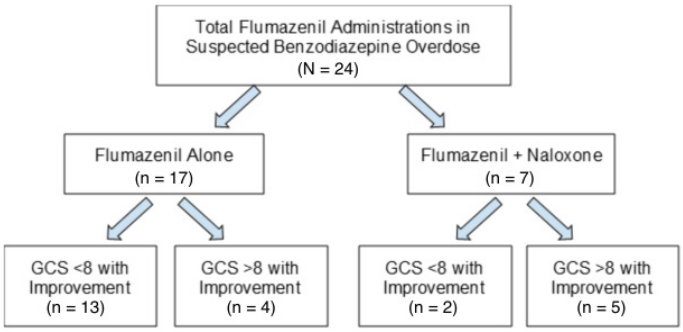


**Figure.** Changes in Glasgow Coma Scale with flumazenil administration in suspected benzodiazepine overdose in a study evaluating the use of flumazenil by emergency medical services clinicians.
*GCS,* Glasgow Coma Scale.

two cases with seizure-like activity (documented indication of "altered mental status of unknown etiology"), and one with confirmed amitriptyline ingestion, flumazenil administration was associated with improvement in GCS.

## DISCUSSION

Overall, there is a significant lack of data regarding the use of flumazenil in the prehospital setting. To our knowledge, this is the first study of its kind to examine adverse effects of prehospital flumazenil use. In a 2025 systematic review on adverse events of both intramuscular and intravenous flumazenil, the study authors noted that due to the lack of quality evidence, especially in the prehospital setting, a conclusion on flumazenil's overall safety is difficult to make.[15] However, in their review, which included one clinical study examining intramuscular flumazenil, and two systematic reviews examining parenteral flumazenil, along with multiple animal studies, overall rates of adverse events were low. Their systematic review also reported that seizures occurred in < 2% of patients receiving flumazenil, with no patients developing refractory status epilepticus, and no reported deaths.

Additionally, prior studies have suggested that the risk of seizures may be dose-dependent, with a higher likelihood observed at doses > 1 mg.[15-17] Among the 69 cases analyzed in our study, the average flumazenil dose was 0.8 mg, with a median of 0.4 mg, a mode of 0.2 mg, and a maximum dose of 7.5 mg. The most frequent pattern of dosing was observed to be an initial dose of 0.2, most commonly given twice. The most common route of administration was intravenous (51/69; 95% CI, 63.5–84.3%), with intramuscular the next most frequently seen (18/69; 95% CI, 15.7–36.4%). No cases documented intranasal administration. As no adverse events were recorded, we were unable to observe any association with adverse events and dosing and/or route of administration.

Rates of opioid overdoses appear to be down trending in the United States; however, rates of benzodiazepine use have been increasing, especially since the COVID-19 pandemic.[18-19] As with all respiratory depressants, a concern for benzodiazepine overdose is airway management. In theory, flumazenil can help reduce the need for advanced airway management by improving a patient's mental status. This benefit might have been seen in our study, as 15 patients with suspected benzodiazepine overdose with initial GCS <. 8 saw an improvement in GCS that otherwise may have required advanced airway management. This concept may be more relevant in rural settings where patients with advanced airways may require prolonged transport times or result in automatic transport to higher level of care centers.

When EMS clinicians documented the indication for flumazenil as "suspected benzodiazepine overdose," a high proportion of patients demonstrated clinical improvement, with 19 of 24 cases (79%; 95% CI, 58%–93%) showing an increase in GCS attributed to flumazenil administration. This finding may highlight the potential value of accurate prehospital recognition of benzodiazepine toxicity when flumazenil is used within EMS protocols, and it underscores the importance of targeted clinician education to support appropriate patient selection.

However, flumazenil is available in only a minority of EMS systems in the United States and is rarely administered in the prehospital setting. This may be because flumazenil has a typical shelf life of approximately 18–36 months (most commonly ~24 months) when stored at controlled room temperature. Also, the average acquisition cost is approximately $10–$25 per 1 mg vial in U.S. hospital purchasing systems. Given this combination of limited shelf life and the expense of maintaining a medication with infrequent prehospital use, many EMS agencies elect not to include flumazenil in their standard formulary. These considerations are reasonable given the infrequent use of flumazenil in the prehospital environment, along with its limited shelf life and the associated costs of maintaining inventory. However, the findings from the present study suggest that exclusion of flumazenil from EMS formularies primarily due to concerns regarding adverse reactions may warrant reevaluation. In our cohort, clinical improvement was commonly observed when flumazenil was administered in cases of suspected isolated benzodiazepine toxicity, supporting the potential utility of more selective, protocol-guided use in appropriately identified patients.

## LIMITATIONS

Our study has several limitations. Firstly, the retrospective design is inherently limited as it restricts the ability to establish control for confounding variables. Additionally, the reliance on EMS documentation may have inaccuracies or missing data. As most EMS documentation is not done in real time, it is difficult to know whether benzodiazepine overdose was truly suspected prior to administration, or whether it was identified in retrospect. Similarly, nearly all patient reports did not include time to effect after flumazenil administration, length of transport time, or whether any adverse reactions were experienced after

the patient was handed off from EMS care. Our sample size is also relatively small, which limits statistical power and subgroup analysis. In the case of coadministration of naloxone, only two cases documented a flumazenil-specific effect on GCS. Our study also was limited with respect to obtaining more current data. Requests to KEMSIS for updated data could not be completed by publication. Neither could we obtain information on flumazenil protocols for specific agencies.

Future studies would ideally look at matched cohorts comparing outcomes in patients with suspected benzodiazepine overdose who did and did not receive flumazenil, including the need for airway intervention, seizure occurrence, and GCS change.

## CONCLUSION

Emergency medical service protocols are often necessarily adapted to local patient populations, operational resources, and system-level training requirements. From a formulary perspective, flumazenil presents practical challenges, including a moderately finite shelf life and a relatively high per-vial acquisition cost within U.S. hospital purchasing systems. In combination with its infrequent deployment in the prehospital setting, these factors provide a rational basis for many EMS systems to exclude it from routine stocking.

Despite these considerations, the present analysis raises questions about whether noninclusion based largely on anticipated low utilization may be overly conservative in select systems. More importantly, this study suggests that exclusion of flumazenil from EMS formularies primarily due to concerns regarding adverse reactions may warrant reevaluation. These findings contribute to a limited but growing body of literature describing outcomes associated with EMS use in carefully selected clinical scenarios.

Taken together, these results may support reconsideration of flumazenil as a selectively available option within EMS protocols, particularly in systems with robust clinical governance and well-defined indications for use.

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# Hemodynamic Effects of Interfacility Dexmedetomidine Infusions During Transport of Patients with Alpha-2-adrenergic Agonist Withdrawal

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**Background:** In the Philadelphia region, there has been an increase in the potency of illicit opioids as well as the addition of nonopioid adulterants. Currently, medetomidine, a veterinary anesthetic that acts as an alpha-2-adrenergic agonist, is a common adulterant in the illicit opioid supply, causing both unique overdose and withdrawal syndromes. Although opioid withdrawal alone is not deadly, with added adulterants, especially medetomidine, this is no longer the case. Dexmedetomidine is an alpha-2-adrenergic agonist frequently used for sedation in the emergency department and intensive care unit. Dexmedetomidine is also used off-label to treat the life-threatening withdrawal from alpha-2-agonists.

**Objective:** This study describes the dosing and hemodynamic effects associated with the interfacility administration of dexmedetomidine in patients with alpha-2 adrenergic agonist withdrawal. Secondarily, we describe the safety of dexmedetomidine in this patient population.

**Methods:** We conducted a retrospective case review of patients receiving dexmedetomidine infusions in the interfacility setting for presumed alpha-2–adrenergic agonist withdrawal. Demographic data, dosing, and vital signs were analyzed descriptively.

**Results:** Over a six-month period, of 217 cases identified, 182 contained complete hemodynamic data. The average age was 39.5 years, and 67% were male. The average transport time was 15.7 minutes (range, 5-40 minutes). The mean dexmedetomidine infusion rate was 1.32 (0.31) mcg/kg/hr. The average mean arterial pressure decreased from 122.1 mm Hg (21.7) at the time of initial patient contact to 118.3 mm Hg (21.7) (mean difference, 3.80; 95% CI, 1.96-5.64) at final patient interaction. Heart rate also showed a minimal change from 104.9 (23.7) to 103.6 (21.8) beats/min (mean 1.3; 95% CI, -0.48 to 3.08). No cases of severe hypotension or clinically significant bradycardia requiring intervention were documented (one-sided 95% CI, 0-1.7%).

**Conclusion:** In this case series of patients, prehospital dexmedetomidine infusions to treat alpha-2-agonist withdrawal were associated with stable hemodynamics without significant bradycardia or hypotension. These findings support the safety of dexmedetomidine infusions for interfacility transport and provide a rationale for examining whether advanced life support clinicians can safely transport patients receiving dexmedetomidine infusions for this indication. [West J Emerg Med. 2026;27(5)1327–1330.]

## INTRODUCTION

Over the past two years, there has been a significant increase in the potency of opioids as well as adulterants found in the illicit drug supply. One of the most common adulterants in the opioid supply in the Philadelphia region is medetomidine, an alpha-2-adrenergic agonist, similar to clonidine. Medetomidine was found in 88% of illicit opioids at the end of 2025 compared to 0% at the beginning of 2024.[1] Adulterants such as medetomidine have transformed generally nonlife-threatening opioid withdrawal into a life-threatening condition manifesting as severe hemodynamic instability with marked hypertension and tachycardia. Dexmedetomidine, an alpha-2-adrenergic agonist, is used off-label to treat the life-threatening withdrawal from medetomidine because of its similar mechanism of action. This medication provides anxiolysis and sedation with minimal respiratory depression, making it an attractive option for treating this specific patient population.[2,3]

While the use of dexmedetomidine is well described in the emergency department (ED), intensive care unit (ICU), and procedural environments, data on its prehospital and interfacility setting use remain sparse.[4,5] Use of dexmedetomidine in the prehospital environment is limited to case reports and small case series.[3,6] This study evaluates the safety profile of dexmedetomidine infusion when used to treat complex opioid withdrawal during interfacility transport.

*Population Health Research Capsule*

What do we already know about this issue?
*Medetomidine, an alpha-2 agonist adulterant in illicit opioids in the Philadelphia region, causes a life-threatening withdrawal syndrome.*

What was the research question?
*Does interfacility dexmedetomidine infusion cause clinically significant hemodynamic or airway instability?*

What was the major finding of the study?
*Dexmedetomidine use in the prehospital environment was safe with no episodes of hypotension/bradycardia or airway compromise.*

How does this improve population health?
*These findings support ALS transport of patients on dexmedetomidine for alpha-2-agonist withdrawal, potentially reducing transfer delays and improving ED throughput.*

## METHODS

### Study Design

This is a retrospective case series of patients between January 1, 2025, and June 30, 2025, from a single interfacility transport agency. We included patients receiving dexmedetomidine infusions for presumed alpha-2-adrenergic agonist withdrawal. The agency provides both air and ground critical care interfacility transport in the Philadelphia region, running approximately 1,600 transports annually.

We identified charts using the internal reporting feature embedded in the electronic patient care reporting (ePCR) system. Search terms included "dexmedetomidine," "Precedex," "Dilaudid," "hydromorphone." The latter two terms were used as many patients who are transported on dexmedetomidine infusions are also transported on hydromorphone infusions. We used both generic and brand names, as well as opioid and alpha-agonist classifications, because of the absence of a standardized charting procedure. Additional search terms, including "withdrawal," "opiate," "opioid," and "altered mental status," were also applied but did not yield additional relevant cases. All identified charts were manually reviewed, and duplicate entries were consolidated into single cases. We excluded patients receiving only Dilaudid/hydromorphone or Precedex/dexmedetomidine for indications unrelated to complex withdrawal (eg, sedation adjunct for mechanical ventilation) because this study specifically focused on patients with alpha-2-agonist withdrawal. Data were extracted by a single reviewer using a standardized data extraction form. The analysis was performed by a separate author (SG).

This study was determined to be exempt by the Temple University Institutional Review Board.

### Data Collection

Extracted variables included age (where available), sex, vital signs, Glasgow Coma Scale (GCS) and dexmedetomidine infusion rate (mcg/kg/hr).

### Vital signs

Initial vital signs were defined as the first documented vital signs by the critical care transport team at the sending facility. All patients were started on a dexmedetomidine infusion prior to the arrival of the interfacility transport team and were maintained during transport at a level determined by the sending emergency physician. We defined destination vital signs as the final documented set at the time of transfer of care at the receiving facility. Vital sign measurements were obtained using standard interfacility monitoring equipment (Zoll X Series) (Zoll Medical Corporation, Chelmsford, MA) and documented according to agency protocol. To determine the maximum and minimum values, all vital signs obtained during transport were used. Dexmedetomidine dosing was analyzed as the documented continuous infusion rate in mcg/kg/hr. Bolus dosing of dexmedetomidine was not employed during transport.

### Outcome Definition

Our primary outcome measures were changes in systolic and diastolic blood pressure, mean arterial pressure (MAP), and heart rate from initial contact to destination. Secondary outcomes included the need for airway intervention. Hypotension was defined as MAP less than 65 mm Hg, or systolic blood pressure less than 90 mm Hg, at any time during transport. Bradycardia was defined as a heart rate less than 50 beats per minute (bpm), as this is our institutional guideline to decrease the dose of dexmedetomidine. Any interventions based on vital signs were noted. No predefined intervention thresholds were mandated by protocol.

### Statistical Analysis

We analyzed data using descriptive statistics where appropriate. Our primary outcome was evaluated using a paired *t*-test for continuous variables.

## RESULTS

A total of 217 patients were identified, with 182 patients having complete data for hemodynamic analysis (Table).

The average transport time was 15.7 minutes (range, 5-40 minutes). Infusion rates for dexmedetomidine ranged from 0.2 to 1.5 mcg/kg/hr, with a mean dose of 1.32 mcg/kg/hr (Figure 1).

### Hemodynamic Effects

Mean arterial pressure decreased from an average of 122.1 (21.7) mm Hg at the time of pickup to 118.3 (21.7) mm Hg at the drop-off destination (Figure 2). Mean heart rate showed minimal change (104.9 [23.7] bpm to 103.6 [21.8] bpm). The lowest recorded blood pressures and heart rates did not meet the definition of hypotension or bradycardia. One person received 500 mL of normal saline for a blood pressure reading of 99/59 with a MAP of 74 mm Hg.

**Table.** Patient demographics and clinical characteristics in a study describing the dosing and hemodynamic effects associated with the interfacility administration of dexmedetomidine in patients with alpha-2 adrenergic agonist withdrawal.

| Number of patients, *n* | 182 |
|---|---|
| Age, years | |
| Mean (SD) | 39.5 (9.0) |
| Median (IQR) | 39 (34–44) |
| Male sex, *n* (%) | 121 (66.5%) |
| GCS at time of EMS pickup, median (IQR) | 13 (10–15) |
| Dexmedetomidine dose (mcg/kg/hr), median (IQR) | 1.5 (1.2–1.5) |

*EMS*, emergency medical service; *GCS*, Glasgow Coma Scale; *IQR*, interquartile range; *SD*, standard deviation.

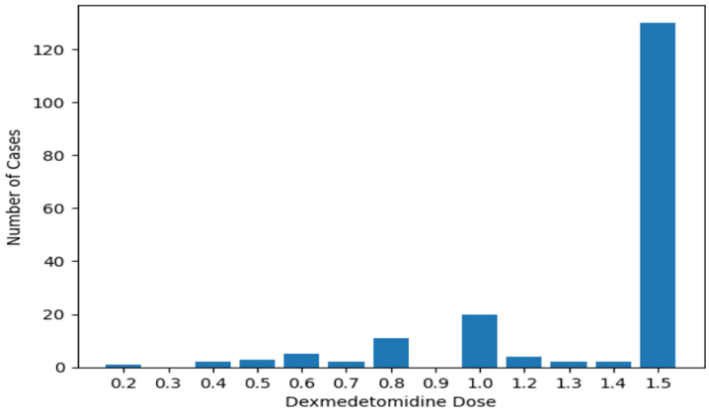


**Figure 1.** Dexmedetomidine dosing ranges (mcg/kg/hour) in a study describing the dosing and hemodynamic effects associated with the interfacility administration of dexmedetomidine in patients with alpha-2 adrenergic agonist withdrawal.

## DISCUSSION

In this retrospective case series of patients receiving dexmedetomidine infusions for presumed alpha-2-agonist withdrawal during interfacility transports showed overall hemodynamic stability with mild reductions in MAP and minimal changes in heart rate. Importantly, no clinically significant episodes of hypotension or bradycardia requiring intervention were identified. The modest reduction in MAP observed is consistent with the known pharmacologic profile of dexmedetomidine and did not appear to translate into clinically significant adverse events. In addition, no patients required intubation, consistent with dexmedetomidine's profile of maintaining respiratory neutrality. While the absence of a comparator group limits causal inference, the consistency of observed physiologic effects supports feasibility and relative safety in selected patients, especially patients who have increased sympathetic tone from acute withdrawal.

Currently, the interfacility transport of patients on dexmedetomidine infusions requires advanced level practitioners, at least at the level of a prehospital registered nurse (PHRN) and is not within the scope of advanced life support (ALS) clinicians in the Commonwealth of Pennsylvania. Because of current volume and staffing challenges, the need for a PHRN crew has resulted in significant delays in transferring patients between facilities to a higher level of care. These delays have led to increased ED boarding times and decreased patient throughput. Allowing ALS clinicians to transport this medication would significantly improve the movement of these patients to inpatient care environments and improve emergency department throughput.

## LIMITATIONS

This study is limited by its retrospective design, the inclusion of a single interfacility transport agency, and the

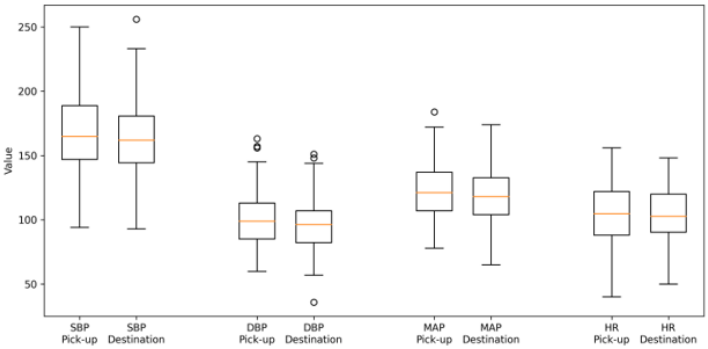


**Figure 2.** Hemodynamics at pickup and destination: Box plots comparing hemodynamic parameters at patient pickup and hospital arrival, including systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate (HR). Boxes represent interquartile ranges with median values; whiskers indicate the range of nonoutlier observations, and individual points represent outliers.

absence of a control group. Patients also received a variety of medications prior to transport by the sending physician, including opioids, typical and atypical antipsychotics, ketamine, benzodiazepines, phenobarbital, and serotonin 5HT3 receptor antagonists. The measurements of vital signs were time-stamped in the ePCR, but there was not a standard time of when to obtain them upon arrival at the bedside.

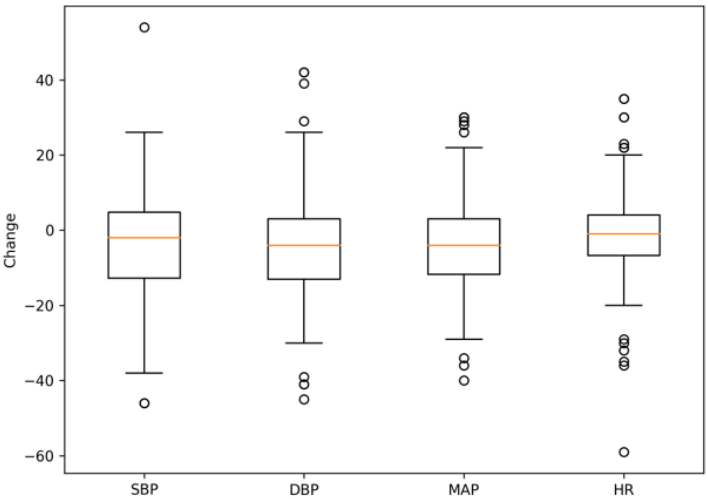


**Figure 3.** Change in hemodynamics (pickup to destination) during dexmedetomidine infusion**:** Box plots demonstrating change in systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate (HR) from patient pickup to hospital arrival following dexmedetomidine administration. Boxes represent interquartile ranges with median values; whiskers indicate the range of nonoutlier observations, and individual points represent outliers.

## CONCLUSION

In this case series, interfacility dexmedetomidine infusions were associated with stable vital signs and no incidence of adverse hemodynamic or airway effects. The use of advanced clinicians for these transports may not be warranted and can potentially be accomplished by an ALS crew, saving resources, increasing availability of transport, and transferring patients more quickly to a higher level of care. This study provides the rationale for a prospective study of interfacility transport of dexmedetomidine infusions by ALS clinicians for alpha-2 agonist withdrawal.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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# Effect of Real-time Feedback on the Quality of Cardiopulmonary Resuscitation for Medical Students in Colombia

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**Introduction:** High-quality cardiopulmonary resuscitation (CPR) is essential to improve survival in cases of cardiac arrest. However, skill acquisition based solely on instructor observation has proven to be limited. In this context, real-time feedback devices emerge as promising tools to optimize CPR training.

**Objective:** In this study our goal was to evaluate the effect of using a real-time feedback device on the quality of CPR performed by medical students at a public university in Colombia.

**Methods:** This was an experimental study with fourth-year medical students, randomly assigned to two groups. Both groups received the same initial theoretical and practical training in basic CPR. Subsequently, the intervention group practiced with a real-time feedback device, while the control group trained without technological feedback. The primary outcome measure was the target of chest compressions, simultaneously meeting both a rate of 100-120 compressions/minute and a depth of 5-6 cm (maximum value: 100%), as well as ventilations delivered within the 500-600 mL volume range. Secondary outcomes included isolated data on compression depth and rate during two simulated scenarios: hands-only CPR for two minutes and five cycles of 30 chest compressions and two ventilations.

**Results:** Of 106 eligible participants, 98 (92.5%) completed the test (46 intervention / 52 control). Regarding the primary outcome, the intervention group showed significantly higher compliance with the compression target compared to the control group (median values: intervention group 31% vs control group 0%, $P < .001$). In the hands-only CPR test, the intervention group achieved a higher compression target (72% [40.7-81] vs 3.4% [0-40]; $P < .05$) and better depth control (5.5 cm [5-5.6] vs 6 cm [5.6-6.1]); $P < .05$], with no differences in rate ($P = .71$). In the test with cycles of 30 chest compressions and two ventilations, the intervention group performed better, with a higher compression target (73% [5-83] vs 0.5% [0-19]), P< .05) and better depth control (5.5 cm [5-5.8] vs 6 cm [5.9-6.1], P < .05). No significant differences were observed in ventilation. Both groups had a median target completion of 0% with tidal volumes (intervention group, 265 mL; control group, 291 mL), accounting for failure at well below the recommended 500-600 mL.

**Conclusion:** Real-time feedback significantly improved chest compression quality in medical students, although ventilation difficulties persisted. Future research is needed to assess long-term skill retention and clinical application. [West J Emerg Med. 2026;27(5)1331–1339.]

## INTRODUCTION

Cardiac arrest remains a significant public health challenge worldwide. Despite advances in resuscitation care, survival rates remain low for both out-of-hospital and in-hospital cardiac arrests.[1-3] Outcome variability after cardiac arrest is significantly influenced by modifiable resuscitation factors, particularly cardiopulmonary resuscitation (CPR) quality metrics such as compression depth, rate, chest recoil, and minimization of interruptions.[4,5] International guidelines emphasize the importance of effective resuscitation training to improve survival rates in these scenarios.[6,7] However, the progressive decline of CPR skills following training continues to be a concern,[8-10] with inconsistencies in CPR quality even among trained personnel.[8,9]

Traditionally, medical students undergo CPR training using simulators with instructor-provided feedback, who guide and correct performance according to quality parameters. Although this method has demonstrated satisfactory learning outcomes in some studies, it is generally considered less effective than technology-assisted teaching methods, which allow real-time feedback on quality parameters.[11-12] Furthermore, it has been reported that instructor judgment alone is insufficient to determine student competence in chest compressions.[13] Although the use of feedback devices has been shown to improve outcomes, and most studies support their inclusion in healthcare training, many institutions still do not integrate them into their teaching models.[14-17]

With the release of updated international guidelines, specific quality parameters have been established to optimize resuscitation effectiveness.[18] Real-time feedback devices now enable more accurate measurement of these parameters, generating objective data that allow immediate adjustments in technique.[19] Recently, there has been growing interest in incorporating these devices into CPR education, as they help to overcome the limitations of subjective visual assessment by instructors and healthcare staff.[20] Previous research has shown that feedback devices can improve short-term learning outcomes.[20-22]

Training in CPR is essential in medical education, as it is crucial to assess the acquisition of high-quality skills and identify areas for improvement to strengthen knowledge.[23,24] Therefore, we sought to assess the impact of real-time feedback devices on the quality of CPR performed by fourth-year medical students.

*Population Health Research Capsule*

What do we already know about this issue?
*High-quality cardiopulmonary resuscitation is crucial for improving survival rates in cardiac arrest.*

What was the research question?
*Does the use of a real-time feedback device during training improve the rate and depth of chest compressions and ventilation volume?*

What was the major finding of the study?
*Training with real-time feedback significantly improved the quality of chest compressions but did not improve ventilation quality.*

How does this improve population health?
*This research supports the integration of real-time feedback technology in medical education.*

## MATERIALS AND METHODS

### Study Design

A randomized, cross-sectional, single-blind study was conducted at Universidad del Valle, Cali, Colombia, from May 5–30, 2025. The study was registered and approved by the institutional ethics committee (code 013-024) and the School of Medicine. Participation was confirmed through signed informed consent, and all data were handled to ensure student anonymity.

### Participants

The medical program offers a mandatory annual course titled "Basic Cardiopulmonary Resuscitation Techniques" for fourth-year students prior to initiating their clinical rotations. Recruitment was carried out through email announcements and calls made by the academic office immediately before the course began. Inclusion criteria were being of legal age and officially enrolled in the course. Exclusion criteria included the following: chronic cardiac or respiratory diseases; pregnancy; motor disabilities that would significantly limit performance of the tests; and language barriers.

### Randomization

Each participant was assigned a numerical code. A researcher external to the study generated a list of these codes in a digital spreadsheet, randomized the order using the "random" function, and allocated participants into two groups with a 1:1 ratio to ensure balance. The first group was designated CPR with feedback and the second CPR without feedback. Participants were notified of their group assignment but were blinded to the characteristics of the testing protocol.

### Sample Size Calculation

We calculated the sample size based on previous data[25] using the following parameters: a confidence level of 95% ($\alpha = 0.05$), a statistical power of 80% ($1 - \beta = 0.20$), and an estimated minimum difference of 20% in the proportion of high-quality CPR between groups (effect size). An additional 10% was added to account for potential losses (dropouts), resulting in a final sample size of 94 participants.

**Feedback Device**

During the study, a single PRESTAN CPR 2000 adult simulator (PRESTAN Products, LLC, Solon, OH) was used. It was purchased at a cost of U.S. dollars 400. This device provides visual cues through light indicators on the thoracic side and auditory signals during compressions. It is equipped with software that records and displays real-time performance via wireless connection to mobile devices or monitors through the PRESTAN CPR feedback app. Data can be exported for quantitative analysis, including compression rate and depth, number of ventilations, ventilation volume, and pause duration, among others. The simulator establishes an upper compression depth limit of 6.1 cm, with any measurement beyond this value representing excessive compression depth.

**Protocol**

The training program, based on the latest International Liaison Committee on Resuscitation guidelines,[23,24,26] consisted of four four-hour weekly sessions. The first session covered theoretical aspects of adult and pediatric CPR, as well as automated external defibrillator use. The subsequent sessions were organized into practical skills stations in the laboratory. The principal investigator met with instructors beforehand to standardize the teaching pathway according to the algorithms in the guidelines,[26] ensuring homogeneous training conditions for all participants.

The intervention group (CPR with feedback) trained with the feedback device, allowing them to view CPR variables in real time and adjust performance immediately during practice. The control group (CPR without feedback) received the same training in a separate space, without the use of feedback devices. To minimize bias, both groups trained using PRESTAN simulators.

At the end of the course, participants from both groups were summoned for the study protocol. In the intervention group, students were paired ("A" and "B"). The protocol had two phases: in phase one, participant "A" performed continuous compressions for two minutes without ventilations, followed by participant "B." A mandatory five-minute rest was provided to minimize fatigue-related confounding. In phase two, each pair completed five CPR cycles (30 compressions followed by 2 ventilations). Within each pair, participant "A" performed chest compressions, while participant "B" delivered ventilations with a bag-valve-mask (BVM). After completing the five cycles, participants switched roles and repeated the test.

Before starting, participants were allowed to familiarize themselves with the simulator and had two minutes of practice for technical adjustment. An investigator explained the simulator's features and feedback tools and answered questions. During phase one, a tablet was placed on the floor in front of the participant; during phase two, it was placed diagonally to allow each participant to track their own performance. Two investigators were present at all times: one supervised and provided instructions, while the other transcribed data exported from the device (Figure 1). The control group followed the same protocol, but the simulator's feedback lights were covered with opaque tape, and no feedback devices were used.

For data collection, a test was considered complete if both phases of the protocol were performed. It was considered incomplete if a participant missed more than one theoretical-practical session or failed to complete one of the two protocol activities.

**Primary and Secondary Outcome Measures**

For the hands-only CPR test, we defined the primary outcome as the target of compressions, calculated as the absolute percentage of optimal chest compressions that simultaneously met both a rate of 100-120 compressions/minute and a depth of 5-6 cm.[27,28] For the test with cycles of 30 chest compressions and 2 ventilations, the outcomes included the total target of compressions across all five cycles, as well as the cycle target of compressions for each individual cycle. Additionally, the total target of ventilations and the cycle target of ventilations were determined. The ventilation target was defined as the percentage of effective ventilations based on an administered volume of 500-600 mL.[29] Secondary outcomes for all tests included the following:: the proportion of compressions within the recommended depth (5-6 cm); chest compressions performed at the recommended rate (100-120 compressions/minute); "hands-off time" defined as the interruption period without chest compressions during

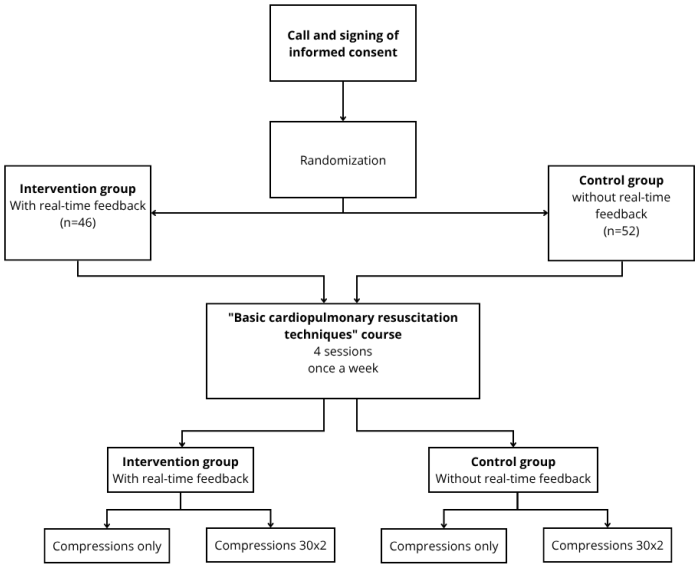


**Figure 1.** Flowchart illustrating participant selection and protocol development process in a study of real-time feedback on quality of cardiopulmonary resuscitation among medical students in Colombia. *Note:* 30x2 compressions refers to cycles of 30 compressions followed by 2 ventilations.

rescue ventilations; and the total CPR time in the modality using cycles of 30 chest compressions and 2 ventilations.

**Statistical Analysis**

We analyzed all data using IBM SPSS software v25 for Windows (International Business Machines Corporation, Armonk, NY). Frequency distributions were calculated for categorical variables, and results were expressed as percentages. To assess the distribution of continuous variables, we applied the Kolmogorov-Smirnov test with Lilliefors correction. Variables with normal distribution were reported as means with standard deviations, whereas non-normally distributed data were described using medians and interquartile ranges, obtained through the Mann-Whitney U test. We assessed statistical significance using the Fisher exact test and the chi-square test.

## RESULTS

A total of 98 students agreed to participate in the study, of whom 57 (58.2%) were women. The predominant age range was 18-25 years (89.8%). Additionally, most participants had never undergone any type of CPR training or external certification prior to completing this university course (92.8%). Of the total included participants, 52 were assigned to the control group and 46 to the intervention group. The evaluation of sociodemographic variables showed no significant differences between groups (Table 1).

For the hands-only CPR test, statistically significant differences were found in the compression target : intervention group, 72% (40.7-81) vs control group, 3.4% (0-40) ($P < .05$), indicating greater accuracy in the simultaneous achievement of recommended compression depth and rate in the intervention group. When analyzing the median compression depth separately, the intervention group achieved 5.5 cm (5-5.6) compared to the control group's 6 cm (5.6-6.1 (P < .05), showing significant differences, with the intervention group remaining within the recommended range of 5-6 cm. No significant differences were found in compression rate, as both groups remained within the recommended range: intervention group 111.5 (106-115) vs control group 111 (108-114); P = .71 (Table 2).

In the test with cycles of 30 chest compressions and 2 ventilations, the total compression target was significantly higher in the intervention group compared to the control group; intervention group 73% (5-83) vs control group 0.5% (0-19); $P < .05$. No significant differences were found between groups in the total ventilation target: intervention group 0% (0-22.5) vs control group 0% (0-20); $P = .99$. Overall, the administered tidal volumes were below the recommended range in both groups: intervention group 265 mL (206-390) vs control group: 291 ml (219-373); P =.990, suggesting substantial difficulty in delivering effective ventilations.

The median compression depth demonstrated better control in the intervention group: 5.5 cm (5-5.8) vs control group 6 cm (5.9-6.1); $P < .05$. Compression rate remained within the recommended range in both groups: intervention group 109 (106-114) vs control group 111 (107-114); $P = .544$. The mean hands-off time was lower in the control group, with significant differences, indicating fewer interruptions in chest compressions: intervention group 6.0 (1.4) vs control group 4.8 (0.79); $P < .05$. Likewise, the mean total time to complete five cycles was longer in the intervention group 111.6 seconds (10.85) vs control group 107.4 (6.45); $P < .05$ (Table 2).

Cycle-by-cycle analysis showed that the median compression target remained consistently higher for the intervention group compared with the control group. No significant differences were observed in ventilation. Both groups had a median target completion of 0% and tidal volumes (intervention group 265 mL; control group 291 mL), well below the recommended 500-600 mL. Compression depth remained within the recommended 5-6 cm range throughout all cycles in the intervention group compared with the control group. Finally, a modest variability in compression rate was observed in the intervention group, while the control group showed more consistency, although without negative impact, as values always remained within the recommended range (Table 2, Figure 2).

No data loss, transcription errors, or software-related issues were reported. Full follow-up of all participants was ensured, and there were no exclusions due to incomplete protocol performance.

**Table 1.** Sociodemographic variables of participants categorized by sex, age, and previous attendance in cardiopulmonary resuscitation (CPR) courses in a study of real-time feedback on CPR quality among medical students in Colombia.

| Variable n (%) | Control n = 52 | Intervention n = 46 | P value |
|---|---|---|---|
| Sex | | | |
| Female | 31 (59.6) | 26 (56.5) | .84 |
| Male | 21 (40.4) | 20 (43.5) | |
| Age | | | |
| 18–25 years | 48 (92.3) | 40 (87) | .51 |
| 26–33 years | 4 (7.7) | 6 (13) | |
| External CPR Courses | | | |
| 6-24 months ago | 1 (1.9) | 1 (2.2) | |
| > 24 months ago | 3 (5.8) | 2 (4.3) | 1 |
| No external courses | 48 (92.3) | 43 (93.5) | |

*CPR*, cardiopulmonary resuscitation

## DISCUSSION

We evaluated whether the use of real-time feedback devices would improve CPR performance among fourth-year

**Table 2.** Comparison of compliance with cardiopulmonary resuscitation (CPR) quality criteria in compression-only and 30:2 modalities (including cycle-specific performance) between intervention and control groups in a study of real-time feedback on CPR quality among medical students in Colombia.

| Modality | Quality Criteria Median (IQR) | Control, N=52 | Intervention, N=46 | P value |
|---|---|---|---|---|
| Compression only | Target compressions (%) | 3.4 (0 - 40) | 72 (40.7 - 81) | .00 |
| | Chest depth (cm) | 6 (5.6 – 6.1) | 5.5 (5 – 5.6) | .00 |
| | Compressions per minute | 111 (108 - 114) | 111.5 (106 - 115) | .71 |
| Cycles of 30 chest compressions and 2 ventilations | Target compressions (%) | 0.5 ( - 19) | 73 (5 - 8) | .00 |
| | Target ventilations | 0 ( - 20) | 0 ( - 22.5) | .99 |
| | Chest depth (cm) | 6 (5.9 - 6,1) | 5.5 (5 – 5.8) | .00 |
| | Compressions per minute | 111 (107 - 114) | 109 (106 - 114) | .54 |
| | Ventilation volume (mL) | 291 (219 - 374) | 265 (206 - 390) | .99 |
| | Hands-off time (sec) | 4.8 (SD 0.8) | 6.0 (DE ± 1.4) | .00 |
| | Total CPR time (sec) | 107.4 (SD 6.4) | 111.63 (DE ± 10.8) | .00 |

| | | Cycles of 30 chest compressions and 2 ventilations (modality by cycle) | | | | |
|---|---|---|---|---|---|---|
| Cycles | | Target compressions (%) | Target ventilations (%) | Chest depth (cm) | Compressions per minute | Ventilation Volume (mL) |
| Control, N=52 | 1 | 0 (0 - 12) | 0 (0 - 0) | 6.0 (6 – 6.1) | 111 (107 - 114) | 91.5 (0 - 330) |
| | 2 | 0 (0 - 9) | 0 (0 - 0) | 6.1 (6 – 6.1) | 111 (107 - 114) | 240 (0 - 366) |
| | 3 | 0 (0 - 7) | 0 (0 - 0) | 6.1 (5.9 – 6.1) | 111 (108 - 114) | 267 (47 - 374) |
| | 4 | 0 (0 - 20) | 0 (0 - 0) | 6.0 (5.9 – 6.1) | 111 (106 - 114) | 230 (0 - 370) |
| | 5 | 0 (0 - 26) | 0 (0 - 0) | 6 (5.9 – 6.1) | 111 (107 - 114) | 240 (0 - 334) |
| Intervention, N=46 | 1 | 63 (19.7 - 83) | 0 (0 - 0) | 5.5 (5.3 – 5.9) | 110.5 (104 - 116) | 194 (0 - 366) |
| | 2 | 77 (41 - 87) | 0 (0 - 0) | 5.6 (5.3 – 5.8) | 109 (106 - 115) | 220 (0 - 371) |
| | 3 | 80 (52 - 90) | 0 (0 - 0) | 5.5 (5.3 – 5.7) | 111 (105 - 114) | 234 (0 -363) |
| | 4 | 80 (53 - 87) | 0 (0 - 0) | 5.5 (5.3 – 5.7) | 109 (105 - 115) | 205 (0 - 374) |
| | 5 | 80 (67 - 90) | 0 (0 - 0) | 5.5 (5.3 – 5.7) | 108 (104 - 114,2) | 207 (0 - 391) |

Data are presented as median (interquartile range) for continuous variables due to non-normal distribution, and as mean (standard deviation) for time variables. Target compressions: percentage of compressions simultaneously meeting correct depth and rate. Target ventilations: percentage of ventilations with tidal volume between 500-600 mL. *P* value was calculated using the Mann-Whitney U test for continuous variables. The feedback device records a maximum depth of 6.1 cm.; therefore, values reported as 6.1 cm represent depths ≥ 6.1 cm.
*SD*, standard deviation.

medical students. Quality guidelines for CPR are as follows: in adults, chest compressions should reach a depth between 5-6 cm; be delivered at a rate of 100-120 compressions per minute; ensure complete chest recoil after each compression; minimize interruptions during CPR; and avoid hyperventilation.[19] Proper implementation of these measures has been associated with increased survival to hospital discharge in patients with cardiac arrest.[7,30]

Our findings showed that both chest compression depth and compliance with the compression target were significantly higher in the group trained with real-time feedback devices. In a study conducted in 30 hospitals in the United States with healthcare workers, it was concluded that chest compressions are often suboptimal and that the use of feedback devices improves compression quality in simulators.[31] These results are relevant because current guidelines emphasize the importance of achieving chest compressions that simultaneously meet both adequate depth and rate, proposing this combined measure as an objective criterion to evaluate compression quality.[27]

Many educational institutions rely on the instructor's subjective assessment to evaluate CPR quality. However, visual assessment has been shown to be highly inaccurate, even among experienced healthcare professionals.[21] This leads to a false perception of CPR quality and causes clinicians to perform suboptimal CPR during simulated cardiac arrest scenarios.[22] In this context, the lack of objective assessment during CPR training may negatively influence skill development.

The low performance of the control group in the primary outcome (simultaneous compression target) could be explained by the strictness of the composite metric. While

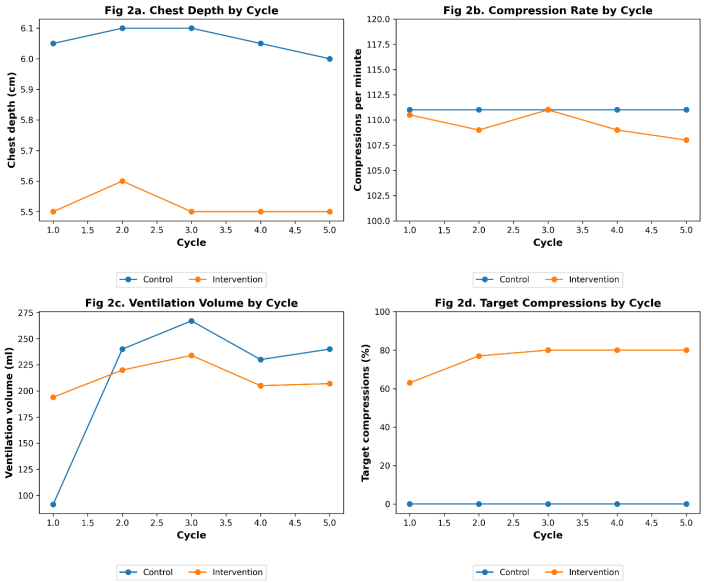


**Figure 2.** Monitoring of compliance with cardiopulmonary resuscitation (CPR) quality criteria (depth, rate, ventilation, and target compressions) during each cycle, stratified by groups in a study of real-time feedback on CPR quality among medical students in Colombia. *Note:* target compressions, percentage of compressions simultaneously meeting correct depth and rate. With regard to chest depth, the feedback device records a maximum depth of 6.1 cm; therefore, values at this level indicate a depth of ≥ 6.1 cm.

participants often achieved adequate depth or rate individually, maintaining both parameters simultaneously proved difficult for them without real-time feedback guidance. A systematic review published in 2021 reported that the use of real-time feedback devices, regardless of the specific type, can guide both laypersons and professionals in achieving high-quality CPR targets.[17] This supports the use of automated devices as a strategy to improve performance in simulated settings. Consistent with the results presented in our study, the intervention group demonstrated higher compliance values for quality variables compared to the control group.

Ventilation is considered a key component of CPR because it facilitates gas exchange. Current guidelines recommend providing 2 ventilations for every 30 compressions when an advanced airway is not available, with a tidal volume of 500-600 mL, or enough to produce visible chest rise.[19] Recent publications have shown that despite efforts to achieve guideline-consistent ventilations, rescuers often fail to deliver adequate volumes with BVM, usually providing volumes below the recommended threshold.[32] In our study, both groups delivered low tidal volumes, resulting in zero compliance with ventilation quality targets.

These findings differ from other reports in simulated settings where ventilation quality was assessed in 20 pairs of paramedics. That study found that real-time ventilation feedback improved compliance with ventilation rate targets (41-71%) and volume targets (31%79%).[33] Typically, in the absence of objective markers, healthcare professionals rely on observing chest rise as an indicator of adequate ventilation volume.[34] An observational study with 106 simulated, adult cardiac arrest resuscitations showed that ventilation practices rarely met guideline targets, even when performed by well-trained professionals.[35] Simulation-based studies suggest that the use of feedback devices may significantly enhance the ability of professionals to achieve recommended ventilation parameters during simulated cardiac arrest resuscitations.[36]

However, it is noteworthy that in our study, the intervention group, despite having real-time feedback devices, demonstrated ventilation performance far below recommendations, similar to that of the control group. Possible explanations include difficulties in BVM technique, mask leaks, or ineffective airway alignment with the simulator. Previous studies have shown that BVM ventilation performed by two rescuers is more effective than when performed by a single individual.[37] The most common deficiency in the latter is ineffective mask sealing,[38] a situation observed in most of our participants. One explanation for the widespread failure to meet ventilation parameters suggests that the difficulty lies in the psychomotor skill required to maintain an effective mask seal and airway patency, rather than in the lack of feedback alone.

We must emphasize that feedback devices that measure tidal volume also present limitations, such as their inability to reflect respiratory system physiology, including airway resistance or lung compliance. Therefore, developing methods to monitor and ensure high-quality ventilation during CPR education is crucial. Furthermore, it should be recognized that performance with a feedback device may reflect a "calibration" to the specific mechanical compliance of the manikin, which does not fully replicate the variable chest stiffness encountered in real patients.

Interruptions in compressions may reduce coronary and cerebral perfusion pressures and have been associated with worse outcomes when interruption time is prolonged.[39] During CPR with cycles of 30 chest compressions and 2 ventilations, compressions are briefly interrupted to allow ventilations. The optimal duration of these interruptions remains uncertain.[40] International guidelines recommend that interruptions should not exceed 10 seconds, and recent studies indicate better clinical outcomes with shorter interruptions.[41] In our study, the mean "hands-off" time was 4.8 seconds for the control group and 6 seconds for the intervention group, with a statistically significant difference. These findings are consistent with other studies where experienced rescuers required between 5-7 seconds to perform this task.[32,41] However, as noted earlier, the tidal volumes delivered were suboptimal.

The study population consisted of fourth-year medical students, 92.85% of whom had never participated in activities related to life support and had limited experience in psychomotor skills that require practice to achieve proficiency.

Real-time audiovisual feedback devices allow immediate monitoring of key parameters, facilitating adherence to CPR quality goals in simulation scenarios.[19] Therefore, incorporating such tools into CPR training may be useful to optimize skill acquisition during educational sessions. A variety of simulators featuring real-time feedback are available on the market. Regarding practicality, the device used represents a cost-effective alternative for low-resource settings compared to high-fidelity simulation centers.

## LIMITATIONS

Future studies should evaluate longer CPR cycles, more closely resembling real-life scenarios, including rescuer switching and assessment of additional variables such as chest compression fraction and chest recoil. These represent some of the limitations of the present study, which also include constraints inherent to the feedback device used. Various devices are available in the market, each with different mechanisms for data acquisition. For example, the equipment used in this study does not allow quantitative analysis of chest recoil within its software. Similarly, compression depth has an upper limit of 6.1 cm, even if the participant exceeds this value. It would be important to compare different feedback devices and assess the similarity or discrepancy among data outputs. Additionally, due to the design of our study, no longitudinal follow-up was performed to evaluate skill retention over time. Finally, it is important to recognize that the simulator is strictly a training tool and not a clinical device. Therefore, the operationalization of improved classroom skills into real-world clinical practice and their direct impact on patient outcomes remain to be evaluated.

## CONCLUSION

The results demonstrate that the application of real-time feedback devices for training medical students in CPR significantly improved chest compression quality during a simulated scenario. However, despite the use of such devices, participants showed difficulty in achieving ventilation targets. Therefore, educational strategies should be directed toward optimizing ventilation techniques to match the improvements observed in compression quality. Additionally, future research is needed to assess long-term skill retention, clinical application in real patients, and comparison between different clinical feedback devices.

### Ethics Approval and Consent to Participate

We confirm that all methods were carried out in accordance with the ethical standards set forth in the Declaration of Helsinki and its subsequent amendments, or comparable ethical standards. The study was registered and approved by the institutional ethics committee (code 013-024) and the School of Medicine. Participation was confirmed through signed informed consent, and all data was handled to ensure student anonymity.

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# Artificial Intelligence-Driven Cost Savings from Emergency Department Chest Pain Patient Evaluation: A Monte Carlo Simulation

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**Introduction:** Chest pain patients presenting to the emergency department (ED) often require risk stratification through stress testing, which may necessitate hospitalization. This practice contributes to ED crowding by occupying beds with low-risk patients who may derive limited benefit from testing, thereby increasing bed occupancy, prolonging ED boarding times, amplifying crowding, and resource strain. Use of an artificial intelligence (AI)-driven clinical decision support tool improves the detection of obstructive coronary artery disease and focuses diagnostic testing on those most likely to benefit.

**Methods:** We created a Monte Carlo simulation informed by available published inputs and ran 1,000 trials to estimate the national impact of using an AI-driven decision-support tool to reduce avoidable downstream cardiac testing among eligible U.S. ED patients with chest pain. Model inputs included patient demographics, chest pain history, electrocardiogram (ECG) findings, medication use, and lab values (including some nonroutine tests). Our primary outcome was U.S. annual cost savings from reclassifying eligible ED patients using an AI-driven decision-support tool. Secondary outcomes included reductions in short-stay hospitalizations, cancer cases, and cancer deaths due to averted radiation exposure.

**Results:** Universal adoption of an AI-driven decision-support tool was estimated to save a mean (standard deviation) of $675 million ($340 million) by avoiding 688,000 (147,000) downstream cardiac diagnostic tests. This resulted in annual decreases of 537,000 (115,000) hospitalizations, 8.30 million (1.96 million) bed hours, 490 (150) new cancer diagnoses, and 250 (80) cancer deaths.

**Conclusion:** Assuming similar recategorization of patients seen in a European outpatient cohort, widespread adoption of an AI-driven clinical decision-support tool to evaluate U.S. ED patients with suspected obstructive coronary disease could yield substantial benefits by reducing avoidable downstream cardiac testing. By accurately identifying patients who do not require urgent diagnostics, this approach could help mitigate crowding, relieve resource strain, and improve patient flow—supporting a more efficient emergency care system. [West J Emerg Med. 2026;27(5)1340–1352.]

## INTRODUCTION

Chest pain is the second leading cause of emergency department (ED) visits in the United States (U.S.), accounting for approximately 7.8 million encounters annually, or 5.5% of all ED visits.[1] Traditional diagnostic tools, including high-sensitivity troponin (hsTn) tests and electrocardiograms (ECG), detect acute myocardial infarction but cannot diagnose obstructive coronary artery disease (CAD) without myocardial injury. Consequently, many patients undergo prolonged ED observation or hospitalization for additional cardiac testing, such as coronary computed tomography angiography (CCTA) and stress testing (ST). Among low-risk patients, these tests consume bed capacity, increase healthcare costs, and cause unnecessary radiation exposure without improving diagnostic yield.[2,3]

Several clinical scores and accelerated diagnostic protocols have been developed to improve risk stratification for chest pain.[4] The HEART score (history, ECG, age, risk factors, and initial troponin) is widely adopted in U.S. EDs due to its high sensitivity for acute coronary syndrome (ACS) and its low adverse-event rate in low-risk patients.[5–14] However, its utility for assessing CAD prevalence is limited, particularly in the absence of acute myocardial injury. Moreover, the HEART score prioritizes sensitivity over specificity (pooled sensitivity of 96% and specificity of ~50% predicting major adverse cardiac events [MACE]), resulting in a high rate of false positives and downstream testing.[15,16] Other models, such as the Diamond Forrester and Duke clinical scores, are recommended by the American Heart Association and American College of Cardiology for estimating CAD prevalence,[17–20] but they often overestimate risk and are rarely used in the ED setting.[19,21,22] In 2019, the European Society of Cardiology introduced the CAD2 model to improve CAD risk prediction.[23,24] While CAD2 demonstrates enhanced accuracy, its performance in diverse populations has been limited, and its complexity hinders its practical utility in ED workflows.[24,25]

These limitations highlight a gap in current ED chest pain evaluation: existing tools are designed to avoid missed events rather than efficiently identify patients who could safely forgo additional testing. Recent studies demonstrate that moderate-risk patients with CAD are at a higher risk of a 30-day rate of MACE than those without CAD, further highlighting the need for improved predictive models.[27] In recent years, advances in machine learning have led to the development of multiple artificial intelligence (AI)–based models aimed at improving CAD detection and risk stratification using routinely available clinical data. These approaches extend beyond traditional rule-based scores by integrating high-dimensional inputs, including lab values, ECG features, and clinical variables, to generate individualized risk predictions. Several studies have demonstrated that machine learning models can outperform conventional risk scores in predicting obstructive CAD and MACE.[28-30]

One such model, Cardio Explorer (Exploris Health AG, Zürich, Switzerland), is an AI tool created via a memetic pattern-based algorithm that integrates multiple analytical methods to evaluate CAD risk as an integrated tool in the electronic health record (EHR) using readily available patient data, supplemented by additional blood tests (no additional inputs are used by Cardio Explorer beyond those listed in Figure 1).[31,32] Validated across low- to high-risk European populations and Conformité Européenne approved for healthcare safety, Cardio Explorer demonstrates superior capability for identifying clinically significant CAD compared to traditional models.[31,32] For example, in one validation study of 696 Dutch patients referred for outpatient cardiac testing, Cardio Explorer had a negative predictive value (NPV) of 95.8%, sensitivity of 82.3%, specificity of 77.4%, and area under the receiving operating curve of 0.87 against a gold standard of cardiac catheterization, CCTA, or nuclear perfusion ST.[31] The Cardio Explorer NPV was comparable to other risk scores, while categorizing more than twice as many patients as very low or low risk (84.4% versus 40.2% and 44.5% for Diamond Forrester and CAD2 models, respectively). These results indicate good overall discriminatory performance and the ability to classify a larger proportion of patients as low risk compared with traditional

*Population Health Research Capsule*

What do we already know about this issue?
*Emergency department chest pain evaluation often leads to avoidable cardiac testing for low-risk patients, increasing hospitalizations and healthcare costs.*

What was the research question?
*Could an artificial intelligence (AI) decision-support tool reduce avoidable cardiac testing and costs in U.S. emergency department chest pain patients?*

What was the major finding of the study?
*A Monte Carlo simulation showed mean (SD) annual savings of $675 million ($340 million), a 17.6% reduction in total spending from 688,000 (147,000) tests averted.*

How does this improve population health?
*Risk stratification guided by AI could prevent 537,000 U.S. hospitalizations, reduce crowding by 8.3 million bed hours, and avert ~490 cancer cases and 250 deaths annually.*

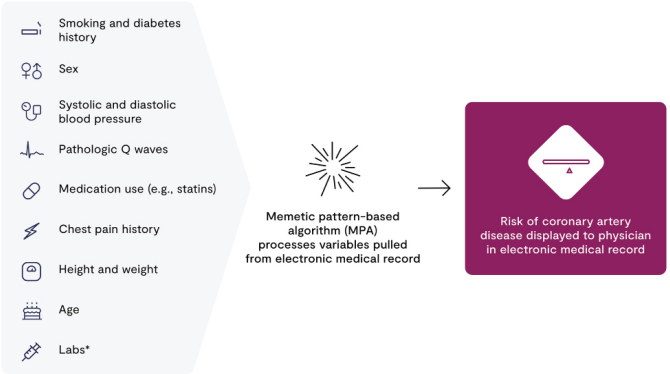



**Figure 1.** Illustration of an artificial intelligence-driven clinical decision tool for emergency department patients with chest pain. *Mean corpuscular hemoglobin concentration, white blood cells, urea, uric acid, troponin, glucose, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, alanine aminotransferase, alkaline phosphatase, amylase, total protein, albumin, and bilirubin. See Online Supplement Table 1 for the medications considered by the AI tool.

approaches.

Existing risk stratification tools, such as the HEART score, rely on threshold-based categorizations, often leading to additional testing and observational management. For example, a low-risk 45-year-old with nonexertional chest discomfort may be classified as intermediate risk, prompting additional testing despite a low likelihood of disease, whereas a 62-year-old with exertional chest pain may not meet categorical thresholds despite higher underlying risk. Given the complexity of chest pain evaluation, a clinical decision support tool such as Cardio Explorer, which provides risk along a continuous spectrum, may enable more precise stratification and more efficient use of resources.

While a prospective U.S. validation study is planned, in this current study we conducted a cost-savings modeling analysis of implementing Cardio Explorer for patients without known CAD presenting to the ED with chest pain, using the HEART pathway as the comparative model. We evaluate Cardio Explorer's potential to minimize unnecessary downstream cardiac testing, reduce radiation exposure, and provide a cost-effective approach to managing chest pain in the ED.

## METHODS

We developed a Monte Carlo simulation model to estimate annual national healthcare cost savings, cardiac diagnostic tests averted, reductions in short-stay hospitalizations, and radiation exposure prevented among eligible ED patients with chest pain undergoing Cardio Explorer evaluation. Monte Carlo simulations run many model iterations using random values selected from underlying data distributions that best represent each model input.[33] The program averages results of each model iteration to display outcome variables as distributions with means and standard deviations, accounting for uncertainty inherent in the model inputs and assumptions. We repeated our analysis for common ED sizes (eg, 30,000, 60,000, and 90,000 annual adult visits) to illustrate institution-specific impact.

Monte Carlo simulations have been used in medical research, including evaluating the national cost savings from dedicated observation units.[34] We conducted a standard simulation using 1,000 iterations, with input parameters derived from the most recent and highest-quality data available via a literature search. We followed the RECORDS checklist for Monte Carlo studies involving medical physics, given our radiation exposure secondary outcomes (see Online Supplement, Table 2).[35] We analyzed publicly available data exempt from institutional review board evaluation. Our model and inputs are displayed in Figure 2 and Table 1.

We estimated input parameters using the most recent National Hospital Ambulatory Care Survey (NHAMCS) for adult U.S. ED patient volume.[36] Next, we estimated the percentage undergoing downstream cardiac diagnostic testing for obstructive CAD within one week of the index visit, as determined in a prior MarketScan commercial claims analysis.[2] This analysis also details the relative frequency of cardiac diagnostic options, including exercise tolerance testing, nuclear perfusion testing, stress echocardiography, and CCTA. To examine the expected change in ST and CCTA from Cardio Explorer use, we used the current proportion of the U.S. ED population with chest pain. categorized as low risk, as determined by a recent U.S. study that used the HEART pathway (38.4% low risk).[12] While the mean age and incidence of hyperlipidemia were higher in the European Cardio Explorer study (65.6 versus 54.0 years; 53.9% versus 43.7%), body mass index > 30 and hypertension rates were higher in the U.S. HEART pathway study (47.4% versus

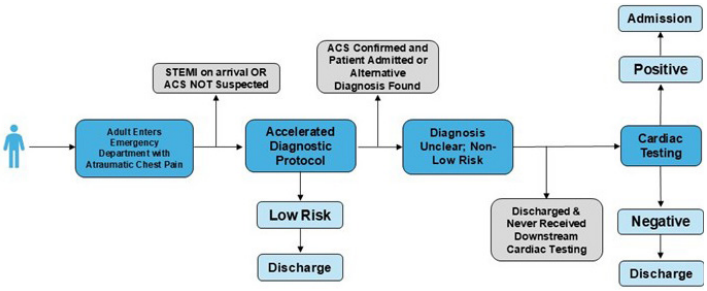



**Figure 2a.** Current state patient flow model for emergency department chest pain visits.
Accelerated diagnostic protocol for department-specific chest pain protocol specifying testing (e.g., electrocardiogram, troponin) and disposition options based on test results and risk stratification.
*ACS*, acute coronary syndrome; *STEMI*, ST-segment elevation myocardial infarction.

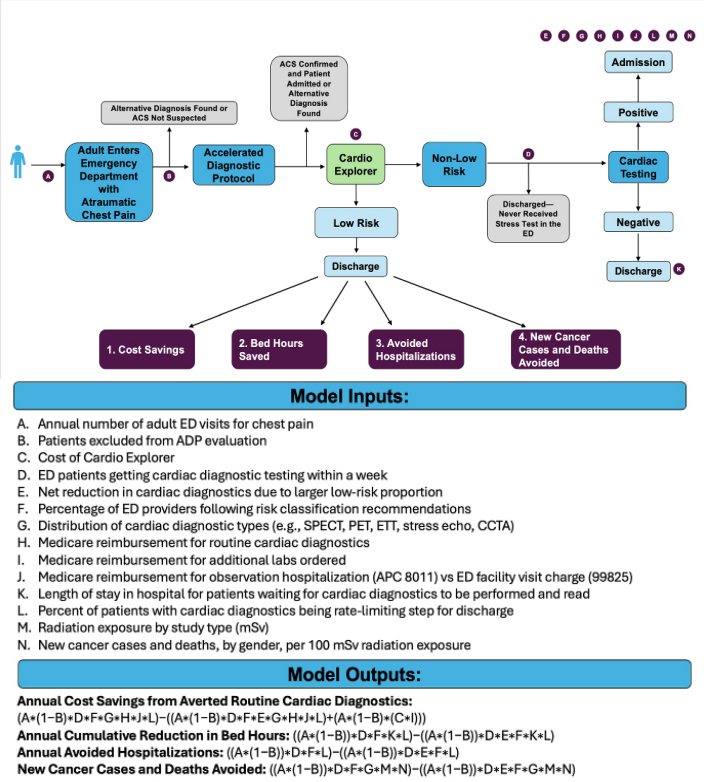



**Figure 2b.** Patient flow model using the artificial intelligence-driven clinical decision tool Cardio Explorer for emergency department chest pain visits.
*ACS*, acute coronary syndrome; *ADP*, accelerated diagnostic protocols; *APC*, ambulatory payment classification; *CCTA*, coronary computed tomography angiogram; *ED*, emergency department; *ETT*, exercise tolerance test; *mSv*, millisievert; *PET*, positron emission tomography; *SPECT*, single photon emission computed tomography.

20.3%; 65.4% versus 45.7%). Next, we examined patient reclassifications from "medium risk," "high risk," and "very high risk" to "low risk" or "very low risk" in Cardio Explorer studies (67.7% low risk).[31] Assuming a similar recategorization among U.S. ED patients, we modeled a net reduction in downstream testing for those reclassified as "low risk" or "very low risk," resulting in approximately a 50% reduction, from 18.5% to 9.7%.

We used Medicare payments as a proxy for hospital and physician service costs, consistent with prior cost-savings analyses and avoiding the arbitrary and variable values associated with charges and payer-specific payments for the same services, respectively.[50] In the base-case model, we assumed a $50 cost per Cardio Explorer visit, reflecting common costs for similar tools in a previous systematic review.[73] We did not separately include labor costs, as they are embedded in the Centers for Medicare & Medicaid Services (CMS) facility payment bundles. We accounted for lab test costs required for the Cardio Explorer risk assessment, which are not typically included in an ED chest pain visit, excluding cases with obvious ST-segment elevation myocardial infarction on arrival or cases in which ACS was never in the differential diagnosis.[37,38]

We also estimated the percentage of visits with cardiac risk stratification testing as the rate-limiting step for discharge, allowing us to estimate the changes in hospitalizations and bed hours averted by reducing ST and CCTA (defined as the cumulative time patients occupy beds in the ED, effectively a proxy for length of stay). To account for differences in patient populations and clinical culture between the U.S. and Europe, we assumed a maximum adoption of 90% in the U.S. in our base case. Finally, we leveraged prior radiation exposure harm data (eg, 800 excess solid cancer cases per 100,000 males from 100-millisievert exposure) and expected test radiation (eg, 10-millisievert mSv for single photon emission computed tomography perfusion ST) to estimate reductions in cancer cases and deaths from avoided tests.[49]

We performed a sensitivity analysis examining the impact of varying key assumptions with the greatest uncertainty: the percentage of visits in which the clinician followed Cardio Explorer recommendations despite practice inertia or alternative risk-stratification models suggesting testing was indicated, and the percentage of visits in which cardiac diagnostics were the rate-limiting step for discharge.

### Statistical Analysis

We used Crystal Ball release 11.1.2.4 (Oracle Corporation, Austin, TX) for analysis. Based on the reported standard deviations (SD), we assumed a normal distribution for all inputs. Unless otherwise specified, we assumed a 10% relative SD for input estimates, with bounds of 0% and 100% for percentage values. For length-of-stay inputs, we assumed Poisson distributions, the most suitable for this dataset.[51] For inputs with interquartile ranges or 95% confidence intervals, we assumed BetaPERT (beta program and evaluation review technique) distributions–smooth distributions characterized by minimum, most likely, and maximum values.[52,53] Accordingly, they are most appropriate for describing variables with a reported range of values.

## RESULTS

### Main Model Outputs

We found that using Cardio Explorer to determine patient eligibility for downstream cardiac diagnostics resulted in a mean U.S. national annual savings (SD) of $675 million ($340 million), representing a 17.6% reduction from the current state, by avoiding 688,000 (147,000) cardiac diagnostic tests. In Figures 3, 4a, 4b, 5a, and 5b, we present the resulting national annual cumulative decreases of 537,000 (115,000) hospitalizations, 8.30 million (1.96 million) bed hours, 490 (150) new cancer diagnoses, and 250 (80) new cancer deaths attributed to radiation exposure from avoidable cardiac diagnostics.

To examine the facility-level impact of Cardio Explorer in this patient population, we also estimated the annual cost

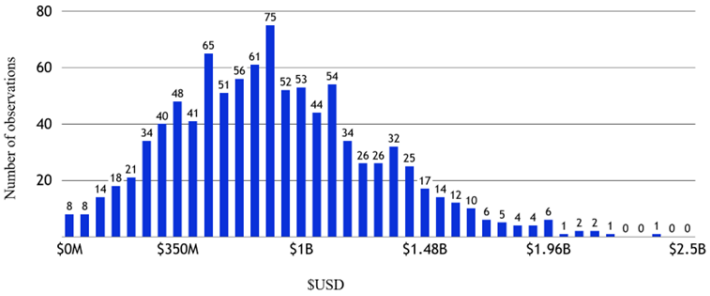



**Figure 3.** Annual national cost savings from Cardio Explorer use**.**
Distributions reflect results from 1,000 Monte Carlo simulation iterations, revealing a mean of $675 million ($340 million).
*B*, billion; *M*, million; *USD*, United States dollars.

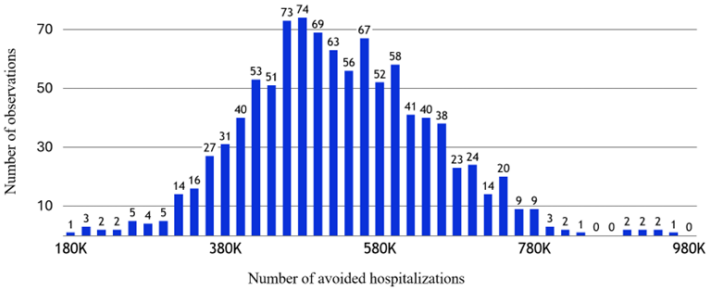



**Figure 4a.** Annual national avoided hospitalizations from Cardio Explorer use**.**
Distributions reflect results from 1,000 Monte Carlo simulation iterations, revealing a mean of 537,000 (115,000).
*K*, thousand.

savings for an ED with various common annual visit volumes using the other base-case model assumptions. At 30,000 annual adult visits, the cost savings would be $115,000 ($65,000) with 1,440 (350) fewer bed hours and 93 (20) avoided hospitalizations. At 60,000 annual adult visits, the cost savings would be $228,000 ($129,000) with 2,900 (700) fewer bed hours and 190 (40) avoided hospitalizations. Finally, at 90,000 annual adult visits, the cost savings would be $336,000 ($201,000) with 4,330 (1,080) fewer bed hours and 280 (60) avoided hospitalizations.

### Sensitivity Analysis

We varied the assumption of a 95% Cardio Explorer compliance rate to examine the impact on our primary outcome, cost savings, by avoiding further cardiac testing. Reducing this value to 80% reduces the cost savings to $439 million ($296 million). Further reducing it to 70% results in cost savings of $278 million ($255 million). Lastly, varying the assumption that cardiac diagnostics are the rate-limiting step for hospital discharge in 90% of cases to 70% reduces the national cost savings to $271 million ($363 million). Lastly, in Table 2, we illustrate the impact of various prices per visit for Cardio Explorer on national and department-level annual cost savings.

## DISCUSSION

This study evaluated the potential benefits of incorporating Cardio Explorer, a novel clinical decision support tool, into the ED evaluation of patients with chest pain and concern for obstructive CAD. While our analysis demonstrates that this specific tool could generate $675 million in annual national cost savings and incremental reduction in radiation-associated cancer cases and deaths, primarily by reducing avoidable cardiac diagnostic testing and associated hospitalizations, the broader implication is more fundamental in that ED chest pain evaluation is entering an era of AI-augmented risk stratification. Rather than viewing Cardio Explorer as a standalone innovation, it should be understood as part of a rapidly expanding ecosystem of AI–enabled diagnostic tools designed to address uncertainty in acute cardiovascular care.

Cardio Explorer should be viewed within the context of evolving U.S. ED practice patterns, where hsTn and AI-driven clinical decision support tools are becoming increasingly prevalent.[54] In Europe, hsTn has been widely adopted, whereas only about one-third of U.S. hospitals have converted from conventional troponin assays.[55,56] Recent analyses of U.S. hospitals adopting hsTn accelerated diagnostic protocols show significant reductions in downstream cardiac testing and hospitalizations with substantial cost savings.[57–59] Cardio Explorer is a rational evolution and companion to these protocols, further reducing avoidable cardiac testing and hospitalizations.

A persistent challenge in chest pain management is the large proportion of patients, over 50% in some studies, who fall into the "observation zone," not meeting discharge or admission criteria and creating clinician uncertainty about discharge without additional testing.[60,61] Cardio Explorer addresses this ambiguity by reclassifying a substantial part of these indeterminate-risk patients into more definitive categories of "very low," "low,"

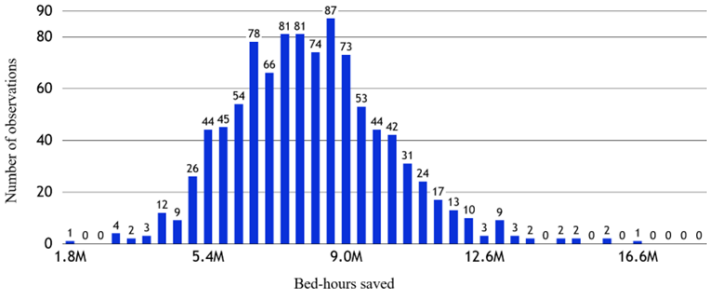



**Figure 4b.** Annual national bed hours avoided from Cardio Explorer use.
Distributions reflect results from 1,000 Monte Carlo simulation iterations, revealing a mean of 8.30 million (1.96 million).
*M*, million.

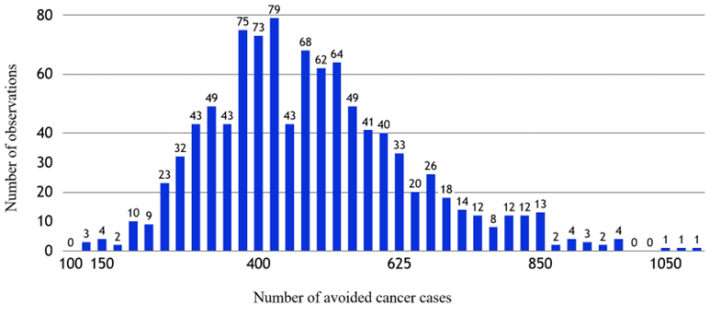
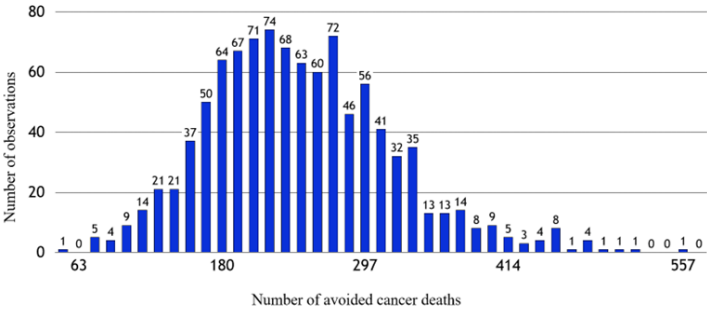



**Figure 5.** Annual reduction in radiation-exposure-related national cancer cases and deaths.
**5a.** Avoided annual cancer cases from Cardio Explorer use. Distributions reflect results from 1,000 Monte Carlo simulation iterations, revealing a mean of 490 (150).

"high," or "very high" risk.[26] This may improve clinicians' confidence in discharge decisions and yield additional savings as hsTn testing prevalence increases and clinicians contend with more cases of troponin levels of ambiguous clinical significance. Additionally, Cardio Explorer may address emergency physicians' historical tendency to recommend downstream cardiac testing for patients with possible unstable angina, a component of ACS characterized by the absence of troponin patterns indicating myocardial injury or ST-segment elevations suggestive of STEMI.[63] Obstructive CAD without ACS is often considered a chronic condition managed by primary care physicians and cardiologists on an elective basis following ED visits. However, identifying obstructive CAD in ED chest pain. patients, whether or not ACS accompanies it, is crucial for optimizing both immediate and longer-term clinical outcomes.

Current cardiac diagnostic pathways lead to prolonged hospital stays even when the risk is unclear or even low. As over 90% of EDs routinely report crowded conditions, reducing bed hours is one of the most cost-effective ways to increase capacity, improve safety, and boost financial performance without adding new beds or staff. For example, one inner-city teaching hospital model estimated that a one-hour reduction in ED boarding could increase daily hospital revenue by approximately $9,693 to $13,298–equivalent to several million dollars annually.[64] This demonstrates how improving patient flow enhances both care and hospital financial performance.[65]




**5b.** Annual avoided cancer deaths from Cardio Explorer use. Distributions reflect results from 1,000 Monte Carlo simulation iterations, revealing a mean of 250 (80).

Cardio Explorer not only improves identification of truly low-risk patients but also appropriately up-classifies a small subset into higher risk categories—individuals that conventional methods may miss. In the validation study, Cardio Explorer categorized 8.5% of patients as "very high risk," compared to 0% and 1.7% in the comparator risk assessments.[31] This up-triaging does not significantly affect index visit costs but may avoid downstream expenses from delayed disease recognition and serves as an important quality and safety mechanism. Currently, these patients are considered acceptable misses due to imperfect risk-stratification tools and the low yield of universal cardiac testing.[66] Cardio Explorer enables a more personalized approach, matching each patient's risk to the diagnostic strategy. In recent years, the promise of precision medicine has been limited primarily to managing chronic diseases and developing targeted therapies.[67] Tools such as Cardio Explorer are advancing precision medicine into the acute care setting. In the ED context, this represents a novel application leveraging real-time biomarkers and clinical data to support individualized triage decisions at scale.

The additional blood tests required by Cardio Explorer could be feasibly added to chest pain order sets with minimal additional effort. Electronic decision support is increasingly used in the clinical space; nearly all EDs now use an EHR, making integration feasible with current technology.[68,69] With proper EHR configuration, Cardio Explorer could be embedded as a click-through module or automated through order sets with minimal staff orientation. However, real-world implementation may require attention to clinician training, workflow integration, and addressing potential skepticism or alarm fatigue. We must also evaluate usability, physician trust, and the impact on decision-making to ensure sustainable integration.

Finally, the projected reductions in radiation-associated cancer cases and deaths should be interpreted cautiously. Cancer risk estimates from low-dose diagnostic imaging remain debated, as commonly used models extrapolate risk from higher dose exposures and may overestimate harm at low doses due to uncertainty in dose–response relationships and confounding.[44,71] While these limitations preclude precise quantification of long-term cancer risk, reducing low-yield imaging remains a widely accepted patient-safety objective. Accordingly, our estimates should be viewed as directional indicators of potential harm reduction rather than definitive predictions of cancer prevention.

Historical risk-stratification models needed to be simple enough for busy clinicians to use in real time, necessitating a limited number of variables and categorizing patients into broad risk groups. Small changes in risk could move a patient

**Table 1.** Model inputs for Monte Carlo simulation of Cardio Explorer use.

| Input | Description | Estimate | SD or Interval | Distribution Type | Source and Reference |
|---|---|---|---|---|---|
| A | Annual number of ED chest pain visits in the US | 8,354,000 | 826,000 | Normal | 2022 NHAMCS (United States)[36] |
| B | Patients excluded from ADP evaluation | 16.5% | 1.65% | Normal | 2017 Multicenter STEMI Registry[37] and 2025 Epic Cosmos Analysis (United States)[38] |
| C | Cost of Cardio Explorer | $50 | NA | Author assumption | Author assumption; see Limitations and Online Supplement |
| D | Percentage of patients in "A" who receive further cardiac diagnostics within a week of the ED visit | 18.5% | 2.9% | Normal | 2011 MarketScan Commercial Claims and Encounters data (United States)[2] |
| E | Percentage of patients receiving further cardiac diagnostics | 9.7% | 0.9% | Normal | Change from "B" above due to an increase in the "very low risk" and "low-risk" groups (Netherlands[31]; United States[39]) |
| F | Percentage of clinicians following advanced diagnostic protocol | 95% | NA | NA | Author assumption; see Sensitivity Analysis |
| **Patients who go on to further cardiac diagnostics distributed as F.1-F.6** | | | | | |
| G.1 | Percentage of conventional stress tests that are myocardial perfusion tests | 64.8% | 0.6% | Normal | 2011 MarketScan Commercial Claims and Encounters data (United States)[2] |
| G.2 | Percentage of perfusion tests that are SPECT | 97.0% | 9.7% | Normal | Medicare 2010–2019 Physician/ Supplier Procedure Summary files (United States)[40] |
| G.3 | Percentage of perfusion tests that are PET | 3% | 0.3% | Normal | Medicare 2010–2019 Physician/ Supplier Procedure Summary files (United States)[40] |
| G.4 | Percentage of conventional stress tests that are Stress Echo | 12% | 1.2% | Normal | 2010–2017 National Emergency Database (United States)[41] |
| G.5 | Percentage of conventional stress tests that are ETTs | 14.2% | 1.4% | Normal | 2011 MarketScan Commercial Claims and Encounters data (United States)[2] |
| G.6 | Percentage of cardiac diagnostic tests that are CCTA | 7.4% | 0.7% | Point estimate | 2010–2017 National Emergency Database (United States)[41] |

from one risk category to another, leading to vastly different management recommendations. For example, a single point difference in the HEART pathway could shift patients from low to intermediate risk, altering the recommendation from discharge without testing to hospitalization for cardiac testing.[68] Such systems can lead to both overuse and underuse of testing depending on arbitrary cutoffs. In contrast, Cardio Explorer employs a continuous, data-rich risk spectrum that reduces reliance on rigid thresholds and better reflects the complex cardiac risk profiles of real-world patients at low marginal cost. While our primary focus is cost savings and reduced radiation exposure, we must acknowledge the potential trade-offs in missed diagnoses if diagnostic imaging is reduced. Cardio Explorer has demonstrated high sensitivity for ischemia prediction in validation studies among intermediate- to high-risk patients.[69] Nonetheless, with a sensitivity < 100%, any shift in diagnostic protocols must be accompanied by careful safety monitoring. Future studies should evaluate clinical outcomes, such as 30-day rates of MACE, to ensure that testing reductions do not compromise the detection of high risk pathology.

Future innovations in ED chest pain evaluation include further refining tools like Cardio Explorer to increase the proportion of patients deemed "very low" and "low" risk, enabling more selective downstream cardiac testing and reducing harm from missed CAD diagnoses. Next steps include validating Cardio Explorer in a U.S.-based ED population. Our analysis could be updated with data from this study to validate the assumptions used. Nevertheless, the underlying physiological patterns used by Cardio Explorer are likely conserved across populations, and the model's adaptability suggests strong generalizability potential once formally tested in the U.S. The significance of certain blood tests (eg, uric acid, amylase) in the Cardio Explorer risk assessment has unclear underpinnings in obstructive CAD pathophysiology based on our historical understanding. Future investigations may better clarify these relationships, further enhancing detection and treatment approaches.

**Table 1.** Continued

| Input | Description | Estimate | SD or Interval | Distribution Type | Source and Reference |
|---|---|---|---|---|---|
| **Medicare reimbursement for cardiac testing by type and additional labs needed for Cardio Explorer** | | | | | |
| H.1 | Medicare payment for perfusion stress/ SPECT (facility) | Bundled in APC 8011 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.2 | Medicare payment for perfusion stress/ SPECT (interpretation) | $62.55 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.3 | Medicare payment for PET (facility) | Bundled in APC 8011 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.4 | Medicare payment for PET (interpretation) | $82.55 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.5 | Medicare payment for CCTA (facility) | $209.28 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.6 | Medicare payment for CCTA (interpretation) | $109.01 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.7 | Percentage of CCTAs that are same-day and show no obstructive CAD | 50% | 5 | Author assumption | |
| H.8 | Extra LOS from a same-day CCTA (hrs) | 4.00 | 1.00 | Author assumption | |
| H.9 | Medicare payment for ETT (facility) | Bundled in APC 8011 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.10 | Medicare payment for ETT (interpretation + supervision) | $85.55 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.11 | Medicare payment for stress echo (facility) | Bundled in APC 8011 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| H.12 | Medicare payment for stress echo (interpretation) | $80.56 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| I.1 | Medicare reimbursement for uric acid | $4.52 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| I.2 | Medicare reimbursement for lipid panel | $13.39 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| I.3 | Medicare reimbursement for alanine aminotransferase | $5.30 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| I.4 | Medicare reimbursement for alkaline phosphatase | $5.18 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| I.5 | Medicare reimbursement for amylase | $6.48 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| I.6 | Medicare reimbursement for total protein | $3.67 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| I.7 | Medicare reimbursement for albumin | $4.95 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| I.8 | Medicare reimbursement for bilirubin | $5.02 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| J.1 | Observation facility cost (APC 8011) | $2,610.71 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| J.2 | Medicare facility cost for ED visit (CPT 99285) | $170.30 | NA | Point estimate | 2025 CMS Medicare Physician Fee Schedule (United States)[42] |
| **Bed hours saved** | | | | | |
| K | ED length of stay for patients with chest pain undergoing a traditional cardiac testing approach (bed-hours) | 15.3 | 1.5 | Normal | Retrospective data from 6 large EDs from 2013-2015 (United States)[43] |

**Table 1.** Continued

| Input | Description | Estimate | SD or Interval | Distribution Type | Source and Reference |
|---|---|---|---|---|---|
| **Avoided hospitalizations** | | | | | |
| L | Percentage of ED observation chest pain visits where cardiac diagnostics are rate-limiting step to discharge | 90% | NA | NA | Author assumption; see sensitivity analysis |
| **Average effective radiation dose from SPECT, PET, and CCTA (mSv)** | | | | | |
| M.1 | Radiation associated with SPECT perfusion stress testing (mSv) | 10 | NA | NA | Dose Imaging Registry (United States)[44–46] |
| M.2 | Radiation associated with PET perfusion stress testing (mSv) | 3 | NA | NA | Dose Imaging Registry (United States)[44–46] |
| M.3 | Percentage of SPECT and PET that is male | 57% | 5.7% | Normal | Large international data registry in 2013 (International multicenter registry; 65 countries)[47] |
| M.4 | Radiation associated with CCTA (mSv) | 3 | 1 | Normal | Dose Imaging Registry (United States)[44–46] |
| M.5 | Percentage of CCTA that is male | 47.3% | 4.7% | Normal | Prospective study at 193 sites in North America between 2010-2013 (United States & Canada)[48] |
| N.1 | Excess solid cancer cases per 100,000 persons from exposure to 100 mSv, males | 800 | 400-1,600 | BetaPERT | BEIR VII model (U.S.-adapted)[49] |
| N.2 | Excess solid cancer cases per 100,000 persons from exposure to 100 mSv, females | 1,300 | 690-2,500 | BetaPERT | BEIR VII model (U.S.-adapted)[49] |
| N.3 | Excess leukemia cases per 100,000 persons from exposure to 100 mSv, males | 100 | 30-300 | BetaPERT | BEIR VII model (U.S.-adapted)[49] |
| N.4 | Excess leukemia cases per 100,000 persons from exposure to 100 mSv, females | 70 | 20-250 | BetaPERT | BEIR VII model (U.S.-adapted)[49] |
| N.5 | Excess solid cancer deaths per 100,000 persons from exposure to 100 mSv, males | 410 | 200-830 | BetaPERT | BEIR VII model (U.S.-adapted)[49] |
| N.6 | Excess solid cancer deaths per 100,000 persons from exposure to 100 mSv, females | 610 | 300-1,200 | BetaPERT | BEIR VII model (U.S.-adapted)[49] |
| N.7 | Excess leukemia deaths per 100,000 persons from exposure to 100 mSv, males | 70 | 20-220 | BetaPERT | BEIR VII model (U.S.-adapted)[49] |
| N.8 | Excess leukemia deaths per 100,000 persons from exposure to 100 mSv, females | 50 | 10-190 | BetaPERT | BEIR VII model (U.S.-adapted)[49] |

*ADP*, Accelerated Diagnostic Protocols; *APC*, ambulatory payment classification; *BetaPERT*, Beta Program and Evaluation Review Technique; *CAD*, coronary artery disease; *CCTA*, coronary computed tomography angiogram; ; *CMS*, Centers for Medicare & Medicaid Services; *CPT*, current procedural terminology; *ED*, emergency department; *ETT*, exercise tolerance test; *hrs*, hours; *LOS*, length of stay; *mSv*, millisievert; *NA*, not applicable; *NHAMCS,* National Hospital Ambulatory Medical Care Survey; *PET*, positron emission tomography; *SD*, standard deviation; *SPECT*, single photon emission computed tomography; *US*, United States.
BetaPERT estimates use the mean as the most likely value, with the stated range for the minimum and maximum.

## LIMITATIONS

Our analysis was based on a simulation model and, thus, was limited by the accuracy of model inputs and structure. We employed Monte Carlo methods to account for uncertainty and used recent, widely accepted sources to inform model variables. Due to the unavailability of more recent analyses, some of our references for model inputs were older and may not reflect current practice patterns. However, we made assumptions and adjustments when data were unavailable. Importantly, we did not account for the costs of EHR integration. However, our main model accounted for the laboratory test costs required by Cardio Explorer, which are not typically part of ED chest pain evaluations. Our analysis should thus inform decision-makers of the price they are willing to pay for this tool while still capturing significant savings and admission avoidance (Table 2).

In addition to the direct cost savings from reduced avoidable testing and hospitalizations, there are several potential benefits not explicitly captured in our model. For example, reclassification from low to high risk in a patient who would have otherwise been discharged could lead to revascularization in a patient who may have otherwise died without a timely, accurate diagnosis. Other investigations have used concepts such as quality-adjusted life years saved and benchmark financial assumptions to quantify the financial value of reduced mortality.[70] Additionally, when appropriate, early discharge avoids unnecessary patient anxiety, missed work, gaps in caregiver coverage, and other indirect costs associated with hospitalization. Chest pain visits with ECG and troponin, performed to evaluate low-risk presentations where additional cardiac testing was previously not considered, would not be affected by Cardio Explorer, except in rare cases where a patient is unexpectedly classified as high-risk by the tool. Finally, a reduction in patient out-of-pocket expenses from reduced testing is another benefit not explicitly quantified in our model.

Additionally, the CAD rate among Cardio Explorer patients classified as "very low" or "low" was approximately 4.2%.[31] These data were collected among European outpatients with chest pain referred for further testing. It is unclear whether our assumption that a U.S. ED population would experience the same risk profile recategorization observed is valid without confirmation. We also used data from prior HEART pathway studies, which are not universally followed in U.S. EDs and have been validated only for 30-day MACE, not CAD. Conversely, Cardio Explorer has been validated to predict occlusive CAD, not 30-day MACE. Given Cardio Explorer's reported sensitivity, some patients classified as low risk may still be at risk for 30-day MACE. While the presence of occlusive CAD likely correlates with 30-day MACE among chest pain patients, further research is needed to study Cardo Explorer's test characteristics with respect to this important clinical outcome.

Physicians in the U.S. may also be motivated by factors different from those of their European counterparts (eg, medicolegal risk), which may affect their willingness to avoid testing, thereby reducing expected cost savings from adopting this cardiac testing paradigm. Furthermore, patients with barriers to outpatient follow-up may be considered for additional diagnostics during the index visit, mitigating some of the cost savings identified in our primary analysis, as captured in our sensitivity analysis.

We represent cost savings as reduced avoidable healthcare expenses, which may be best realized in accountable care organizations or global budget frameworks, such as those in most European countries or Maryland. In a fee-for-service environment, hospitals may capture cost savings less directly and may experience revenue declines, negatively impacting net operating budgets. Nonetheless, the operational benefits of improved ED capacity, reduced crowding, and enhanced quality of care support the broader value of this tool even in traditional reimbursement environments. Hospitals at capacity, especially tertiary care centers, that regularly decline or delay transfer requests due to crowding, may particularly benefit from increased backfill of more complex patients and the associated higher payments. Prior investigations reveal that the opportunity cost of shifting patients to less resource-intensive plans of care (eg, inpatient to observation units)

**Table 2.** Cardio Explorer price sensitivity analysis on primary outcome of cost savings.

| Cardio Explorer Price Per Visit | National cost savings | 30,000 annual adult visit ED cost savings | 60,000 annual adult visit ED cost savings | 90,000 annual adult visit ED cost savings |
|---|---|---|---|---|
| $0 | $1.0 billion ($351 million) | $179,000 ($67,000) | $365,000 ($137,000) | $544,000 ($219,000) |
| $50 | $675 million ($340 million) | $115,000 ($65,000) | $228,000 ($129,000) | $336,000 ($201,000) |
| $80 | $596 million ($355 million) | $69,000 ($65,000) | $153,000 ($136,000) | $218,000 ($193,000) |
| $100 | $357 million ($325 million) | $47,000 ($69,000) | $85,000 ($135,000) | $154,000 ($199,000) |
| $200 | -$256 million* ($334 million) | -$90,000 ($65,000) | -$181,000 ($130,000) | -$268,000 ($200,000) |

*Negative mean values represent net cost at that price.
*ED*, emergency department.

nearly doubles direct cost savings.[72]

Finally, although Exploris Health, the developer of Cardio Explorer, funded this study, the sponsor had no role in study design, model development, data analysis, interpretation of results, or manuscript preparation. Several authors have also disclosed financial relationships with the sponsor but were included due to their publication history and clinical expertise. We aimed to provide full transparency regarding these associations while explicitly detailing our methodology to enable reproducible results and mitigate bias.

## CONCLUSION

Our simulation model indicates that integrating a novel digital decision-support tool into ED chest pain evaluation could improve patient selection for downstream cardiac testing. Widespread adoption could lead to substantial national cost savings, reduce unnecessary short-stay hospitalizations, and lower radiation exposure, thereby preventing avoidable cancer cases and related mortality. Reduced ED bed-hours directly translate into decreased crowding and more efficient patient flow throughout the care continuum. Further research is warranted to validate its effectiveness in U.S. emergency care settings and to identify barriers to broader implementation.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. Exploris Health AG funded this study. C.W.B. is a paid speaker for Roche Diagnostics and has previously served on advisory boards for Roche, Salix Pharmaceuticals, Pfizer, Terumo, and AstraZeneca; consults for Exploris Health AG, Abbott Laboratories, and AxumEdge Consulting; and is an advisor to Quai.MD, Vera Health, and Lucia Health Guidelines. A.L. consults for Exploris Health AG. H.P.B.L.R. is a paid speaker for Roche Diagnostics. He consults for Roche Diagnostics, Exploris Health AG, Novartis, Boehringer-Ingelheim, AstraZeneca, and Vifor and he is a stock owner of Exploris Health AG. He receives payment for expert testimony for Novartis. He coordinates the public-private partnership iCARE4CVD under the IHI JU (grant number 101112022). M.J.Z. is an advisory board member and stock owner of Exploris Health AG. There are no other conflicts of interest or sources of funding to declare.

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# Intubation Practices and Outcomes in Diverse Emergency Departments Within a Single Health System

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**Introduction:** Endotracheal intubation (ETI) is a life-saving procedure commonly performed in emergency departments (ED). Prior research has demonstrated significant variability in ETI experience, practices, and outcomes across EDs. Health systems often include a mix of ED environments, from large academic hospitals to community-based and freestanding EDs. However, little is known about how ETI experiences and outcomes vary within a single health system. Our objective in this study was to compare first-attempt success across three EDs representing different practice environments but within one health system.

**Methods:** This retrospective observational study used institutional data from 1,659 ETI events between November 2021–January 2025 to compare ETI-related outcomes across three EDs representing a spectrum of settings: an academic Level I trauma center (A); a community teaching hospital (B); and a nonteaching community site (C). Our primary outcome measure was first-attempt success. We also assessed adverse airway outcomes and ETI-related patient and procedural characteristics. Chi-square tests evaluated the association of ETI-related outcomes and hospital sites.

**Results:** Annual ED volumes were approximately 82,000 (A), 64,000 (B), and 49,000 (C), with respective ETI encounters per 1,000 patients of 5, 2, and 0.4. The community teaching hospital had the highest first-attempt success rate of 90.2% (B: 331/367; 95% CI, 87.2-93.2), followed by the academic center with 84.6% (A: 1038/1227, 95% CI, 82.6-86.6), and then by the nonteaching community site with 78.5% (C: 51/65; 95% CI, 68.5-88.5) ($P$ = .01). Adverse airway outcomes occurred in 10.5% of ETIs and did not vary significantly between sites (A: 139/1,227 [11.3%]; B: 29/367 [7.9%]; C: 6/65 [9.2%], $P$ = .16). The most common indication was airway protection, followed by altered mental status and cardiopulmonary arrest for all three sites. Trainees performed the majority of ETIs at hospital A (1,096/1,227; 89.3%), while attending physicians predominated at B (295/367; 80.4%) and C (64/65; 98.5%).

**Conclusion:** We found significant variation in first-attempt success between the three ED sites, although overall success and adverse airway outcomes were comparable. These findings suggest that first-attempt success may be impacted by factors such as patient differences, role and training level of laryngoscopists, and inherent site-level differences such as patient volume and acuity. [West J Emerg Med. 2026;27(5)1353–1363.]

## INTRODUCTION

### Background

Endotracheal intubation (ETI) is a life-saving procedure performed on critically ill patients in emergency departments (ED). The primary goal of the procedure is to secure the airway and provide respiratory support.[1] First-attempt success is widely accepted as the most important outcome measure for ETI because failure to intubate on the first attempt is associated with adverse airway outcomes. Adverse airway outcomes are comprised of tracheal intubation-associated adverse events and hypoxia, which are associated with poor short- and long-term outcomes.[2-5] Further, as the number of attempts increases, the incidence of adverse outcomes increases substantially.[6]

### Importance

While previous studies have compared first-attempt success rates between different departments of individual hospitals,[7,8] little is known about how ETI practices and outcomes differ between academic and community EDs, especially within single health systems. Academic EDs are fully university affiliated, serve as primary training sites with a tiered team of trainees, and support clinical, educational, and research missions, whereas community EDs lack full academic affiliation, have minimal or no trainee involvement, and focus primarily on direct clinical care. Most studies looking at ETI first-attempt success include only Level I trauma or academic medical centers, which limits generalizability to community-based settings. Prior studies suggest that distinguishing between community and academic EDs is important because they differ in their operations, resources, patient populations, and outcomes.[9]

To the best of our knowledge, there is only one prior study that has characterized ETI in community EDs.[10] While the authors found that ETI practices in community EDs tend to mirror those of academic centers, the distinction between these contexts may be important in accounting for factors such as the frequency of ETI procedures,[11] available equipment, and presence of different levels of laryngoscopists who perform ETI.[12-14] Community EDs may exist as part of a larger health system that includes academic centers or may operate independently; to date, no studies have examined ETI practices within a single health system that encompasses both academic and community EDs.

### Goals of this Investigation

The goal of this investigation was to compare ETI outcomes across three EDs that are part of a single health system but represent a spectrum of settings from an academic quaternary care and Level I trauma center to community-based hospitals. This project is part of a larger health system initiative to examine our local emergency airway performance to inform improvement efforts and drive airway excellence. We sought to characterize and understand the variation in practice across the three distinct EDs by evaluating the primary outcome of first-attempt success. We also investigated adverse airway outcomes and differences in local environment, patients, and procedural practices.

*Population Health Research Capsule*

What do we already know about this issue?
*First-attempt success in emergency department (ED) intubation varies by factors such as equipment and operator, and failed attempts increase adverse airway outcomes.*

What was the research question?
*How do endotracheal intubation (ETI) success and adverse outcomes vary across three EDs within one health system?*

What was the major finding of the study?
*First-attempt success differed by site (90.2% vs 84.6% vs 78.5%; P = .01); adverse outcomes were similar (10.5%; P = .16); confidence intervals overlap.*

How does this improve population health?
*Understanding site-level variation in airway success may inform targeted training and system strategies to improve emergency care outcomes.*

## METHODS

### Design and Setting

We conducted a retrospective observational study using data from an institutional database of emergency ETI procedures. The study was set within a three-hospital health system, each facility operating its own ED (Figure).

Hospital A is a quaternary academic medical center and designated Level I trauma center with an embedded pediatric ED (PED). It houses 1,062 inpatient beds, 172 of which are pediatric beds, and manages approximately 82,000 ED visits annually. Hospitals B and C are community hospitals. Hospital B has 388 adult inpatient beds, an 18-bed neonatal intensive care unit, and an annual ED volume of approximately 64,000 visits, while Hospital C is a smaller facility with 204 adult beds and 49,000 annual ED visits.

Resident physicians provide care at both Hospitals A and B. During the study period, there was no overlap in attending emergency physicians across the three sites, although a small number of resident physicians who trained at Hospital A subsequently joined the attending staff at Hospitals A and B. The PED at Hospital A is always staffed by fellowship-trained

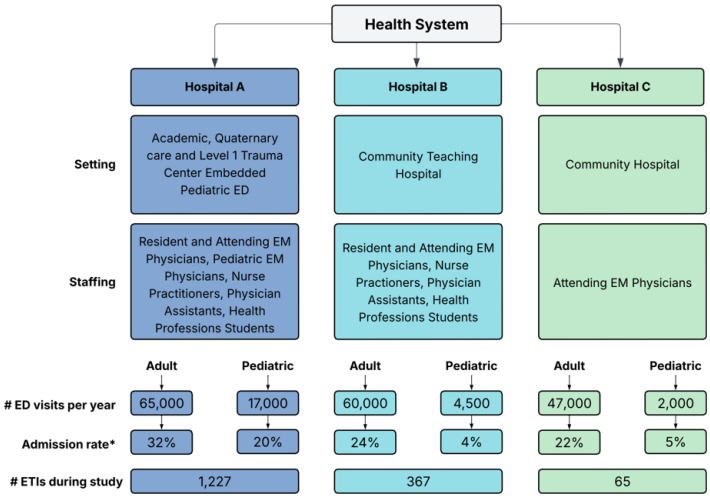


**Figure.** Descriptions of health system hospitals with three distinct emergency departments in a study examining variations in practice by evaluating first-attempt success for endotracheal intubations,
*Hospital B and Hospital C do not have pediatric units. The admission rate for these hospitals represents transfer to a pediatric hospital, mostly Hospital A for admission.
*ED,* emergency department; *EM,* emergency medicine; *ETI,* endotracheal intubation.

pediatric emergency physicians, and coverage is supplemented further by a dedicated group of general emergency physicians who devote at least 30% of their clinical practice to pediatric patients. While pediatric patients are also treated at Hospitals B and C, these sites do not have pediatric emergency physician specialists.

## Data Collection

Data was collected from an institutional dataset that captures emergency ETI events across the institution and includes discrete and retrievable data elements aligned with National Emergency Airway Registry standards. The development of this dataset was part of an institutional effort to improve airway performance. An airway taskforce composed of a multidisciplinary team of physicians and informatics specialists developed a standardized documentation tool in the electronic health record. From 2021, all airway events in the health system's three EDs were documented using this standardized note. We considered all 1,703 documented ED ETI procedures from the three EDs from November 2021–January 2025 for inclusion in this study. We excluded 44 documented procedures (2.58% of total) because the number of attempts was not recorded. Several criteria of medical record review studies were followed, as outlined in Worster et al (2005),[15] including training data abstractors, using clear case-selection criteria, defining variables, identifying our database, describing our sampling method, and describing management of missing data.

## Outcomes of Interest and Definitions

The primary outcome of interest was first attempt success, defined as a patient encounter with only one ETI attempt resulting in successful placement of an endotracheal tube. We also analyzed the outcome of adverse airway outcomes, which were defined as the presence of a tracheal intubation-associated adverse event and/or peri-intubation hypoxia within 20 minutes of the procedure's start. Peri-intubation hypoxia was defined as an oxygen saturation drop below 80% in a patient who achieved a saturation of at least 90% during peri-intubation pre-oxygenation. Tracheal intubation-associated adverse events were defined as complications arising during or because of ETI; these included cardiac arrest, hypotension, mainstem intubation, inadequate sedation, dental/lip trauma, emesis, dysrhythmia, hypertension, direct airway injury, esophageal intubation, laryngospasm, pneumothorax, and malignant hyperthermia.[16]

To add further context, we sought to characterize the following patient and procedural characteristics of ETI. Patient characteristics included the following:

- ETI indication: reasons why a patient required ETI, as determined by the laryngoscopist. Each encounter may have multiple linked indications given that many indications overlap in clinical practice, among them airway protection/clearance, altered mental status, apnea/bradypnea, blood in airway, cardiac with medical cause, cardiac with surgical cause, cardiopulmonary arrest, emergency drug administration, endotracheal tube exchange, hemodynamic instability, hypercarbia, neuromuscular weakness, procedure, re-intubation after unplanned extubation, respiratory distress, respiratory failure, shock/sepsis, therapeutic hyperventilation, facial trauma, neck trauma, and upper airway obstruction.
- Airway difficulty: a yes/no subjective assessment made by the laryngoscopist at the time of ETI; typically, this reflected a patient's anatomical features or significant injury to or blood secretions in the airway.

Procedural aspects include the following:

- Laryngoscopist characteristics: role, specialty, and level of training of personnel who performed ETI during each attempt.
- ETI technique: Two techniques were used—direct laryngoscopy, in which the operator visualizes the vocal cords directly, and video laryngoscopy, in which the operator visualizes the cords indirectly via a camera-equipped screen.

## Statistical Analysis

We summarized patients' and procedural intubation characteristics, stratified by hospital ED, using descriptive statistics. Categorical variables were reported with frequency counts and percentages of nonmissing values. The first-attempt success rate and its 95% confidence interval were reported. We used the chi-squared test to analyze the

association between first-attempt success and hospital ED and adverse airway outcomes and hospital ED. *P* values were assessed at a significance level of 0.05. We performed all statistical analyses using SAS v9.4 (SAS Institute Inc, Cary, NC) and Microsoft Excel v16.102.3 (Microsoft Corporation, Redmond, WA).

## RESULTS

### Number of Endotracheal Intubations and Patient Characteristics

Of 1,659 ETI events documented across the three EDs, nearly three-quarters occurred at Hospital A (1,227/1,659; 74%). Close to one-quarter occurred at Hospital B (367/1,659; 22.1%), with only a small percentage occurring at Hospital C (65/1,659; 3.9%) (Table 1).

More ETI occurred in male patients compared to female patients (980/1,659; 59.1% versus 678/1,659; 40.9%) across the three sites. Adults made up most patients who underwent ETI (1,540/1,659; 92.8%). The median age for adult patients was 61 years and for pediatric patients four years. The number of pediatric ETIs was small (119/1,659 [7.2%]) and varied dramatically between sites; very few pediatric ETIs occurred outside Hospital A. Overall, 341 (20.6%) ETI events were noted to have a difficult airway (Table 1). The proportion of difficult airways was highest at Hospital A, which had 275 (22.4%) (Hospital C: 12 [18.5%], Hospital B 54 [14.7%]).

### Indications for Endotracheal Intubation

The three most frequent ETI indications were consistent across the health system. The most common category was altered mental status/neurologic; the most frequent subcategory was airway protection with 67.8% of system-wide ETI events (A: 852/1,227, 69.4%; B: 230/367, 62.7%; C: 43/65, 66.2%). The second most common sub-category was altered mental status both overall (658/1,659, 39.7%) and at each hospital (A 490/1,227, 39.9%; B: 139/367,

**Table 1.** Demographic characteristics of patients undergoing endotracheal intubation, by each health system emergency department site and overall.

| | Overall | Hospital A | Hospital B | Hospital C |
|---|---|---|---|---|
| Total ETIs, N (%) | 1,659 (100%) | 1,227 (74%) | 367 (22.1%) | 65 (3.9%) |
| Patient characteristics: | | | | |
| Sex, N (%) | | | | |
| Male | 980 (59.1%) | 732 (59.7%) | 213 (58.0%) | 35 (53.8%) |
| Unknown | 1 (0.1%) | 1 (0.1%) | 0 (0.0%) | 0 (0.0%) |
| Age, N (%) | | | | |
| Pediatric | 119 (7.2%) | 117 (9.5%) | 0 (0.0%) | 2 (3.1%) |
| Adult, age known | 1538 (92.7%) | 1108 (90.5%) | 367 (100.0%) | 63 (96.9%) |
| Adult, age unknown | 2 (0.12%) | 2 (0.16%) | 0 (0.0%) | 0 (0.0%) |
| Median adult | 61 | 60 | 63 | 65 |
| Median pediatric | 4 | 4 | - | 3.5 |
| Difficult airway | | | | |
| Anticipated today | 341 (20.6%) | 275 (22.4%) | 54 (14.7%) | 12 (18.5%) |
| History of | 26 (1.6%) | 22 (1.8%) | 4 (1.1%) | 0 (0.0%) |
| ETI Indication | | | | |
| AMS/Neurologic: | | | | |
| Airway protection** | 1125 (67.8%) | 852 (69.4%) | 230 (62.7%) | 43 (66.2%) |
| Altered mental status | 658 (39.7%) | 490 (39.9%) | 139 (37.9%) | 29 (44.6%) |
| Neuromuscular weakness | 6 (0.4%) | 4 (0.3%) | 2 (0.5%) | 0 (0.0%) |
| Hemodynamic instability | | | | |
| Cardio/pulmonary arrest | 408 (24.6%) | 282 (23.0%) | 115 (31.3%) | 11 (16.9%) |
| Hypoxia | 276 (16.6%) | 174 (14.2%) | 85 (23.2%) | 17 (26.2%) |
| Hemodynamic instability | 112 (6.8%) | 76 (6.2%) | 29 (7.9%) | 7 (10.8%) |
| Shock/sepsis | 56 (3.4%) | 32 (2.6%) | 21 (5.7%) | 3 (4.6%) |
| Cardiac - medical | 49 (3.0%) | 33 (2.7%) | 15 (4.1%) | 1 (1.5%) |

**Table 1.** Continued

| Total ETIs, N (%) | Overall 1,659 (100%) | Hospital A 1,227 (74%) | Hospital B 367 (22.1%) | Hospital C 65 (3.9%) |
|---|---|---|---|---|
| Respiratory | | | | |
| Respiratory failure | 257 (15.5%) | 169 (13.8%) | 70 (19.1%) | 11 (16.9%) |
| Respiratory distress | 129 (7.8%) | 81 (6.6%) | 37 (10.1%) | 11 (16.9%) |
| Hypercarbia | 100 (6.0%) | 68 (5.5%) | 28 (7.6%) | 4 (6.2%) |
| Apnea/bradypnea | 68 (4.1%) | 43 (3.5%) | 22 (6.0%) | 3 (4.6%) |
| Upper airway obstruction | 8 (0.5%) | 5 (0.4%) | 1 (0.3%) | 2 (3.1%) |
| Trauma* | | | | |
| Blood in airway | 101 (6.1%) | 86 (7.0%) | 8 (2.2%) | 7 (10.8%) |
| Trauma - face | 60 (3.6%) | 59 (4.8%) | 1 (0.3%) | 0 (0.0%) |
| Unknown | 44 (2.7%) | 38 (3.1%) | 6 (1.6%) | 0 (0.0%) |
| Procedure | 30 (1.8%) | 27 (2.2%) | 3 (0.8%) | 0 (0.0%) |
| Trauma - neck | 17 (1.0%) | 17 (1.4%) | 0 (0.0%) | 0 (0.0%) |
| Therapeutic hyperventilation | 4 (0.2%) | 3 (0.2%) | 1 (0.3%) | 0 (0.0%) |
| Other | | | | |
| ETT exchange | 16 (1.0%) | 9 (0.7%) | 7 (1.9%) | 0 (0.0%) |
| Other | 11 (0.7%) | 8 (0.7%) | 3 (0.8%) | 0 (0.0%) |
| Emergency drug administration | 5 (0.3%) | 5 (0.4%) | 0 (0.0%) | 0 (0.0%) |
| Reintubation after unplanned extubation | 1 (0.1%) | 1 (0.1%) | 0 (0.0%) | 0 (0.0%) |
| Cardiac - surgical | 1 (0.1%) | 1 (0.1%) | 0 (0.0%) | 0 (0.0%) |

Values are presented as counts with corresponding percentages, calculated using each hospital's total number of ETIs. Age is categorized into pediatric (< 18 years of age) and adult (≥ 18) groups. Median age is provided for each cohort. For ETI indication, multiple indications could be linked to each ETI event as determined by the laryngoscopist. This differs from prospective airway registries where there is a single indication assigned to each ETI event. "Difficult airway today" refers to intubations assessed as difficult during the documented ETI event. "Difficult airway history" reflects documented history of airway difficulty in the patient chart.
*Airway protection indication includes both trauma patients as well as medical reasons, although the majority (almost 100%) of ETI for trauma occurred at Hospital A.
*AMS,* altered mental status; *ETI,* endotracheal intubation; *ETT,* endotracheal tube.

37.9%; C 29/65, 44.6%). The second most common subcategory was hemodynamic instability and third was preintubation cardiopulmonary arrest associated with 33.3% (408/1,659) of ETI events and a similar trend at each hospital (A: 282/1,227, 23.0%; B: 115/367, 31.3%; C: 11/65, 16.9%). Airway protection (61/119, 51.3%) and respiratory (47/119, 39.5%) were the most common indications for pediatric intubations.

All but one of the ETI associated with the indication of face and neck trauma took place at Hospital A. No trauma-related indications occurred at Hospital C. A full description of ETI indications is found in Table 1.

**First-Attempt Success and Overall Success**

The health system ED first-attempt success rate was 85.6% (95% CI, 83.9-87.3). However, we found a statistically significant relationship between first-attempt success and each ED ($P$ = .01). Hospital B achieved the highest first-attempt success rate (90.2%; 95% CI, 87.2-93.2), followed by Hospital A (84.6%; 95% CI, 82.6-86.6), and Hospital C (78.5%; 95% CI, 68.5-88.5). Overall success was over 99% for all three hospitals. Only two ETI events were ultimately unsuccessful, one resulting in death (Hospital A) and one resulting in cricothyrotomy (Hospital B).

**Adverse Airway Outcomes**

There was no statistically significant difference in the rate of adverse airway outcomes among the three hospitals ($P$ = .16). The health system ED rate was 10.5% (174/1,659) (Table 2). Hospital A had the highest proportion of adverse airway outcomes, with 11.3% (139/1,227) followed by Hospital C, with 9.2% (6/65) and Hospital B with the least frequent rate of 7.9% (29/367). Hypoxia was more frequent than any tracheal intubation-associated adverse event and occurred in 4.7% (78/1,659) of total ETI: 5.6% (69/1,227), at Hospital A, 1.6% (6/367) at Hospital B, and 4.6% (3/65), at Hospital C. Hypotension was the most frequent tracheal intubation-associated adverse event, occurring in 2.7% (44/1,659) of

encounters. Hospital B had the highest rates of hypotension, occurring in 4.6% (17/367) of encounters, followed by Hospital A in 2.1% (26/1,227), and 1.5% (1/65) at Hospital C.

Peri-intubation cardiac arrest occurred in 1.4% (24/1,659) of encounters. Return of spontaneous circulation was achieved in 63% (15/24) of these events, including 78% (14/18) at Hospital A, 20% (1/5) at Hospital B, and 0% (0/1) at Hospital C. Death occurred in 37% (9/24) of peri-intubation cardiac arrests: 22% (4/18) at Hospital A, 80% (4/5) at Hospital B, and 100% (1/1) at Hospital C. Other differences in less frequent adverse airway outcomes are listed in descending order of frequency in Table 2.

**Laryngoscopists**

Most final attempts were performed by physician trainees (residents and fellows) (1,160/1,659; 69.9%). However, the majority (89.3%) were performed at hospital A (1,096/1,227) (B: 64/367, 17.4%). Among physician trainees who performed final-attempt ETIs, most were at the PGY-3 level, followed by PGY-2 and PGY-1. By contrast, emergency attending physicians performed only 6.8% (83/1,227) final-attempt ETIs at Hospital A. They performed most procedures at Hospital B and Hospital C, accounting for 80.4% (295/367) and 98.5% (64/65), respectively.

Additionally, respiratory therapists, nurse practitioners, and physician assistants performed comparatively small numbers of final-attempt ETIs. Respiratory therapists played the largest role at Hospital B, performing 2.2% (8/659) of final-attempt ETIs. Nurse practitioners and physician assistants played the largest role at Hospital A, performing 1.8% (22/1,227) of final-attempt ETIs. All EDs had mechanisms to call for additional personnel in the case of difficult ETIs. This included mechanisms to activate an emergency response from anesthesia and surgical teams. At Hospitals B and C, the standard procedure was for one person to attempt the ETI then page anesthesia or surgical teams if they were unsuccessful or anticipated further difficulties. At Hospital A, it was common practice for several people in the ED (for example, escalating from resident to attending) to attempt the ETI prior to calling for additional help. Hospital A was the only hospital to have any final-attempt ETIs performed by anesthesiologists, critical airway team members, trauma service members, and intensivists—all of these occurred via hospital A's critical airway response team. A full description of ETI laryngoscopists is found in Table 3.

**Visualization Technique and Devices**

Direct video laryngoscopy was the predominant

**Table 2.** Adverse airway outcomes by hospital and overall.

| Adverse Airway Outcome | Overall | Hospital A | Hospital B | Hospital C | *P* value |
|---|---|---|---|---|---|
| Any AAO | 174 (10.5%) | 139 (11.3%) | 29 (7.9%) | 6 (9.2%) | .16 |
| Hypoxia | 78 (4.7%) | 69 (5.6%) | 6 (1.6%) | 3 (4.6%) | |
| Tracheal intubation-associate adverse event | | | | | |
| Hypotension | 44 (2.7%) | 26 (2.1%) | 17 (4.6%) | 1 (1.5%) | |
| Cardiac arrest | 25 (1.5%) | 19 (1.5%) | 5 (1.4%) | 1 (1.5%) | |
| Death | 10 (0.6%) | 5 (0.5%) | 4 (1.1%) | 1 (1.5%) | |
| Mainstem intubation | 18 (1.1%) | 17 (1.4%) | 1 (0.3%) | 0 (0.0%) | |
| Inadequate sedation | 14 (0.8%) | 13 (1.1%) | 1 (0.3%) | 0 (0.0%) | |
| Dental/lip trauma | 3 (0.2%) | 2 (0.2%) | 1 (0.3%) | 0 (0.0%) | |
| Emesis no aspiration | 5 (0.3%) | 4 (0.3%) | 1 (0.3%) | 0 (0.0%) | |
| Dysrhythmia | 5 (0.3%) | 5 (0.4%) | 0 (0.0%) | 0 (0.0%) | |
| Hypertension | 4 (0.2%) | 4 (0.3%) | 0 (0.0%) | 0 (0.0%) | |
| Direct airway injury | 3 (0.2%) | 3 (0.2%) | 0 (0.0%) | 0 (0.0%) | |
| Esophageal intubation | 2 (0.1%) | 1 (0.08%) | 0 (0.0%) | 1 (1.5%) | |
| Emesis with aspiration | 2 (0.1%) | 1 (0.08%) | 0 (0.0%) | 1 (1.5%) | |
| Laryngospasm | 1 (0.06%) | 1 (0.08%) | 0 (0.0%) | 0 (0.0%) | |
| Pneumothorax | 1 (0.06%) | 0 (0.0%) | 1 (0.3%) | 0 (0.0%) | |
| Malignant hyperthermia | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | 0 (0.0%) | |

Listed in order of overall health system descending frequency. Values represent the number and percentage of total endotracheal intubation (ETI) encounters. Percentages were calculated using the total number of ETIs at each hospital and overall. Multiple adverse events could be linked to a single ETI.
*AAO,* adverse airway outcome.

**Table 3.** Role of the final intubation attempt operator by hospital and overall.

| Final-attempt laryngoscopist | Hospital A | Hospital B | Hospital C | Overall |
|---|---|---|---|---|
| Resident / Fellow | 1,096 (89.3%) | 64 (17.4%) | 0 (0.0%) | 1,160 (69.9%) |
| PGY 1 | 296 (24.1%) | 1 (0.3%) | 0 (0.0%) | 297 (17.9%) |
| PGY 2 | 287 (23.4%) | 60 (16.3%) | 0 (0.0%) | 347 (20.9%) |
| PGY 3 | 443 (36.1%) | 2 (0.5%) | 0 (0.0%) | 445 (26.8%) |
| PGY 4 | 44 (3.6%) | 0 (0.0%) | 0 (0.0%) | 44 (2.7%) |
| PGY 5 + | 6 (0.5%) | 0 (0.0%) | 0 (0.0%) | 6 (0.4%) |
| Unknown PGY | 19 (1.5%) | 1 (0.3%) | 0 (0.0%) | 20 (1.2%) |
| Emergency attending | 83 (6.8%) | 295 (80.4%) | 64 (98.5%) | 442 (26.6%) |
| Nurse practitioner/physician assistant | 22 (1.8%) | 0 (0.0%) | 1 (1.5%) | 23 (1.4%) |
| Respiratory therapist | 11 (0.9%) | 8 (2.2%) | 0 (0.0%) | 19 (1.1%) |
| Anesthesiologist | 6 (0.5%) | 0 (0.0%) | 0 (0.0%) | 6 (0.4%) |
| Trauma service | 5 (0.4%) | 0 (0.0%) | 0 (0.0%) | 5 (0.3%) |
| Critical airway team | 2 (0.2%) | 0 (0.0%) | 0 (0.0%) | 2 (0.1%) |
| Intensivist | 1 (0.1%) | 0 (0.0%) | 0 (0.0%) | 1 (0.1%) |
| Other | 1 (0.1%) | 0 (0.0%) | 0 (0.0%) | 1 (0.1%) |
| Unknown | 3 (0.2%) | 2 (0.5%) | 1 (1.5%) | 6 (0.4%) |

Resident postgraduate year (PGY) levels are broken out separately. "Unknown (PGY)" reflects cases where resident training level was not specified. The "Resident / Fellow" row includes all PGY levels and unknowns. Percentages are calculated using total endotracheal intubation events at each hospital and overall.
*PGY,* postgraduate year.

visualization technique across all three EDs, used in 1,405 ETIs (84.7%) compared with 148 ETIs (8.9%) via direct laryngoscopy. Video laryngoscopy rate was highest at Hospital A (1,085/1,227; 88.4%), followed by Hospital B (283/367; 77.1%) and Hospital C (37/65; 65.9%). Hospital C had the greatest proportion of direct laryngoscopy (21/65; 32.3%), compared with Hospital B (61/367; 16.6%) and Hospital A (66/1,227; 5.4%). All three EDs had equivalent access to both video laryngoscopy and direct laryngoscopy equipment.

### Pediatric Experience

During the study period, of the 119 ETI events in pediatric patients (< 18 years of age), 117 (98.3%) occurred at Hospital A, which has an embedded PED, and two occurred at Hospital C (1.7%). The overall first-attempt success rate in d pediatric patients was 72.3% (86/119). This was 72.6% (85/117) at Hospital A and 50% (1/2) at Hospital C. The rate of pediatric adverse airway outcome was 20.2% (24/119), with 11.8% of pediatric encounters experiencing hypoxia (14/119). Difficult airway at the time of ETI was reported in 21.8% of pediatric patients (26/119).

## DISCUSSION

In this retrospective, observational study of ETI events across three EDs within a single health system, we found a statistically significant relationship between first-attempt success and hospital site, but no significant relationship between adverse airway outcome and hospital. Patient and procedural characteristics also varied broadly between sites. Importantly, the rate of ETI between sites was variable, with Hospital A performing 5/1,000 patient visits, Hospital B 2 /1,000, and Hospital C just 0.4 per 1,000. This likely reflects baseline patient acuity with sicker patients being treated at the large academic tertiary-care center compared with the two community hospitals and is further evidenced by the higher admission rates seen at Hospital A (Figure 1). However, this study was not designed to determine the causes of site-level differences in procedural frequency.

Despite differences in ETI rates, overall success rate for emergency airway management was > 99% ,which is consistent with previously described patterns in adult and pediatric emergency airway rescue.[17,18] The overall FAS rate (85.6%) across all three sites also aligns with prior literature,[19-22] but masks site-level variation. Several factors may contribute to these differences.

Hospital B had the highest first-attempt success rate and reflected a clinical environment where experienced attendings perform most procedures (80%) but are still required to supervise and teach trainees who perform 20% of ETIs. This is compared to Hospital A, where physician trainees performed nearly 90% of ETIs, and Hospital C, where

attendings performed all ETIs. These patterns suggest that differences in laryngoscopist experience may be associated with site-level differences in first-attempt success, which supports the need for further study on how procedural context and laryngoscopist role relate to airway outcomes in different ED environments. Prior studies have shown that skill proficiency in ETI is associated with the average number of procedures performed annually, with attending physicians who perform < 3 ETIs per year or supervise < 5 having lower proficiency,[23] which may be relevant when interpreting the variation observed across our three study sites. Future work should more directly address the role of skill maintenance for laryngoscopists in diverse ED settings.

The distribution of adverse airway outcomes similarly supports the importance of site-level analysis, even in the absence of statistically significant differences. The overall adverse airway outcome rate was 10.5%, and rates did not differ significantly between hospitals ($P = .16$). These findings suggest relative system-level consistency in overall adverse airway outcomes, although because we did not conduct statistical analysis on individual adverse airway outcomes, local variation in patient characteristics, and procedural context may still be clinically important and worth further exploration.

The academic ED, Hospital A, had the highest proportion of documented difficult airways. This likely reflects the higher acuity and medical complexity of patients at this site. Further study is needed to understand whether the differences in difficult airways represent statistical significance. Future work may also focus on clinically meaningful differences and how to prepare community sites within health systems for difficult airways and to see whether these differences can be mitigated by strategies such as rotation or training of attending physicians through the academic, higher acuity site.

While Hospital A had the highest proportion of adverse airway outcome, it also had the lowest rate of death from peri-intubation cardiac arrest with 73.7% (14/19) of peri-intubation cardiac arrest events resulting in death (compared with 80% [4/5] at Hospital B and 100% [1/1]) at Hospital C. Given the small number of cardiac arrest events at the latter two hospitals, these differences should be interpreted cautiously. It is possible that the finding reflects differences in patient population, resuscitation practices, or chance. For example, due to the finding that Hospital A had the most medically complex patients (as indicated by the higher admission rate and more cases of "difficult" airways), higher rates of return of spontaneous circulation could reflect multiple factors such as better site-level resuscitation competency, earlier recognition and intervention in peri-intubation cardiac arrest or teams that are more practiced in caring for critically ill patients.[24] As our institutional database grows, this may be an area for future statistical analysis rather than firm interpretation at this stage.

Hypoxia was the most common adverse airway outcome across the health system. The higher rate of hypoxia at Hospital A may be partially explained by differences in patient population, including higher baseline acuity, as evidenced by the higher admission rate. Additionally, Hospital A had the most pediatric encounters. Hypoxia was documented in 12% (14/117) of pediatric encounters at Hospital A, compared with 5.2% (58/1110) among adult patients. This higher rate of peri-intubation hypoxia is consistent with prior pediatric airway literature and may reflect increased susceptibility to hypoxia in this population.[16]

While adverse airway outcomes such as cardiac arrest often reflect underlying patient instability, other complications such as inadequate sedation, dental/lip trauma, mainstem intubation, and airway injury may be more preventable. Nearly all occurred at Hospital A. These events are rare; therefore, it is possible that the higher rate at Hospital A reflects the higher number of ETI procedures. Nonetheless, these findings may help identify areas for additional review and quality improvement.

Overall, the similarity in adverse airway outcome rates across the three hospitals suggests some amount of system-level consistency in airway management. Nonetheless, targeted site-specific interventions remain valuable based on clinical context. For example, academic centers such as Hospital A may benefit from interventions that improve readiness specifically for high-risk ETIs. Examples include pre-intubation assessment and checklist tools and "difficult airway" alerts in patient charts, which can improve airway management outcomes.[25-27] In contrast, community EDs such as Hospital C that are staffed only by attending physicians and see a much lower volume of ETI procedures may benefit from interventions such as high-fidelity simulation for high stakes, low frequency airway scenarios and peri-intubation cardiac arrest and other in-service training methods that emphasize maintenance of competency.[28] They may also benefit from protocols that rapidly mobilize additional team members to augment the leaner team structure that many community centers use compared with academic centers.[29]

Regarding visualization technique, our findings demonstrate a predominance of video laryngoscopy across all three EDs, with particularly high use at Hospital A. These findings align with broad consensus in emergency medicine favoring video laryngoscopy to achieve higher first-attempt success rates, particularly among less experienced laryngoscopists.[1,30-39] The variation between hospitals may reflect differences in operator level of training. Hospital C, where 100% of laryngoscopists are attending physicians, had the highest use of direct laryngoscopy. By comparison, Hospital A, where laryngoscopists are primarily residents, had the lowest use of direct laryngoscopy. Because each hospital stocks identical airway equipment, these differences are unlikely to be explained by resource availability; however, in this study we were unable determine reasons for equipment choices made by laryngoscopists. Given the large evidence-base supporting video laryngoscopy for improved patient

outcomes as cited above, future work should explore what factors influence the choice of laryngoscopy technique in different ED contexts.

Our data also offer insight into the pediatric ETI experience across a health system. The overall pediatric first-attempt success rate was 72.3%, lower than the overall cohort, but consistent with what has been previously found.[40-42] Further, the pediatric adverse airway outcome rate was 20.2%, nearly double the overall adverse event rate of 10.5%. Pediatric encounters account for a large proportion of the adverse airway outcomes at Hospital A (Of 139 adverse airway outcomes, 17.3% were in pediatric patients despite pediatric patients only accounting for 9.5% of total ETIs.) This is consistent with prior literature, which demonstrates that first-attempt success tends to be lower and adverse airway outcome s tend to be higher in pediatric patients due to their unique anatomy and physiology,[43,44] with the most difficult and complicated adverse airway outcomes occurring in infants and toddlers.[16,45,46] Further, prior studies show that pediatric patients who present to PEDs tend to be sicker than those who present to general EDs.[47] Taken together, these findings support continued attention to pediatric airway prepareness within health systems.

## LIMITATIONS

Our study has several limitations. Firstly, our data depend on direct input by individuals, and we were unable to verify the accuracy of documentation via video event review or other methods. Further, while it is institutional protocol for all ETI events to be documented using the same standardized procedure note that feeds into the database used in this study, it is possible that some events were documented using a different method or were not documented at all; however, since billing for the ETI procedure is linked to the institutional documentation, we believe the rate of mis-documentation is likely very low if not zero. Additionally, the procedure note contains definitions for each piece of data collected to ensure consistency across documenters. For example, our note defines an "attempt" as passing the laryngoscope beyond the teeth, but the definition varies across the literature on first-attempt success, making it difficult to directly compare our results with those studies that use a different definition.

Being this study is retrospective electronic health record-driven analysis, we also acknowledge potential under-reporting of time-delayed tracheal intubation-associated adverse events. For example, we found that rates of hypotension were < 4% at each site, which is much lower compared with prospectively collected data on tracheal intubation-associated adverse events. Because certain tracheal intubation-associated adverse events, such as hypotension, may not occur or be recognized until several minutes after the procedure is complete, this creates a systematic bias toward under-reporting of these time-delayed events, compared with events that occur more contemporaneously with the procedure such as right mainstem intubation, hypoxia, and direct airway injury.

Lastly, as noted above, we considered the embedded PED and general ED at Hospital A as a single site, which may limit the generalizability of the findings given the variation in pediatric and adult patients.

## CONCLUSION

The goal of this study was to investigate site-level variation in emergency endotracheal intubation across three different EDs that are part of a single health system. We found evidence of significant variation in first-attempt success between the sites, although rates of adverse events were comparable and overall success rates were over 99% across the hospitals. These findings suggest that procedural success is impacted by factors such as patient differences, role and training level of laryngoscopists, and inherent site-level differences such as patient volume and acuity. Further analysis and intervention should be tailored to the characteristics of specific sites.

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# Emergency Severity Index Stratified by Post-Triage Lactate: Association with In-Hospital Mortality in Admitted Patients

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**Introduction:** The Emergency Severity Index (ESI) is a widely used triage tool in emergency departments (EDs) and is associated with adverse outcomes. Lactate has also been associated with mortality in various ED populations. This study evaluated whether lactate levels measured after triage at the treating physician's discretion are associated with in-hospital mortality across ESI levels in admitted ED patients.

**Methods:** This study is a secondary analysis of prospectively collected data from adult patients presenting to the ED of a Swiss tertiary care center in 2013, 2015, 2017, and 2019. The study included admitted patients who underwent post-triage lactate measurement at the treating physician's discretion. Only the first lactate value measured in the ED was analyzed and categorized as < 2.0, 2.0–3.9, and ≥ 4.0 mmol/L. The primary outcome was in-hospital mortality; secondary outcomes were 30-day mortality and intensive care unit (ICU) admission. Associations were assessed using multivariable logistic regression models adjusted for age and sex. Model discrimination was compared using receiver operating characteristic curve analysis.

**Results:** Among 3,909 patients admitted from the ED who had a lactate drawn (of 17,327 ED presentations during the study period; 22.6%), the median age was 72 years and 2,062 (52.8%) were male. In-hospital mortality occurred in 168 (4.3%), 30-day mortality in 258 (6.6%), and ICU admission in 698 (17.9%). In ESI levels 2 (n = 1,826) and 3 (n = 1,722), crude in-hospital mortality was similar (59 [3.2%] and 44 [2.6%], respectively), but varied after stratification by lactate level. In ESI level 2 patients, in-hospital mortality occurred in 24 (2.0%) among those with lactate < 2.0 mmol/L (n = 1,210) and in 18 (17.8%) among those with lactate ≥ 4.0 mmol/L (n = 101), corresponding to an age- and sex-adjusted absolute risk difference of 16.0% (95% CI, 8.8–23.3). In ESI level 3, in-hospital mortality occurred in 20 (1.6%) at lactate < 2.0 mmol/L (n = 1,254) and in 8 (15.1%) at lactate ≥ 4.0 mmol/L (n = 53), corresponding to a risk difference of 12.5% (95% CI, 3.7–21.3). Discrimination for in-hospital mortality was higher when lactate was considered alongside ESI (area under the curve [AUC] 0.844 versus 0.799; ΔAUC 0.045, 95% CI, 0.021–0.069), with smaller increases for 30-day mortality and ICU admission.

**Conclusion:** In admitted ED patients who had lactate measured after triage at physician discretion, higher lactate levels were associated with increased in-hospital mortality across ESI levels, particularly among patients triaged as ESI levels 2 and 3. [West J Emerg Med. 2026;27(5)1364–1373.]

## INTRODUCTION

Triage is one of the main tasks of an emergency department (ED), in which patients are categorized based on acuity and prognosis.[1] The Emergency Severity Index (ESI) is a well-established, reliable, and valid five-level triage tool. Patients are classified according to presenting symptoms, resource needs, and vital signs.[2] Despite being primarily an acuity-based triage tool, the ESI is known to be associated with hospital admission and mortality.[3–5] Its discriminatory performance for adverse outcomes can be enhanced by incorporating additional parameters. Adding physician disease severity ratings to any ESI level was associated with higher mortality in ED patients.[6] Similarly, markers of vulnerability, such as impaired mobility or the Clinical Frailty Scale, were more strongly associated with 30-day mortality than the ESI among patients aged 65 years and older, highlighting their potential utility in triage decision-making.[7,8] Another study found that combining ESI with the quick Sequential Organ Failure Assessment (qSOFA) score improved discriminatory accuracy for in-hospital mortality and intensive care unit (ICU) admission compared to ESI alone.[9] Likewise, adding the Peripheral Perfusion Index or the Shock Index to the ESI improved discrimination of high-acuity unselected ED patients.[10]

Lactate has been shown to be associated with adverse outcomes in both unselected ED patients and those presenting with specific acute conditions, including infection, sepsis, trauma, pneumonia, pulmonary embolism, and stroke.[11–18] To date, no study has evaluated whether lactate levels are associated with outcomes across ESI levels in admitted ED patients. Given that incorporating lactate into triage would represent a substantial operational shift, we aimed to assess whether lactate levels obtained after triage at the discretion of the treating physician are associated with in-hospital mortality across ESI levels and may provide additional information beyond ESI.

*Population Health Research Capsule*

What do we already know about this issue?
*Both the Emergency Severity Index (ESI) and lactate are associated with mortality in emergency department (ED) patients, but the association of lactate across ESI levels is unclear.*

What was the research question?
*Is post-triage lactate associated with mortality across ESI levels in admitted ED patients?*

What was the major finding of the study?
*In ESI 3 patients, mortality rose from 1.6% with lactate < 2 to 15.1% with ≥ 4 mmol/L (RD 12.5%; 95% CI, 3.7–21.3).*

How does this improve population health?
*Lactate could help identify high-risk ESI 3 patients who may benefit from more timely evaluation or closer monitoring.*

## METHODS

### Study Design and Setting

This study is a secondary analysis based on prospectively collected data from the EMERGE cohort, which serves quality control purposes and benchmarking between Swiss EDs. The study was conducted in the ED of a tertiary care center in Switzerland, with an annual ED census of approximately 55,000 patients aged 16 years and older. Obstetric, pediatric, and ophthalmologic patients are treated in separate facilities on campus. All patients presenting to the ED were assessed for inclusion 24 hours a day, 7 days a week. Data were collected from 21 October to 11 November 2013 (EMERGE cohort 1), 1 February to 23 February 2015 (EMERGE cohort 2), 30 January to 19 February 2017 (EMERGE cohort 3), and 18 March to 20 May 2019 (EMERGE cohort 4). The study was approved by the local ethics committee (EKNZ-236/13). The results are reported in accordance with the STROBE guidelines.[19]

### Selection Of Participants

All consecutive patients presenting to the ED during the study periods were screened for eligibility. Patients were excluded if they left without being seen, were directly referred to other departments, declined informed consent, or had repeated ED visits during the study periods (only the index visit was included). For the primary analysis, we included adult patients who were admitted to the hospital and had a lactate measurement obtained during the ED stay at the discretion of the treating physician. Patients discharged from the ED or with missing ESI or lactate values were excluded. The rationale for excluding patients discharged from the ED is their generally very low risk of mortality.[3,20,21] In addition, lactate measurements are typically obtained in clinically sicker patients, who are more likely to require admission. Therefore, the analysis was restricted to admitted patients to focus on a higher risk population. For descriptive comparisons of ESI distributions and crude in-hospital mortality according to lactate measurement status, admitted patients without lactate measurements were included.

### Data Collection

Upon arrival, all patients were registered by the study team, and an electronic health record (EHR) was created. The study team consisted of trained medical students. Data on demographics (age, sex), ESI triage level, patient

disposition (discharge, hospital admission, or ICU admission), in-hospital and 30-day mortality were prospectively and consecutively collected. Clinicians ordered nonprotocolized lactate measurements at their discretion during routine clinical care. Consequently, this secondary analysis used data extracted from the EHR for a select subset of patients who underwent testing.

*Triage Process*

All patients were triaged by a triage clinician using the German version of the ESI, version 4.[3] The ESI stratifies patients into five acuity categories based on their presenting symptoms, anticipated resource requirements, and vital signs. High-acuity patients are classified as ESI levels 1–2, intermediate-acuity patients as ESI level 3, and low-acuity patients as ESI levels 4–5. Triage personnel assign an ESI level 1 to patients requiring immediate life-saving interventions (eg, airway or respiratory support, emergency medications, or hemodynamic interventions, such as fluid resuscitation or blood products). Patients in high-risk situations (such as those at high risk for deterioration, exhibiting acutely altered mental status, or experiencing severe pain or distress) are assigned an ESI level 2. The remaining patients are classified into ESI levels 3–5 based on the expected number of required resources (more than one in ESI level 3, one in ESI level 4, and none in ESI level 5). Examples for resources are laboratory tests, electrocardiograms, or radiographs. For patients triaged as ESI level 3, vital signs must also be measured. In the presence of danger-zone vital signs (heart rate greater than 100 beats/min, respiratory rate greater than 20 breaths/min, or oxygen saturation less than 92% in adult patients), reassignment to ESI level 2 should be considered.[22] Notably, the fifth version of the ESI manual (released in 2023) integrated a complete set of vital signs for all low-acuity patients; however, its benefit remains uncertain.[2,23]

*Lactate Measurement*

Venous lactate was measured in the treatment area after triage at the discretion of the treating physician and was not part of a standardized protocol. In routine clinical practice, lactate measurement was typically performed shortly after triage, with earlier measurement in higher acuity patients (ESI levels 1–2) and later measurement in lower acuity patients depending on ED workflow. Accordingly, lactate measurements were obtained in a select subset of patients. Clinicians performed bedside lactate measurements using a point-of-care analyzer in the ED (Radiometer ABL90 FLEX PLUS; Radiometer Medical ApS, Brønshøj, Denmark). This analysis evaluated only the first lactate level obtained in the ED. To improve clinical interpretability, stratified lactate levels were used instead of continuous lactate levels. Based on thresholds used in previous studies, lactate levels were categorized as low (< 2.0 mmol/L), intermediate (2.0–3.9 mmol/L), and high (≥ 4.0 mmol/L).[24–27]

**Outcomes**

The primary outcome was in-hospital mortality. Admission was defined as transfer from the ED to any hospital ward with a minimum stay of one night. Patients who died in the ED prior to an overnight stay were considered admitted and counted as in-hospital deaths. Secondary outcomes included 30-day mortality and ICU admission. Thirty-day mortality was defined as death occurring within 30 days after presentation to the ED. Follow-up was performed by reviewing the hospital information system; contacting patients, proxies, or primary care physicians; and consulting health insurance companies or civil registries. Patients lost to follow-up were considered alive. Admission to the ICU was defined as transfer to the ICU, intermediate care unit, or stroke unit during the hospital stay.

**Statistical Analysis**

For categorical variables, data are presented as frequencies and percentages; continuous variables are reported as medians with interquartile ranges (IQRs). Given that lactate testing was performed selectively at physician discretion, patients without a lactate value were considered not to have undergone measurement rather than to have conventional missing data. Consequently, the primary analyses were restricted to admitted patients with available ESI and lactate data, and missing lactate values were not imputed. Descriptive analyses comparing patients with and without lactate measurements were performed without imputation. To assess whether lactate provided additional information beyond ESI within this selected cohort, logistic regression models were fitted for ESI alone and for the combined ESI-by-lactate specification; adjusted models included age and sex. Nested model comparisons were performed using likelihood-ratio tests (two-sided $P < .05$). Discrimination was assessed using the area under the receiver operating characteristic curve (AUC) with 95% confidence intervals (CIs). Changes in discrimination (ΔAUC) were reported with 95% CIs; statistical inference for nested models relied on likelihood-ratio tests, with ΔAUC estimates presented descriptively. Patients lost to follow-up at 30 days were coded as survivors in the primary analysis, with sensitivity analyses excluding them or recoding them as deaths (Supplementary Table S1). Due to small sample sizes, ESI levels 4 and 5 were combined. Adjusted analyses were considered primary and are presented in the main manuscript, whereas unadjusted analyses are provided in the Supplementary Materials (Supplementary Tables S2, S3, and S4 and Figure S1). Because this study was a secondary analysis of a prospectively collected cohort, no formal sample size calculation was performed a priori. The sample size was determined by the number of eligible patients available during the study periods. We did not perform a post hoc power calculation, because effect estimates and 95% CIs provide a more informative indication of estimate precision. All

analyses were conducted in R, version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

### Baseline Characteristics

During the study period, 17,327 patients presented to the ED. Of 14,440 enrolled patients, 10,531 were excluded, mainly due to discharge from the ED (9,439 patients). The final cohort included 3,909 admitted patients (Figure 1).

In these, median age was 72 years (IQR 55–83), and 52.8% were male. In-hospital mortality occurred in 168 patients (4.3%), 30-day mortality in 258 (6.6%), and 698 (17.9%) were admitted to the ICU; 76 (1.9%) were lost to follow-up and considered alive. Most patients were triaged as ESI level 2 (1,826/3,909; 46.7%) or level 3 (1,722/3,909; 44.1%). In-hospital mortality was highest in ESI level 1 (64/286; 22.4%), followed by level 2 (59/1,826; 3.2%) and level 3 (44/1,722; 2.6%), with similar patterns for 30-day mortality and ICU admission. In ESI level 4 and 5 patients (n = 75), adverse outcomes were rare, with one in-hospital death (1.3%) and four ICU admissions (5.3%). Most patients had a lactate < 2.0 mmol/L (2,641/3,909; 67.6%), followed by 2.0–3.9 mmol/L (1,041/3,909; 26.6%) and ≥ 4.0 mmol/L (227/3,909; 5.8%). In-hospital mortality increased with higher lactate levels: 2.3% (< 2.0 mmol/L), 4.8% (2.0–3.9 mmol/L), and 25.1% (≥ 4.0 mmol/L), again with similar patterns for 30-day mortality and ICU admission. Detailed distributions are presented in Table 1.

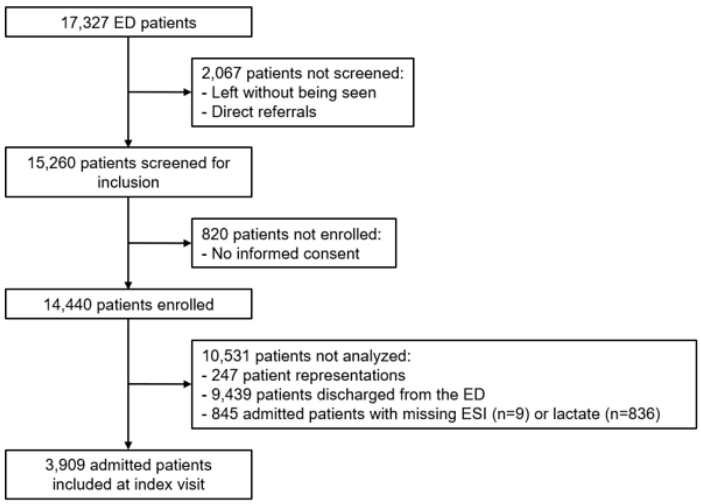


**Figure 1.** Flowchart of admitted adult emergency department patients with lactate measurements obtained after triage at physician discretion in a study that evaluated whether lactate levels were associated with in-hospital mortality across Emergency Severity Index levels.
*ED*, emergency department; *ESI*, Emergency Severity Index.

### Primary and Secondary Outcomes

Although crude in-hospital mortality was similar between patients triaged as ESI level 2 and 3 (3.2% and 2.6%, respectively), differences became more pronounced after stratification by lactate level. In ESI level 2 patients, in-hospital mortality increased from 2.0% among those with lactate < 2.0 mmol/L to 17.8% among those with lactate ≥ 4.0 mmol/L, corresponding to an age- and sex-adjusted absolute risk difference of 16.0% (95% CI, 8.8–23.3). In ESI level 3 patients, in-hospital mortality increased from 1.6% at lactate < 2.0 mmol/L to 15.1% at lactate ≥ 4.0 mmol/L, corresponding to a risk difference of 12.5% (95% CI, 3.7–21.3) (Table 2, Figure 2).

Among patients without lactate measurements, crude in-hospital mortality was also similar between ESI levels 2 and 3 (1.2% and 1.4%, respectively) (Table 3).

Across ESI levels 1–3 patients, lactate ≥ 4.0 mmol/L was associated with increased in-hospital and 30-day mortality, while associations with ICU admission varied by ESI level. In ESI level 1 and 2 patients, lactate values between 2.0–3.9 mmol/L were not associated with in-hospital mortality, 30-day mortality, or ICU admission. In contrast, in ESI level 3 patients, lactate values between 2.0–3.9 mmol/L were associated with in-hospital and 30-day mortality, but not with ICU admission (Tables 2 and 4).

Among the 1,722 patients triaged as ESI level 3, a lactate level ≥ 2 mmol/L captured 24 of 44 in-hospital deaths (54.5%) and 49 of 153 ICU admissions (32.0%), whereas a lactate level ≥ 4 mmol/L captured 8 of 44 in-hospital deaths (18.2%) and 8 of 153 ICU admissions (5.2%). The number of patients who would need to be flagged to capture one event was 19.5 vs 6.6 for in-hospital mortality and 9.6 vs 6.6 for ICU admission for the ≥ 2 mmol/L and ≥ 4 mmol/L thresholds (Supplementary Table S5). After adjustment for age and sex, models including both ESI and lactate showed higher discrimination for in-hospital mortality compared with ESI alone (AUC, 0.844 vs 0.799; ΔAUC, 0.045), with smaller differences for 30-day mortality (ΔAUC, 0.025) and ICU admission (ΔAUC, 0.006) (Table 5, Figure 3).

For in-hospital mortality, stratified analyses showed consistent benefits across age groups, with AUC increasing from 0.834 to 0.900 in patients < 65 years and from 0.746 to 0.796 in those ≥ 65 years (Supplementary Table S6).

## DISCUSSION

This study showed that among admitted ED patients who had lactate measured after triage at the treating physician's discretion, higher lactate levels were associated with increased in-hospital mortality and 30-day mortality across ESI levels, whereas associations with ICU admission were weaker and varied by ESI level. Differences in outcomes across lactate categories were particularly evident among patients triaged as ESI levels 2 and 3, in whom overall mortality rates were similar.

**Table 1.** Baseline characteristics and outcomes of admitted adult emergency department patients stratified by Emergency Severity Index and lactate category.

| | N (%) | Age median (IQR) | Male % | In-hospital mortality n (%) | 30-day mortality n (%) * | ICU admission n (%) |
|---|---|---|---|---|---|---|
| All patients | 3,909 | 72 (55–83) | 52.8 | 168/3,909 (4.3%) | 258/3,909 (6.6%) | 698/3,909 (17.9%) |
| ESI level 1 | 286/3,909 (7.3%) | 71 (57–80) | 59.8 | 64/286 (22.4%) | 75/286 (26.2%) | 171/286 (59.8%) |
| ESI level 2 | 1,826/3,909 (46.7%) | 70 (54–81) | 55.3 | 59/1,826 (3.2%) | 100/1,826 (5.5%) | 370/1,826 (20.3%) |
| ESI level 3 | 1,722/3,909 (44.1%) | 75 (58–84) | 49.7 | 44/1,722 (2.6%) | 81/1,722 (4.7%) | 153/1,722 (8.9%) |
| ESI level 4–5 | 75/3,909 (1.9%) | 65 (41–82) | 34.7 | 1/75 (1.3%) | 2/75 (2.7%) | 4/75 (5.3%) |
| Lac < 2.0 mmol/L | 2,641/3,909 (67.6%) | 72 (54–83) | 50.4 | 61/2,641 (2.3%) | 120/2,641 (4.5%) | 401/2,641 (15.2%) |
| Lac 2.0–3.9 mmol/L | 1,041/3,909 (26.6%) | 73 (58–83) | 57.1 | 50/1,041 (4.8%) | 74/1,041 (7.1%) | 213/1,041 (20.5%) |
| Lac ≥ 4 mmol/L | 227/3,909 (5.8%) | 71 (58–80) | 59.9 | 57/227 (25.1%) | 64/227 (28.2%) | 84/227 (37.0%) |

Data are presented for admitted adult emergency department patients with lactate measurements obtained after triage at physician discretion (N = 3,909). *Patients lost to follow-up (n = 76) were considered alive.
*ESI*, Emergency Severity Index; *ICU*, intensive care unit; *IQR*, interquartile range; *Lac*, lactate.

The ability of the ESI to discriminate adverse outcomes is limited by its design as an acuity-based tool that relies in part on the subjective clinical judgment of triaging clinicians. In the present study, most patients were triaged as ESI level 2 or 3, which is consistent with previous findings.[4,28] As expected, the highest in-hospital mortality was observed among patients triaged as ESI level 1. Among admitted patients with lactate measurements obtained after triage at the treating physician's discretion, crude mortality rates for patients in ESI levels 2 and 3 were similar, at 3.2% and 2.6%, respectively. This may reflect differences in case mix and the selective use of lactate measurement after triage, as lactate was preferentially

**Table 2.** In-hospital mortality of admitted adult emergency department patients stratified by Emergency Severity Index and lactate category.

| | | In-hospital mortality | |
|---|---|---|---|
| | N (%) | n (%) | aOR (95% CI) |
| ESI level 1 | 286/3,909 (7.3%) | 64/286 (22.4%) | |
| Lac < 2.0 mmol/L | 121/286 (42.3%) | 16/121 (13.2%) | Ref |
| Lac 2.0–3.9 mmol/L | 93/286 (32.5%) | 17/93 (18.3%) | 1.30 (0.59–2.87) |
| Lac ≥ 4 mmol/L | 72/286 (25.2%) | 31/72 (43.1%) | 5.27 (2.53–10.97) |
| ESI level 2 | 1,826/3,909 (46.7%) | 59/1,826 (3.2%) | |
| Lac < 2.0 mmol/L | 1,210/1,826 (66.3%) | 24/1,210 (2.0%) | Ref |
| Lac 2.0–3.9 mmol/L | 515/1,826 (28.2%) | 17/515 (3.3%) | 1.56 (0.82–2.95) |
| Lac ≥ 4 mmol/L | 101/1,826 (5.5%) | 18/101 (17.8%) | 11.75 (6.01–22.97) |
| ESI level 3 | 1,722/3,909 (44.1%) | 44/1,722 (2.6%) | |
| Lac < 2.0 mmol/L | 1,254/1,722 (72.8%) | 20/1,254 (1.6%) | Ref |
| Lac 2.0–3.9 mmol/L | 415/1,722 (24.1%) | 16/415 (3.9%) | 2.22 (1.14–4.32) |
| Lac ≥ 4 mmol/L | 53/1,722 (3.1%) | 8/53 (15.1%) | 10.57 (4.28–26.10) |
| ESI level 4–5 | 75/3,909 (1.9%) | 1/75 (1.3%) | |
| Lac < 2.0 mmol/L | 56/75 (74.7%) | 1/56 (1.8%) | Ref |
| Lac 2.0–3.9 mmol/L | 18/75 (24.0%) | 0/18 (0.0%) | NA |
| Lac ≥ 4 mmol/L | 1/75 (1.3%) | 0/1 (0.0%) | NA |

Data are presented for admitted adult emergency department patients with lactate measurements obtained after triage at physician discretion (N = 3,909). Adjusted odds ratios were estimated from age- and sex-adjusted logistic regression models. Within each ESI level, patients with lactate < 2.0 mmol/L served as the reference group. Adjusted odds ratios were not estimable for strata with zero events.
*aOR*, adjusted odds ratio; *ESI*, Emergency Severity Index; *Lac*, lactate; *Ref*, reference.

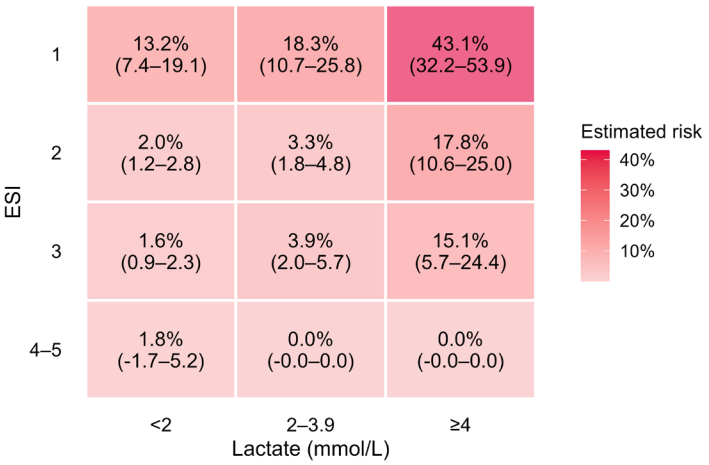


**Figure 2.** In-hospital mortality across Emergency Severity Index and lactate categories in admitted adult ED patients with lactate measurements obtained after triage at physician discretion, adjusted for age and sex. Values represent absolute risk estimates (95% confidence intervals) derived from logistic regression models. Confidence intervals extending below zero reflect limited precision due to small cell sizes in these strata. *ED*, emergency department; *ESI*, Emergency Severity Index.

obtained in older and more severely ill patients, whereas those without lactate measurements were younger and had lower mortality (Supplementary Table S7). Notably, crude mortality rates were also similar between ESI levels 2 and 3 among admitted patients without lactate measurements (Table 3), supporting the interpretation that this pattern is not solely attributable to selection related to lactate measurement, but may also reflect limited discrimination of the ESI within these categories.

When stratified by lactate level, differences in mortality became more apparent. In ESI level 3 patients, a lactate threshold of ≥ 2 mmol/L identified a large proportion of patients who died, whereas a threshold of ≥ 4 mmol/L identified fewer patients with higher mortality. These findings suggest that lactate may help to further characterize differences in risk within this intermediate-acuity group.

These results are consistent with previous studies showing that higher lactate levels are associated with adverse outcomes and may provide additional information when considered alongside established clinical scores. For example, studies evaluating the National Early Warning Score (NEWS) have reported that higher lactate levels were associated with increased in-hospital mortality and ICU admission in general ED populations.[29] Similarly, in patients with suspected sepsis, lactate ≥ 2 mmol/L has been associated with higher sensitivity for mortality or prolonged ICU stay when considered alongside qSOFA.[30] Likewise, higher lactate levels have been associated with mortality across established severity scoring systems such as Acute Physiology and Chronic Health Evaluation II, SOFA, and Mortality in Emergency Department Sepsis in septic ED patients.[31]

In the present study, discrimination for 30-day mortality and ICU admission was lower than for in-hospital mortality, likely reflecting the impact of postadmission factors and institutional decision-making beyond the patient's initial physiological condition. In older patients, previous studies have reported that lactate, when considered alongside different triage scales or clinical scores such as the Modified Early Warning Score (MEWS), NEWS, and qSOFA, was not associated with differences in discrimination of poor outcomes.[32] In our study, however, increases in discrimination for in-hospital mortality were observed in older patients when lactate was considered alongside ESI, which may reflect differences in study populations and the selective use of lactate measurements.

The optimal lactate threshold associated with adverse outcomes in unselected adult ED patients remains uncertain, with reported cutoffs ranging from 2.0 to 4.0 mmol/L.[12,26,33] In this study, even moderately elevated lactate levels (2.0–3.9

**Table 3.** Emergency Severity Index levels and in-hospital mortality stratified by lactate measurement status in admitted emergency department patients.

| | All admitted patients (*N* = 4,745) | | With lactate measurements (*n* = 3,909) | | Without lactate measurements (*n* = 836) | |
|---|---|---|---|---|---|---|
| | *n* (%) | IHM, *n* (%) | *n* (%) | IHM, *n* (%) | *n* (%) | IHM, *n* (%) |
| ESI level 1 | 306/4,745 (6.4%) | 67/306 (21.9%) | 286/3,909 (7.3%) | 64/286 (22.4%) | 20/836 (2.4%) | 3/20 (15%) |
| ESI level 2 | 1,994/4,745 (42.0%) | 61/1,994 (3.1%) | 1,826/3,909 (46.7%) | 59/1,826 (3.2%) | 168/836 (20.1%) | 2/168 (1.2%) |
| ESI level 3 | 2,235/4,745 (47.1%) | 51/2,235 (2.3%) | 1,722/3,909 (44.1%) | 44/1,722 (2.6%) | 513/836 (61.4%) | 7/513 (1.4%) |
| ESI level 4–5 | 210/4,745 (4.4%) | 1/210 (0.5%) | 75/3,909 (1.9%) | 1/75 (1.3%) | 135/836 (16.1%) | 0/135 (0%) |

Lactate measurements were obtained after triage at physician discretion. All patients refer to admitted index-visit patients with non-missing ESI; nine admitted patients with missing ESI were excluded from this ESI-stratified table.
*ESI,* Emergency Severity Index; *IHM,* in-hospital mortality.

**Table 4.** Thirty-day mortality and intensive care unit admission of admitted adult emergency department patients stratified by Emergency Severity Index and lactate category.

| | | 30-day mortality | | ICU admission | |
|---|---|---|---|---|---|
| | *N* (%) | *n* (%) | aOR (95% CI) | *n* (%) | aOR (95% CI) |
| ESI level 1 | 286/3,909 (7.3%) | 75/286 (26.2%) | | 171/286 (59.8%) | |
| Lac < 2.0 mmol/L | 121/286 (42.3%) | 21/121 (17.4%) | Ref | 65/121 (53.7%) | Ref |
| Lac 2.0–3.9 mmol/L | 93/286 (32.5%) | 21/93 (22.6%) | 1.26 (0.60–2.65) | 53/93 (57.0%) | 1.06 (0.61–1.84) |
| Lac ≥ 4 mmol/L | 72/286 (25.2%) | 33/72 (45.8%) | 4.47 (2.15–9.30) | 53/72 (73.6%) | 2.35 (1.24–4.46) |
| ESI level 2 | 1,826/3,909 (46.7%) | 100/1,826 (5.5%) | | 370/1,826 (20.3%) | |
| Lac < 2.0 mmol/L | 1,210/1,826 (66.3%) | 55/1,210 (4.5%) | Ref | 228/1,210 (18.8%) | Ref |
| Lac 2.0–3.9 mmol/L | 515/1,826 (28.2%) | 26/515 (5.0%) | 1.02 (0.63–1.66) | 119/515 (23.1%) | 1.26 (0.98–1.62) |
| Lac ≥ 4 mmol/L | 101/1,826 (5.5%) | 19/101 (18.8%) | 5.52 (3.02–10.12) | 23/101 (22.8%) | 1.23 (0.75–1.99) |
| ESI level 3 | 1,722/3,909 (44.1%) | 81/1,722 (4.7%) | | 153/1,722 (8.9%) | |
| Lac < 2.0 mmol/L | 1,254/1,722 (72.8%) | 42/1,254 (3.3%) | Ref | 104/1,254 (8.3%) | Ref |
| Lac 2.0–3.9 mmol/L | 415/1,722 (24.1%) | 27/415 (6.5%) | 1.80 (1.09–2.97) | 41/415 (9.9%) | 1.19 (0.81–1.75) |
| Lac ≥ 4 mmol/L | 53/1,722 (3.1%) | 12/53 (22.6%) | 8.78 (4.13–18.69) | 8/53 (15.1%) | 1.89 (0.87–4.11) |
| ESI level 4–5 | 75/3,909 (1.9%) | 2/75 (2.7%) | | 4/75 (5.3%) | |
| Lac < 2.0 mmol/L | 56/75 (74.7%) | 2/56 (3.6%) | Ref | 4/56 (7.1%) | Ref |
| Lac 2.0–3.9 mmol/L | 18/75 (24.0%) | 0/18 (0.0%) | NA | 0/18 (0.0%) | NA |
| Lac ≥ 4 mmol/L | 1/75 (1.3%) | 0/1 (0.0%) | NA | 0/1 (0.0%) | NA |

Data are presented for admitted adult emergency department patients with lactate measurements obtained after triage at physician discretion (N = 3,909). Adjusted odds ratios were estimated from age- and sex-adjusted logistic regression models. Within each ESI level, patients with lactate < 2.0 mmol/L served as the reference group. Adjusted odds ratios were not estimable for strata with zero events.
*aOR*, adjusted odds ratio; *ESI*, Emergency Severity Index; *ICU*, intensive care unit; *Lac*, lactate; *Ref*, reference.

mmol/L) were associated with adverse outcomes, consistent with prior research.[34] However, the association of intermediate lactate elevations with adverse outcomes differed across triage categories. While lactate levels of 2.0–3.9 mmol/L were not associated with adverse outcomes in ESI levels 1 and 2, they were associated with both in-hospital and 30-day mortality in ESI level 3 patients. This suggests that moderately elevated lactate levels may help to further characterize differences in risk within this heterogeneous triage level.

If lactate were measured systematically at the time of triage, it might enhance the discrimination of the ESI for patients ultimately admitted. In this context, point-of-care lactate testing may be of interest for identifying more subtle high-risk presentations, particularly among patients triaged as ESI level 3 who may otherwise appear clinically stable but could warrant more timely evaluation or closer monitoring. However, this potential role remains hypothetical and requires prospective evaluation.

## LIMITATIONS

Several limitations should be acknowledged. First, our study was conducted at a single tertiary care center in Europe,

**Table 5.** Discriminatory performance of Emergency Severity Index (ESI) and ESI–lactate models in admitted adult emergency department patients with lactate measurements obtained after triage at physician discretion.

| Outcome | AUC (95% CI): ESI | AUC (95% CI): Lac | AUC (95% CI): ESI×Lac | ΔAUC (95% CI) | LR $\chi^2$ | LR P |
|---|---|---|---|---|---|---|
| In-hospital | 0.799 (0.76–0.83) | 0.794 (0.76–0.83) | 0.844 (0.81–0.87) | 0.045 (0.021–0.069) | 88.43 | < .001 |
| 30-day | 0.791 (0.76–0.82) | 0.776 (0.75–0.80) | 0.816 (0.79–0.84) | 0.025 (0.009–0.041) | 74.85 | < .001 |
| ICU | 0.709 (0.69–0.73) | 0.603 (0.58–0.63) | 0.715 (0.69–0.74) | 0.006 (0.001–0.012) | 16.94 | .03 |

AUCs are derived from age- and sex-adjusted logistic regression models. ΔAUC indicates the change in AUC after adding lactate to the ESI. Likelihood-ratio tests compare nested ESI-only and combined ESI×lactate logistic regression models.
*AUC,* area under the curve; $\chi^2$, chi-square statistic; *ESI,* Emergency Severity Index; *ICU,* intensive care unit; *LR,* likelihood ratio; *Lac,* lactate.

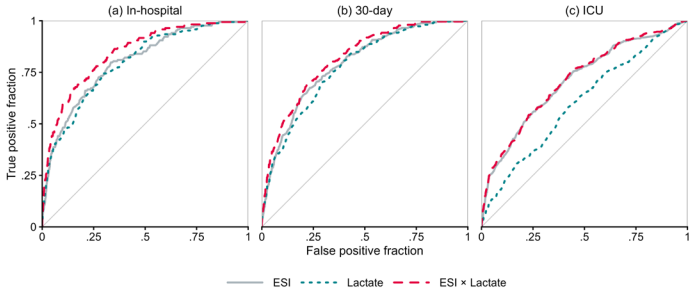


**Figure 3.** Receiver operating characteristic curves comparing age- and sex-adjusted models based on Emergency Severity Index (ESI) alone, lactate alone, and combined ESI–lactate model for (a) in-hospital mortality, (b) 30-day mortality, and (c) intensive care unit admission in admitted adult emergency department patients with lactate measurements obtained after triage at physician discretion. *ESI,* Emergency Severity Index; *ICU*, intensive care unit.

which limits its external validity. Second, the exclusion of discharged patients may have introduced selection bias toward a higher risk population, thereby limiting generalizability. In our cohort, 30-day mortality was 0.3% among discharged patients compared to 5.9% among admitted patients, consistent with previous reports.[35] Third, lactate levels were measured at the treating physician's discretion, potentially introducing selection bias. Patients without lactate measurements (and the small number with missing ESI) had lower rates of in-hospital mortality (1.4% vs 4.3%), 30-day mortality (2.8% vs 6.6%), and ICU admission (9.6% vs 17.9%) compared to included patients (Supplementary Tables S7 and S8), suggesting that less severely ill patients were underrepresented in the final cohort. Fourth, only the first lactate level was analyzed, without considering subsequent changes or lactate clearance, which may be more strongly associated with adverse outcomes than a single value.[36–38] However, the aim was to evaluate the association of lactate during initial evaluation.

Fifth, the influence of potential confounding factors on lactate levels, such as alcohol consumption, liver disease, seizure, and medication, was not investigated and may have affected lactate measurements.[39] Such information may be unavailable or unreliable during triage. Sixth, although lactic acidosis was previously reported to be more strongly associated with in-hospital mortality than hyperlactatemia, we did not differentiate between them to maintain a simple and clinically applicable approach.[40,41] Seventh, details regarding prehospital care were not provided. Nevertheless, patients referred by general practitioners usually receive no prehospital treatment, and those brought in by emergency medical services have short transport times of less than 10 minutes due to the hospital's central urban location. Eighth, the presence of hypotension was not analyzed separately. However, blood pressure is not included in the ESI algorithm version 4 to determine triage levels. In addition, previous studies have shown that the association between lactate levels and adverse outcomes is independent of blood pressure and the presence of shock.[24,42]

Finally, outcomes such as ICU admission may be influenced by factors including advance directives, institutional protocols, and resource availability. In addition, elevated lactate levels may directly influence clinical decision-making and disposition, since high lactate values are often perceived as markers of critical illness and may prompt ICU admission independent of the patient's underlying physiological status. This may introduce confounding by indication and should be considered when interpreting associations between lactate levels and ICU admission.

## CONCLUSION

Among admitted ED patients with lactate measurements obtained after triage at the discretion of the treating physician, higher lactate levels were associated with in-hospital mortality across ESI levels, particularly in patients triaged as ESI levels 2 and 3. Given the single-center design, these findings should be validated in prospective studies across diverse ED settings.

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# Intravenous Ketamine for Depressed and Suicidal Adolescents in the Emergency Department: A Randomized Double-Blind Trial

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**Introduction:** Adolescents frequently seek care in the emergency department (ED) for behavioral health emergencies. Due to national shortages in staffing, limited opportunities to begin treatment on site in most centers and, thus, the frequent default to elusive inpatient psychiatric beds as a means of stabilization, adolescents may spend prolonged amounts of time boarding in the ED, often without treatment. Ketamine is a rapid-acting antidepressant with emerging evidence in adults, but data are limited on its effectiveness in suicidal youth. We aimed to evaluate the effectiveness of a single dose of intravenous (IV) ketamine on depression and suicidality scores compared to placebo in adolescents with treatment-resistant depression presenting to the ED with suicidal ideation.

**Methods:** We conducted a two-arm randomized double-blind placebo controlled trial on a convenience sample of adolescents 12–17 years of age with treatment-resistant depression (trialed at least two antidepressants for at least four weeks each) who presented to the ED with suicidal ideation requiring psychiatric admission. Exclusion criteria included psychosis, substance abuse disorder, intoxication, developmental delay, aggressive behavior, and medical contraindications to ketamine. Subjects were randomized to receive a single dose of ketamine (0.2 mg/kg IV, maximum 35 mg) or saline placebo over two minutes. They completed the Beck Youth Inventory (BYI) and Suicidal Ideation Questionnaire (SIQ) at baseline and at 1 hour, 3 hours, 1 day, 3 days, and 7 days post-treatment. We compared groups with the Fisher exact and two-sided rank-sum tests. Our primary outcome measure was the proportion of subjects with a reduction of ≥ 50% on the BYI and SIQ within 3 hours after treatment.

**Results:** The 29 subjects (14 placebo, 15 ketamine) did not differ significantly in demographic and clinical characteristics. Despite reductions in BYI and SIQ in both groups, the proportions achieving ≥ 50% reductions did not differ significantly at 1 hour (SIQ: placebo, 0% vs ketamine 14.3 % [$P$ = .48]; BYI Anxiety Inventory: placebo, 0% vs ketamine 21.4% [$P$ = .22]; BYI Depression Inventory: placebo, 0% vs ketamine 15.4% [$P$ = .22]). Differences at 3 hours were less pronounced. Adverse effects were more frequent in the ketamine group, most notably signs of dissociation (7% vs 60%, $P$ = .004), with none after the 1-hour observation period.

**Conclusion:** The ED offers an opportunity to deliver rapid-acting antidepressant treatment for suicidal adolescents. Although low-dose ketamine was not associated with greater reductions in depression or suicidality than placebo, this study demonstrated feasibility and highlights the need for larger studies to determine optimal ketamine dosing, route of administration, and implementation strategies in the ED setting. [West J Emerg Med. 2026;27(5)1374–1383.]

## INTRODUCTION

In the United States, an estimated 3.7 million children and adolescents (14.7%) experience depression.[1] Adolescents with depression are more likely to face mental health challenges in adulthood, as well as have poor academic performance, higher risk of unemployment, and increased susceptibility to substance abuse. The severity of illness has been increasing over the past 20 years, leading to suicide being the second leading cause of death in the U.S. among individuals 10–24 years of age.[2] Moreover, about one-fourth of adolescents report having considered committing suicide over the prior year.[3] The national youth mental health crisis was further exacerbated by the COVID-19 pandemic, when adolescents faced school closures, isolation, fear of illness, and decreased access to care.[2]

The emergency department (ED) often serves as a recommended primary destination for patients facing a behavioral health emergency, leading to a significant increase in ED use.[4] Burstein et al reported a doubling of ED visits among youth for suicidal ideation and suicide attempts from 2007–2015.[5] Yard et al compared adolescent ED visits for suicide attempts before the pandemic to after the onset of the pandemic, and described a 31% increase in 2020 compared to 2019, and a 39% increase in 2021 compared to 2019, with a more pronounced increase among females.[6] As EDs continue to receive a growing volume of behavioral health emergencies, there remains a critical need for timely, EDbased interventions for imminently suicidal adolescents. While multiple systemic factors can contribute to prolonged ED length of stay ("boarding"), a central challenge is the limited availability of rapid, targeted treatments for acute suicidality in the emergency setting. Current ED management of suicidal patients focuses on safety assessment, observation, and disposition planning, rather than targeted treatment of suicidal ideation. Because the ED is often the only unavoidable access point for youth, developing effective acute treatments has the potential to reduce symptom severity during the ED stay and improve the care trajectory for these patients.

Unfortunately, severe youth depression is often refractory to current first-line treatments, including psychotherapy and pharmacotherapy with selective serotonin reuptake inhibitors (SSRI). There are only two SSRIs approved by the U,S. Food and Drug Administration for depression in youth, and roughly 40% of adolescents with depression fail to respond to initial treatment.[7] Even among those who respond to medications, onset of antidepressant effect often takes several weeks. Ketamine, a rapid-acting N-methyl-D-aspartate receptor antagonist, has emerged as a promising intervention for rapid reduction of depressive symptoms and suicidal ideation. Ketamine acts by increasing the activity of glutamate, an excitatory neurotransmitter, in the frontal cortex. Ketamine also increases brain-derived neurotrophic factor, which stimulates synaptogenesis.[8] Numerous studies over the past 20 years have demonstrated that ketamine at subdissociative doses has rapid and sustained antidepressant and antisuicidal effects in adults with mood disorders.[9-13]

There have been limited studies on ketamine use for depression in adolescents, but they did find ketamine to be safe and effective for reducing depression and suicidality.[14-23] While there is extensive data on the safety and efficacy of ketamine for procedural sedation and analgesia in adult and pediatric EDs,[24] there is limited research on its use for mental health indications in this setting. Although ketamine 0.2 mg/kg intravenous (IV) reduces symptoms of depression and suicidality in the adult ED setting,[25-28] no data exist on the effectiveness of ketamine for acute depression and suicidal ideation in the pediatric ED setting. Therefore, we sought to evaluate the efficacy and safety of ketamine in adolescents with acute suicidal ideation. We hypothesized that among adolescents with treatment-resistant depression presenting to the ED with suicidal ideation, a significantly greater proportion would have reductions of ≥ 50% on both the Beck Youth Inventory Questionnaire (BYI) and the Suicidal Ideation Questionnaire (SIQ/SIQ Jr)—measures of depression and suicidality, respectively—within three hours after a single subdissociative dose of ketamine 0.2 mg/kg IV than after placebo.

*Population Health Research Capsule*

What do we already know about this issue?
*ED boarding is common for suicidal adolescents with limited treatment; ketamine shows rapid antidepressant effects in adults, but pediatric data are limited.*

What was the research question?
*Does intravenous (IV) ketamine reduce depression and suicidality compared to placebo in suicidal adolescents with treatment resistant depression in the ED?*

What was the major finding of the study?
*A single dose of IV ketamine did not significantly decrease depression or suicidality compared to placebo within 3 hours in depressed adolescents in the ED.*

How does this improve population health?
*The ED offers an opportunity to deliver rapid-acting antidepressant treatment for suicidal adolescents, which could lower the strain on EDs and inpatient psychiatry units.*

## METHODS

### Study Design

We conducted a two-arm, prospective, randomized double-blinded, placebo-controlled trial comparing ketamine to normal saline placebo. The study followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines and was approved by the institutional review board of the University of California, San Diego (UCSD) and Rady Children's Hospital Research.[29] The study was registered under clinicaltrials.gov ID NCT05217706 and was exempt from an investigational new drug application.

### Study Setting and Population

Rady Children's Hospital San Diego, an academic medical center affiliated with UCSD, serves as the region's sole tertiary children's hospital. The 63-bed pediatric ED has approximately 100,000 annual visits, 15% of which are by adolescents and 4% with behavioral health complaints. All patients with behavioral health complaints undergo evaluation by an emergency physician and social worker. They also complete a Patient Health Questionnaire-9 (PHQ-9), which consists of nine items to measure the severity of depression at a given time point. Scores 5-9 indicate mild depression, 10-14 moderate depression, 15-19 moderately severe depression, and ≥ 20 indicates severe depression.

### Subject Enrollment

Adolescents 12–17 years of age were eligible to participate in the study if they presented to the ED with a chief complaint of suicidal ideation or suicide attempt, had treatment-resistant depression, and required inpatient psychiatric care on the basis of involuntary hold or parental voluntary admission. Treatment-resistant depression was defined as having trialed two antidepressant medications for at least four weeks each without improvement.[30] Exclusion criteria included the following: non-English speaking; history of a primary psychotic disorder; current psychotic episode; no parent/guardian to provide consent; a history of substance use disorder in the prior six months; acute intoxication; homicidal ideation or aggressive behavior; current use of medication that could interact with ketamine due to its effect on N-methyl-D-aspartate receptors (lithium, lamotrigine, dextromethorphan, methadone); autism spectrum disorder; developmental delay or intellectual disability; uncontrolled hypertension or hemodynamically significant cardiovascular disease (coronary artery disease, heart failure); pregnancy or breastfeeding; and allergy or prior adverse reaction to ketamine. All subjects continued their current medications throughout the trial.

Eligible patients were identified from the ED electronic tracking board and chart review. Research team members approached eligible patients and their families, explained the study, and obtained written consent from the parent/guardian and assent from the adolescent. If the parent/guardian was not present, he/she could provide verbal consent by phone and written consent electronically. Participants were then randomized to receive placebo or ketamine by the investigational drug pharmacist. The patient, family members, care team, and research team were blinded to group allocation.

### Measures

Depression and suicidality were measured using the BYI and SIQ (or SIQ–Junior, as appropriate). The BYI is a self-report scale to assess symptoms of depression, with five subscales: Depression Inventory; Anxiety Inventory (BAI-Y); Self-Concept Inventory (BSCI-Y); Anger Inventory; and Disruptive Inventory. Total scores range from 0–100 with scores > 69 associated with severe depression.[31] A higher self-concept score is associated with lower risk of depression. The SIQ is a validated self-report measure to assess severity and frequency of suicidal thoughts. It consists of 30 items and is appropriate for students in grades 10–12. Scores range from 0–120, with scores > 41 associated with increased risk of suicide attempt in the following six months. The SIQ–JR consists of 15 items and is designed for students in grades 7–9. Scores range from 0–60, with scores > 31 associated with increased risk of suicide attempt in the following six months.[32]

These measures were selected because they were self-administered and did not require trained mental health professionals for completion. The BYI and SIQ were done at baseline and at 1 hour, 3 hours, 1 day, 3 days, and 7 days after treatment. Our primary outcome was the occurrence of reductions of ≥ 50% in both the BYI and SIQ/SIQ–JR at three hours after treatment. We recorded the occurrence of reductions of ≥ 50% in the scores at all other time points, as consistent with other studies on depression.[21,23] To assess active suicidality, we also included a written yes/no question to the SIQ at all time points. If the subject was in the ED or our inpatient psychiatric facility, the questionnaires were completed in person. If the subject was transferred or discharged, contact was made via telephone by a member of the research team to complete the questionnaire. Participants were compensated with a $20 gift card after study completion.

### Study Procedures

The investigational drug services pharmacy provided either ketamine 0.2 mg/kg (minimum 10 mg, maximum 35 mg) or normal saline in a volume-matched syringe, based upon a predetermined randomization scheme known only to the pharmacy staff. We chose the ketamine dose based on the effectiveness of 0.2 mg/kg in adult ED patients.[25-28] A sedation-credentialed emergency physician ordered the study drug (titled "investigational ketamine or placebo," and a nurse administered the medication over two minutes with a study team member present. The nurse monitored subjects, recording heart rate, respiratory rate, blood pressure and oxyhemoglobin saturation at baseline and at five minutes and

one hour after administration. Adverse events were monitored by the enrolling member of the study team (physician or medical student) and managed by the patient's treating physician. After the one-hour monitoring period, the subjects resumed standard ED and psychiatric care. Standard care in our ED of suicidal patients included close monitoring by a behavioral health assistant outside the room with the patient door open and frequent reassessments by nursing. The patient's nurse and emergency physician verified all home medications. There was also a social worker assessment every 12 hours and consultation with a psychiatrist for patients who were in the ED over 24 hours. Patients did not receive psychotherapy or initiate new psychotropic medications while in the ED.

**Sample Size**

We calculated our sample size based on the precision of the measured effect size; 15 per group would allow us to demonstrate a difference in proportions achieving adequate response (≥ 50% reduction from baseline) of 0.6 between groups (12/15 in ketamine group versus 3/15 in placebo group), with a 95% confidence interval of 0.24–0.78.[21]

**Statistical Analyses**

We summarized demographic characteristics of the study population using descriptive statistics. We conducted subanalyses of response rates and scores on high-severity subsets with baseline SIQ scores > 41 or SIQ–JR scores > 31 and baseline Beck Depression Inventory scores > 29. We omitted from analyses specific time points in which any subjects had missing values. We analyzed data using STATA 18 (StataCorp LLC, College Station, TX) and compared ketamine and placebo groups using the Fisher exact test for categorical data and the Wilcoxon rank-sum test for continuous data.

## RESULTS

During the study enrollment period from March 2022–December 2023, we screened 1,228 patients 12–17 years of age who presented to the ED with any behavioral chief complaint (CONSORT diagram, Figure 1). Of the 74 eligible patients, 16 were not approached due to patient sleeping or inadequate staffing, and 28 declined enrollment. The most common reasons for declining included parental concerns regarding insufficient data on ketamine in adolescents and adolescents' refusal of IV placement. Of the 30 patients enrolled, 15 (50%) were randomized to the control group, and 15 (50%) were randomized to the intervention group. One participant in the placebo group did not meet the definition of treatment-resistant depression and was removed from analysis. Twelve subjects completed all study procedures and all scheduled questionnaires. The remainder had ≥ 1 missing BIY or SIQ score during the 7-day follow-up period after

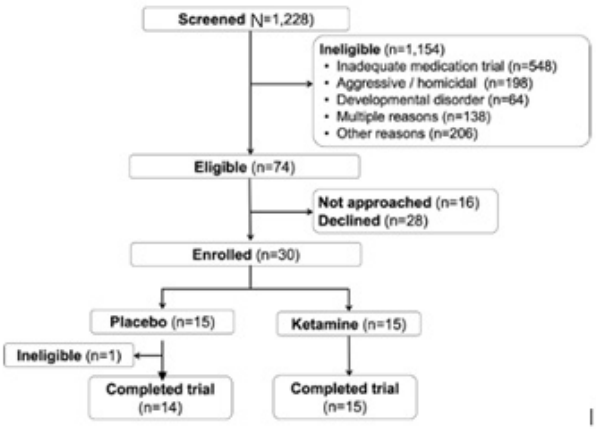


**Figure 1.** Consolidated Standards of Reporting Trials diagram depicting study enrollment for a randomized controlled trial comparing low-dose ketamine to placebo for adolescents presenting to the emergency department with suicidal ideation. This diagram outlines patient screening, enrollment, randomization, allocation, and follow-up.

discharge. Of the enrolled subjects, 21 were transferred to inpatient psychiatric facilities, 6 were admitted to our crisis stabilization unit for 1-2 days, and 2 were discharged from the ED after crisis stabilization. There was no significant difference in disposition between the two groups. Median ED length of stay was two days.

Approximately two-thirds of enrollees were female, and one-fourth identified as non-binary (Table 1). This sex distribution was like that of all suicidal patients in the ED during the study period, which was 66% female. Approximately three-fourths of enrollees were White, and one-third were Hispanic. During the study period, about half of all suicidal patients in the ED were White and one-fourth were Hispanic. While all subjects had treatment-resistant depression, they often had comorbid psychiatric diagnoses, most commonly anxiety (66%). All subjects reported having trialed SSRIs. Subjects who received ketamine were significantly more likely to be currently taking aripiprazole ($P = .03$) and multiple medications ($P = .05$) than controls. There were no significant differences in median PHQ-9 scores, baseline BYI and SIQ scores between groups. Although not statistically significant, subjects who received ketamine were two times more likely to have a severe baseline PHQ-9 score than in the control group. There were no significant differences in medical comorbidities, which included type 1 diabetes mellitus, severe eczema, abnormal uterine bleeding, asthma, celiac disease, and migraines.

There were decreases from baseline in BDI-Y, BAI-Y, and SIQ scores and increases in BSCI-Y scores in both groups (Figures 2 and 3). However, none represented statistically significant differences between groups. Seven subjects of 15 in the ketamine group (47%) and four (29%) of the 14 in the

**Table 1.** Baseline demographic and clinical characteristics of participants randomized to low-dose ketamine or placebo in a randomized controlled trial of adolescents presenting to the emergency department with suicidal ideation.

| | Placebo group (n = 14) | Ketamine group (n = 15) | *P* |
|---|---|---|---|
| Gender Identity, n (%) | | | .13 |
| Female | 8 (57.1) | 10 (66.7) | |
| Transgender male | 1 (7.1) | 0 (0) | |
| Nonbinary | 5 (35.7) | 2 (13.3) | |
| Male | 0 (0) | 3 (20.0) | |
| Age, yr., median (IQR) | 15 (14, 16) | 16 (15, 16) | .36 |
| Ethnicity, Hispanic, n (%) | | | .24 |
| Race, n (%) | 6 (42.9) | 3 (20.0) | 1.00 |
| White | 11 (78.6) | 12 (80.0) | |
| Asian | 1 (7.1) | 2 (13.3) | |
| Mixed | 1 (7.1) | 1 (6.7) | |
| Declined to answer | 1 (7.1) | 0 (0) | |
| Chronic health issues* | 4 (28.6) | 1 (6.7) | .17 |
| Mental health diagnoses, n (%) | | | |
| Anxiety | 10 (71.4) | 9 (60.0) | .70 |
| Other[1] | 4 (28.6) | 9 (60.0) | .14 |
| ADHD | 3 (21.4) | 4 (26.7) | 1.00 |
| Eating disorder | 2 (14.3) | 6 (40.0) | .22 |
| Trial medications, n (%) | | | |
| SSRI | 14 (100) | 15 (100) | .07 |
| SNRI Other | 5 (35.7) | 1 (6.7) | .02 |
| Current medications, n (%) | 1 (7.1) | 8 (53.3) | |
| Aripiprazole | 1 (7.1) | 8 (53.3) | .02 |
| Fluoxetine | 3 (21.4) | 4 (26.7) | 1.00 |
| Escitalopram | 4 (28.6) | 5 (33.3) | 1.00 |
| Multiple | 2 (14.3) | 8 (53.3) | .05 |
| Other | 7 (70.0) | 6 (40.0) | .72 |
| None | 0 (0) | 2 (13.3) | .48 |
| Baseline scores, median (IQR) | | | |
| PHQ-9 | 18 (16-23) | 22 (18-24) | .32.53 |
| SIQ | 120 (75-138) | 129 (88-144) | .71 |
| BSCI-Y | 21.5 (19-25) | 20 (13-30) | .43 |
| BAI-Y | 32 (30-41) | 38 (30-43) | 1.00 |
| BDI-Y | 42 (33-44) | 40.5 (34-52) | .57 |
| Disposition, n (%) | | | |
| Transferred to inpatient psychiatric facility | | | |
| Admitted crisis stabilization unit 1-2 days | 11 (78.6) | 10 (66.7) | |
| Discharged after crisis | 3 (21.4) | 3 (20.0) | |
| Admitted to crisis stabilization unit for 1-2 days | 0 | 2 (13.3) | |

* Placebo patients: 1 with severe eczema; 1 with abnormal uterine bleeding; 1 with asthma, celiac, endometriosis; and 1 with migraines. One ketamine patient had type 1 diabetes.

[1] Other includes post-traumatic stress disorder (placebo group: 2, ketamine group: 3), obsessive-compulsive disorder (placebo group: 0, ketamine group: 2), personality disorder (placebo group: 1, ketamine group: 1), oppositional defiant disorder (placebo group: 1, ketamine group: 1).

*ADHD*, attention-deficit/hyperactivity disorder; *BAI-Y*, Beck Anxiety Inventory; *BDI-Y*, Beck Depression Inventory; *BSCI-Y*, Beck Self-Concept Inventory; *IQR*, interquartile range; *PHQ-9,* Patient Health Questionnaire-9; *SSRI*, selective serotonin reuptake inhibitor; *SNRI*, serotonin-norepinephrine reuptake inhibitor; *SIQ*, Suicidal Ideation Questionnaire; *yr*, years.

placebo group had ≥ 50% reduction in score on at least one follow-up measurement. However, there was no statistically significant difference in the proportions with ≥ 50% reduction in scores (Table 2). The ketamine group included all four patients who experienced score reduction of ≥ 50% within three hours, which occurred in various combinations: 1 SIQ only (1); 1 BDI and BAI (1); BDI, BAI, and BSCI (1); and SIQ, BDI, and BAI (1). Of the seven subjects in the ketamine group with score reductions at any timepoints, four were within 1 hour, 1 within 1 day, and 2 within 3 days; 6 of 7 had

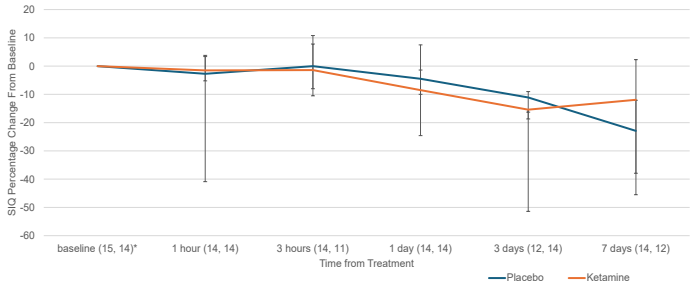


**Figure 2.** Percentage change in Suicidal Ideation Questionnaire (SIQ) scores among adolescents receiving low-dose ketamine vs placebo in the emergency department. The figure depicts mean percentage change from baseline SIQ scores at each assessment point, with error bars representing standard error (n = number of subjects).
*SIQ*, Suicidal Ideation Questionnaire.

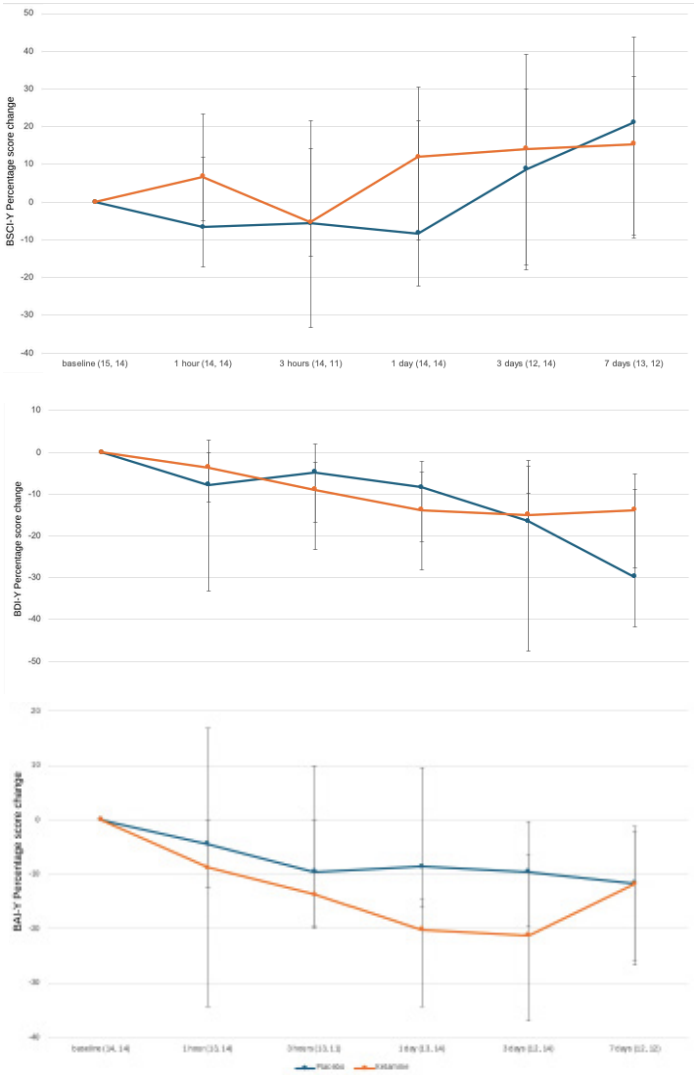


**Figure 3.** Percentage change in Beck Inventory Sub-Scores among adolescents receiving low-dose ketamine vs placebo in the emergency department. The figure depicts mean percentage change from baseline Beck Inventory scores at each assessment point, with error bars representing standard error.
Top: Beck Self-Concept Inventory (BSCI-Y); Middle: Beck Depression Inventory (BDI-Y); Bottom: Beck Anxiety Inventory (BAI-Y).

sustained decrease at 7 days. Of the four subjects with score reductions in the placebo group, three were within 1 day and were sustained for 7 days, and 1 was at 7 days. Presence of active suicidality, elicited from 21 (72.4%) of subjects, did not significantly differ between groups at any time points.

Vital sign changes after administration of treatment differed little between groups, with only a significant difference in heart rate change in the ketamine group at five minutes compared to the placebo group ( $P = .004$) (Table 3). All vital signs were normal at one hour. Self-reported adverse effects were more common in the ketamine group than the control group ($P < .001$) (Table 4). Nine (60%) in the ketamine group reported sensations compatible with ketamine's known dissociative effect and reported feeling "weird" or "out of it" compared to one in the placebo group (7%, $P = .004$). Dizziness occurred in five participants (33%) in the ketamine group compared to none in the placebo group ($P = .03$). One subject in the ketamine group experienced a serious adverse event, consisting of altered mental status and abnormal jerking movements. She was treated with one dose of lorazepam by the clinical care team. There were no vital sign changes during this event, and the team documented a suspected psychogenic non-epileptic event. None of the patients required physical or chemical restraints while in the ED. No self-reported effects persisted beyond the one-hour observation period.

## DISCUSSION

This is the first study, to our knowledge, to examine the use of ketamine for depression and suicidal ideation in adolescents in the pediatric ED setting. There were decreases from baseline in BDI-Y, BAI-Y, and SIQ scores and increases in BSCI-Y scores in both groups (Figures 2 and 3). However, none represented statistically significant differences between groups. Patients who received a placebo also experienced improvement in scores, likely due to support from staff and follow-up psychiatric care.

Most patients did not experience serious adverse effects. The most common adverse effects reported by subjects receiving ketamine were consistent with mild dissociative symptoms. While dissociation may be psychologically distressing, especially if patients are unprepared, it may be important to ketamine's effectiveness for depression. Luckenbaugh et al found that the dissociative effect of ketamine is correlated to its antidepressant properties.[33] This may be due to ketamine's disruption of the "default mode network," a group of structures in the brain that controls one's

**Table 2.** Number of adolescents demonstrating a significant reduction in suicidal ideation after receiving low-dose ketamine vs placebo in the emergency department at various time points.

| | Placebo group | Ketamine group | *P* value |
|---|---|---|---|
| Reduction by > 50% in SIQ | 0/14 (0) | 2/14[1] (14.3) | .48 |
| 1 hour | 0/11[1] (0) | 2/14[1] (14.3) | .49 |
| 3 hours | 1/14 (7.1) | 2/14[2] (14.3) | 1.00 |
| 1 day | 2/14 (14.3) | 3/13[2] (23.1) | .65 |
| 3 days | 2/12[2] (16.7) | 2/14[2] (14.3) | 1.00 |
| 7 days | | | |
| Reduction by > 50% in BAI-Y | 0/14 (0) | 3/14[1] (21.4) | .22 |
| 1 hour | 0/11[1] (0) | 0/14[1] (0) | - |
| 3 hours | 0/14 (0) | 2/14[2] (14.3) | .48 |
| 1 day | 1/14 (7.1) | 0/12[2] (0) | 1.00 |
| 3 days | 1/12[2] (8.3) | 1/13[2,3] (7.7) | 1.00 |
| 7 days | | | |
| Reduction by > 50% in BDI-Y | 0/14 (0) | 2/13[1] (15.4) | .22 |
| 1 hour | 0/11[1] (0) | 0/13[1] (0) | - |
| 3 hours | 2/14 (14.3) | 2/13[2] (15.4) | 1.00 |
| 1 day | 1/14 (7.1) | 3/12[2] (25) | .31 |
| 3 days | 1/12[2] (8.3) | 2/12[2,3] (16.7) | 1.00 |
| 7 days | | | |
| Active suicidality[4] | | | |
| Baseline | 7/12 (63.7) | 5/7 (71.4) | 1.00 |
| 1 hour | 6/12 (50.0) | 2/8 (25.0) | .37 |
| 3 hours | 1/9 (11.1) | 2/7 (28.6) | .55 |
| 1 day | 3/10 (30.0) | 5/8 (62.5) | .34 |
| 3 days | 2/12 (16.7) | 1/6 (16.7) | 1.00 |
| 7 days | 1/12 (8.3) | 1/7 (14.3) | 1.00 |

Data are given as n/N (%).
[1] Data missing for patients who were sleeping
[2] Data missing for patients who were unable to be reached.
[3] One patient completed the Suicidal Ideation Questionnaire but not the Beck Depression Inventory at day 7.
[4] Data collected for 9 ketamine and 12 placebo patients.
*BAI-Y*, Beck Anxiety Inventory; *BDI-Y*, Beck Depression Inventory; *SIQ*, Suicidal Ideation Questionnaire.

sense of self, ego, and repetitive thinking, and plays a role in depression. It is important for clinicians to be aware of this dissociative effect and to reassure patients that it is transient and expected.

Prior studies conducted in inpatient and outpatient psychiatric settings typically reported a dosing protocol with an infusion of 0.5 mg/kg IV given over 40 minutes.[9-13] However, three studies in adult ED settings (two randomized controlled trials [RCT] and one open label) demonstrated that a single dose of ketamine 0.2 mg/kg IV given over 2-5 minutes provided rapid and transient relief of depressive symptoms and suicidality within hours.[25-27] In the RCT by Domany et al, 88% of the ketamine group had resolved suicidal ideation within 90 minutes of infusion.[25] We selected a low dose of ketamine at 0.2 mg/kg IV given over 2 minutes based on these studies and our institutional sedation protocol. Additionally, this dosing regimen was more feasible than a 40-minute infusion in the fast-paced ED setting.

Similar dosing was previously reported in an RCT in adolescents by Zhou et al, although repeated doses of 0.25 mg/kg were able to be used because the study took place in an inpatient setting.[22] An RCT by Dwyer et al comparing 0.5 mg/kg IV ketamine to midazolam,[21] and an open-label study by Cullen et al using 0.5 mg/kg IV ketamine both demonstrated reduction in depression scores in adolescents.[23] While these studies and our study included patients with treatment-resistant depression who had already trialed at least 1–2 antidepressants, Lineham et al examined predictors of ketamine response in adolescents with depression and found that subjects who had fewer medication trials were more likely to respond to ketamine.[34] Further studies are needed to determine the optimal dosing, frequency, and route of ketamine for adolescents, as well as to identify which patients are more likely to respond.

Another important aspect contributing to the effectiveness of ketamine and other psychedelics is the concept of "set and setting." Set refers to the patient's mindset and emotional state prior to treatment, and setting refers to the environment in which treatment occurs.[35] Qualitative studies have found that set and setting were influential to the ketamine experience, and that a safe, calm, supportive environment is vital.[36,37] Patients have reported feelings of awe, connectedness, altered perception of time and space, physical sensations, and ego dissolution. This may be distressing if patients are not properly counseled and prepared. While we did follow a script on counseling patients on expected effects, it is challenging to create a calm environment in an often chaotic ED. Studies on Emergency Psychiatric Assessment, Treatment, and Healing (EmPATH) units have shown that a designated calm, clinical space for patients experiencing behavioral health crisis can decrease boarding times and need for inpatient psychiatric hospitalization.[38-40] Although creating such an environment within a traditionally chaotic ED can be challenging, future studies may evaluate pragmatic strategies such as noise-canceling headphones, music, or eye masks to reduce sensory overload, or assess ketamine administration within EmPATH units to determine whether environmental modification further improve treatment response and patient-centered outcomes.

## LIMITATIONS

The study had several limitations. Our sample size, based on an assumption of 50% reduction in scores, limited our ability to detect smaller differences. Larger trials powered to detect smaller effect sizes may reveal clinically important reductions in measures of depression and suicidal ideation. Because the study was conducted at a single site, a busy urban

**Table 3.** Median vital sign changes among adolescents receiving low-dose ketamine versus placebo in the emergency department.

| | Placebo (median, IQR) | Ketamine (median, IQR) | *P* value |
|---|---|---|---|
| Baseline | | | |
| Heart Rate (bpm) | 78 (72-92) | 76.5 (65-83) | .35 |
| Systolic blood pressure (mm Hg) | 115 (104-123) | 117 (110-126) | .45 |
| Diastolic blood pressure (mm Hg) | 66 (59-74) | 64.5 (58-66) | .25 |
| 5-minute vitals change | | | |
| Heart Rate (bpm) | 5 (-7, 0) | 5 (-1, 8) | .004 |
| Systolic blood pressure (mm Hg) | 0.5 (-10, 6) | 5.5 (1, 11) | .14 |
| Diastolic blood pressure (mm Hg) | 0 (-2, 4.5) | 8 (0, 16) | .09 |
| 1-hour vitals change | | | |
| Heart Rate (bpm) | 5.5 (-3, 7) | 2 (1, 4) | .68 |
| Systolic blood pressure (mm Hg) | -2.5 (-4, 7) | -2 (-5, 4) | .64 |
| Diastolic blood pressure (mm Hg) | 1.5 (-2, 8) | -1 (-7, 6) | .31 |

*bpm*, beats per minute; *IQR*, interquartile range.

children's hospital, our results may not be generalizable to all settings. There were more females than males enrolled, mirroring the gender distribution of suicidal patients seen in our ED. Due to the high volume of the ED, staffing limitations as well as bed availability created occasional challenges with enrollment. Members of the study team recruited patients when available, including during business hours and while on clinical shifts. Patients with behavioral health complaints often presented to the ED at night, and missed enrollments could have led to selection bias. However, many eligible patients remained in the ED and were available for recruitment in the morning. We also omitted scheduled study procedures when enrollees were sleeping during night shifts. Although missing data decreased the study's power to detect differences, we prioritized patient comfort and avoided the confounding that could have resulted from the completion of study instruments by subjects awakened overnight.

We chose the most restrictive definition of treatment-resistant depression (trialed two anti-depressants) based on prior literature, which limited our eligible patients. However, this entry criterion was selected for patients with the highest severity of depression and who needed treatment most. Study instruments were only available in English, which excluded non-English speaking patients. We decided to use self-administered scales to facilitate data collection in the busy ED setting. Use of the SIQ was a major limitation, because it asked how subjects felt over the past 30 days, aiming to capture subjectivity of their sense of the last month rather than capturing how they felt at that moment. Thus, this scale may have been less useful for dynamic changes during the ED stay.

While we used validated instruments, they were not originally designed to capture hour-to-hour changes in mood and suicidal ideation. This may have limited the ability to detect short-term changes during the ED stay, and this should be considered when interpreting the results. Although the study was blinded, due to the self-reported physiologic effects of ketamine, both subjects and clinicians could have suspected which substance the subject had received. Subjects were followed for seven days, and some were lost to follow-up. Responses to BYI and SIQ at any time after the one hour monitored period may have been influenced by external factors other than the study agent, such as psychiatric care and hospital or home environment. Longer studies are needed to determine the duration of the effects of ketamine.

**Table 4.** Self-reported adverse effects among suicidal adolescents receiving low-dose ketamine vs placebo in the emergency department.

| | Placebo | Ketamine | *P* value |
|---|---|---|---|
| Adverse effects, n (%) | | | |
| None | 10 (71.4) | 1 (6.7) | < .001 |
| Dissociation | 1 (7.1) | 9 (60.0) | .004 |
| Drowsiness | 2 (14.3) | 4 (26.7) | .65 |
| Dizziness | 0 (0) | 5 (33.3) | .03 |
| Nausea/Vomiting | 1 (7.1) | 5 (33.3) | .10 |
| Other[1] | 1 (7.1) | 6 (40.0) | .80 |

[1]Other effects include nystagmus, visual hallucinations, headache, and anxiety.

## CONCLUSION

Despite its effectiveness in the treatment of acute depression and suicidality in the adult ED setting, we found no significant differences in depression and suicidality scores between adolescent ED patients receiving a single dose of 0.2 mg/kg IV ketamine and those receiving placebo. Larger studies may reveal a clinically useful effect size and determine an optimal route and dosing for effectiveness of ketamine treatment in adolescents in the ED setting. If future research demonstrates its ability to lessen acute symptoms of adolescent depression and suicidality in the ED setting, ketamine could impact the adolescent mental health crisis by

lowering the strain on EDs and inpatient psychiatry units.

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# From De-escalation to Restraint: A Qualitative Study of Emergency Clinician Decision-Making in Patient Agitation

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**Introduction:** Managing agitation in the emergency department (ED) is challenging and frequently involves decisions about physical restraints and emergent medications. While institutional protocols and behavioral response teams exist, little is known about how individual clinicians make decisions about restraint use—decisions with significant implications for safety, ethics, and equity. The objective of the study was to explore how emergency physicians, residents, and nurses make decisions about physical restraint and emergent medication use during episodes of patient agitation in the ED.

**Methods:** We conducted a qualitative study using semi-structured interviews with 35 emergency clinicians (18 attending physicians, 7 senior residents, and 10 nurses) at an urban academic ED. Interviews were transcribed and analyzed using inductive thematic analysis.

**Results:** Clinicians described three key factors informing restraint decision-making: (1) commitment to patient-centered care through noncoercive de-escalation; (2) real-time assessment of threats to staff and patient safety; and (3) team-based collaboration in both the restraint decision and implementation process. Participants shared a common mental model that prioritized verbal de-escalation before moving to pharmacologic or physical restraint. Clinicians acknowledged that unconscious bias and identity-based dynamics, including age, gender and race, may influence perceptions of threat and decision-making.

**Conclusion:** Emergency clinicians share a consistent framework for managing patient agitation, suggesting potential for a standardized, team-based algorithm. Future interventions should consider clinician and patient identities, aiming to reduce disparities and enhance safety while minimizing restraint use. [West J Emerg Med. 2026;27(5)1384–1392.]

## INTRODUCTION

Acutely agitated patients are common in the emergency department (ED). Studies estimate as many as 1.7 million ED visits in the United States annually involve agitated patients.[1] The American Association for Emergency Psychiatry's Project BETA (Best practices in evaluation and treatment of agitation) emphasizes the importance of noncoercive de-escalation as a preferred response.[2] However, when verbal and behavioral de-escalation techniques are not effective, ED teams may physically restrain and chemically sedate patients to ensure patient and staff safety.

Restraint use in the ED has important consequences and

implications for patients, staff, and health equity. First, restraint use is associated with significant patient morbidity, including physical injury and psychological trauma, and potential mortality.[3–6] Second, emergency physicians (EP) and nurses face high rates of workplace violence, specifically from agitated patients.[7,8] Effective de-escalation techniques and restraint use may reduce the risk of violence experienced by ED staff.[9] Third, recent research has demonstrated that clinicians are more likely to restrain Black and Hispanic patients and men.[10–12] Understanding how clinicians make decisions about restraint use has important implications for addressing workplace violence and health inequities.

Previous research examining restraint use in the ED has largely focused on a systems- and team-level perspective. One qualitative study showed that latent hierarchal structures, power dynamics, and disparate goals of care among team members posed significant challenges to the success of noninvasive de-escalation strategies.[13] However, interprofessional simulation education regarding agitation events in the ED has been shown to improve communication and cooperation among team members, as well as reinforce dual awareness of both patient and staff safety during agitation events.[14–16] Institutions have created behavioral response teams, typically composed of interdisciplinary staff members, who respond to agitation events in the ED. Studies suggest these behavioral response teams increase staff perceptions of safety and decrease restraint use.[15,16] However, few studies have examined restraint use in the ED from individual clinician perspectives.

One qualitative study of Black, Latino, and multiracial emergency clinicians found perceived bias in restraint use, including staff viewing Black patients as more violent and aggressive and using less de-escalation and engagement prior to applying restraints compared to White patients.[17] Our qualitative study examining gender and physician experiences with restraint use decision-making showed that female EPs perceived a lack of respect for their clinical authority; they compensated by building consensus among the team to implement their decision to use restraints.[18] Overall, there is a lack of research at the level of individual emergency clinician decision-making regarding restraint use.

We performed a qualitative study to understand individual emergency clinician perspectives on decision-making about restraint use in an institution that treats acute agitation as a behavioral health code. Understanding clinical decision-making regarding restraint use can provide insights into the individual, team, and systemic factors that inform restraint use and help establish practice standards that minimize restraint use while promoting patient and staff safety.

*Population Health Research Capsule*

What do we already know about this issue?
*Institutional protocols and behavioral response teams can help de-escalation and agitation management in the emergency department.*

What was the research question?
*We explored individual decision-making of clinicians regarding the use of physical restraint and emergent medication use in agitation.*

What was the major finding of the study?
*Clinicians use a shared mental model of prioritizing de-escalation and assessing threats to patient and staff safety in a team-based approach.*

How does this improve population health?
*A standardized, team-based algorithm could help address disparities in restraint use while enhancing patient and staff safety.*

## METHODS

Our qualitative study focused on emergency clinician decision-making regarding physical restraints and emergent medications in the ED. The Institutional Review Board of Baylor College of Medicine provided ethics approval (H-50511). We used a case study-based approach informed by phenomenology, which elicits the meanings that participants attribute to their experiences—in this case decision-making in the ED. We followed Consolidated Criteria for Reporting Qualitative Research (COREQ) standards for qualitative research (see Appendix A).[19]

### Study Setting

The study site was an urban academic ED with an annual visit volume of 80,000 in the Southern United States. The patient population the ED serves has a high level of unmet social needs, with approximately half uninsured and 21% receiving Medicaid.[23,24] Approximately 10% of ED visits are for behavioral health complaints, and the ED has a designated behavioral health patient care area staffed by emergency psychiatrists. Driven by patient outcomes, and regulatory oversight, the institution has increasingly emphasized prioritizing verbal de-escalation and minimizing use of psychoactive medications. In the electronic health record (EHR), orders for violent physical restraints and emergent psychoactive medications must include a justification for use. Restraint use is accompanied by a face-to-face evaluation documented in a note separate from the ED history and physician or nursing notes in the EHR. In 2022, the institution created a crisis intervention team (CIT) composed of an attending EP, emergency psychiatrist, and nursing and security

staff, which responds to behavioral health codes—situations in which a patient is agitated and unable to be verbally de-escalated by bedside staff. This behavioral health code is broadcast hospital-wide, comparable to a rapid response code or a code stroke. There are on average 104 behavioral health codes every month.

New staff, including faculty and nurses, undergo orientation on institutional policies for managing agitated patients. All staff must complete institution-specific online training modules, which emphasize institutional criteria for restraint use and proper documentation. However, staff backgrounds and restraint-use training vary significantly. Residents primarily learn on-shift, whereas attendings bring diverse institutional policies, and nursing staff experience high turnover (30% turnover annually since COVID-19). Consequently, prior work experiences drive a high degree of operational variability despite standardized modules.

### Study Sample and Recruitment

Staff nurses, senior residents received recruitment emails via their listserves, while attending EPs received individualized emails to ensure that those recruited to the study worked in the public safety-net hospital, because the other sites served by the academic ED do not have a similar volume of behavioral health patients. Additionally, as described elsewhere,[18] we sought to have an equal number of women and men respondents to understand how gender might impact experiences regarding application of restraints. Participants received a $50 gift card.

### Data Collection

Led by a senior researcher with qualitative research expertise, the study team developed and pilot tested an interview guide informed by a review of the literature and priorities of the research team (Appendix B). The interview focused on experiences with decision-making regarding ED restraint use, team dynamics, patient factors, and training. Interviews were conducted by video conference; they were digitally recorded and then professionally transcribed.

### Data Analysis

Data analysis was done retrospectively. Using an inductive approach, in which themes emerge from participants' responses rather than an a priori framework, we reviewed initial transcripts and created a preliminary codebook (Appendix C). Subsequently, each interview transcript was coded independently by two to three team members, with discrepancies in coding resolved through consensus discussion. We elucidated themes through consensus discussions. No new themes emerged after six attending EP interviews, four nursing interviews, and four resident physician interviews, indicating thematic saturation and adequate sample size.[22] We used a matrix to compare themes that emerged by professional group (attending versus resident physician versus nurse).

The research team included EPs, a psychiatrist, medical students, and public health professionals. We held consensus discussions and ensured that each transcript was coded by both a clinician and a nonclinician to ensure that our themes reflected participants' responses rather than our own professional experiences.

## RESULTS

### Participant Characteristics

A total of 35 participants completed individual semi-structured interviews. Of those invited to participate, 18 of 41 attendings, 7 of 15 resident physicians, and 10 of 93 nurses completed an interview; the remaining individuals did not respond, Every participant was asked to self-identify their gender, race, and ethnicity. Demographic characteristics are listed in Table 1. Workplace violence was common. Of the total respondents, 67% (12/18) of attendings, 71% (5/7) of senior residents, and 50% (5/10) of nurses had personally been assaulted by a patient in the ED. All 35.participants reported knowing a colleague who had been assaulted.

Three major themes emerged regarding factors influencing individual decision-making on the management of agitated patients: patient-centered strategies for de-escalation; threats to patient and staff safety; and team collaboration (Table 2). Discussion of these factors did not differ by clinical role, although nurses emphasized the threat of workplace violence to themselves and attendings emphasized a feeling of responsibility for the overall team's safety. Nurses, residents, and attendings held a shared mental model regarding emergent restraint and medication use in the ED.

### Patient-Centered Strategies for De-escalation

Participants placed the patient at the center of decision-making and clinical care. Nurses, residents, and attendings emphasized providing care responsive to patient preferences, needs and values, as well as respecting patient's rights consistent with the institutional policies. Participants described wanting to minimize harm to the patient and cited the institutional culture of de-escalation, specifically trying various redirection methods before using restraints.

*First-line choice for management of agitation*

Verbal de-escalation and redirection were widely acknowledged to be the first-line choices for management of agitated patients. Nurses and physicians described identifying patient triggers and offering solutions, such as food, blankets, walking around the ED, or a nicotine patch.

> [I think through], where are the resources available to help with de-escalation? I make sure I know where things are, like food and water and blankets and physical needs, so that I'm not relying on other people in those situations.
>
> - ID 23, attending

**Table 1.** Demographic characteristics of participants in a qualitative study examining emergency clinician decision-making on restraint use.

| Characteristic | Participants (N = 35) |
|---|---|
| Gender (self-identified) | |
| Woman | 17 |
| Man | 18 |
| Nonbinary | 0 |
| Race (self-identified)** | |
| Asian or other Pacific Islander | 6 |
| Black or African-American | 6 |
| Multiracial | 1 |
| White | 20 |
| Other | 2 |
| Ethnicity (self-identified)** | |
| Hispanic | 9 |
| Non-Hispanic | 26 |
| Professional role | |
| Attending physician | 18 |
| Resident physician | 7 |
| Nurse | 10 |
| Average years of practice (range when applicable) | |
| Attending physician | 10 (4-18) |
| Resident physician | 3 |
| Nurse | 9 (1-22) |
| Prior self-reported de-escalation workplace training (n, %) | |
| Attending physician | 8 (44%) |
| Resident physician | 2 (29%) |
| Nurse | 10 (100%) |
| Prior restraint workplace training (n, %) | |
| Attending physician | 15 (83%) |
| Resident physician | 4 (57%) |
| Nurse | 10 (100%) |

**In cases where participants reported their race as Hispanic, we classified their ethnicity as Hispanic and report race as "Other." To avoid identifying participants who were underrepresented in emergency medicine, data are provided in aggregate and not by professional role.

*Unique patient triggers and de-escalation strategies*

Staff also sought to identify triggers and de-escalation strategies specific to each patient.

> I had a patient in the waiting room. He was autistic, and he told me he liked [the rubber bubble popping things]. So I ran to the gift shop, bought one, brought it back, and he was very calm. Once we got him out of the waiting room, then we… gave him a computer and let him watch YouTube.
>
> - ID 16, nurse

**Assessing Threats to Patient and Staff Safety**

Participants' perspectives were informed by high rates of workplace violence and a desire to prevent physical harm to both patients and staff. Participants assessed threats to patient and staff safety in the ED based on (1) patient characteristics and (2) prior de-escalation attempts and behavior.

> I have had colleagues that got straight up punched, and if whatever happens to that person is debilitating, they have to leave their job. That's bad for the rest of the patients around them. I think there is a tendency after those events, at least in the acute phase, to…act, rather than wait and see what happens.
>
> - ID 18, attending

*Patient characteristics are used in threat assessment*

Participants commonly cited size, sex, and age as patient factors that affected their assessment of potential threat. Older patients with dementia were viewed as less threatening but higher risk of causing unintentional harm to themselves and staff. In contrast, participants described hypervigilance around younger, larger patients due to higher risk of violence.

> If the patient is a 5'1", 90-pound person, I feel like we can manage any aggression. With a 6'5", 320-pound person, you get a little nervous for the safety of yourself and safety of your staff. You may be a little bit more aggressive about restraining someone if you think they might get aggressive…. Gender does play a role because men tend to be bigger. There's a lower threshold to sedate someone who's a bigger threat to your patient and your staff.
>
> - ID 1, attending

Participants were asked if they had ever been in situations where it seemed like the race of a patient influenced how the care team made decisions about using restraints, given evidence that clinicians disproportionately apply restraints to patients of color. Responses were mixed. Participants often acknowledged that implicit bias exists but denied seeing this in their own practice.

> I've worked here 18 years, and we're equal opportunity restrainers: if you are aggressive, or if you are threatening the staff, I feel like you should put staff safety first. I don't care what color you are.
>
> - ID 13, nurse

However, other participants highlighted patient's race—specifically Black race—as a key factor influencing their decision-making.

> I think that there is a level of fear especially with males of color. When they arrive and they're loud and aggressive and screaming, there's probably a lower threshold to restrain and medicate those patients because of not only their race, but also their size and gender.
>
> - ID 12, nurse

**Table 2.** Themes, subthemes, and key quotes in a qualitative study examining emergency clinician decision-making on restraint use.

| Category | Subtheme | Key Quotes |
|---|---|---|
| Patient-centeredness | First-line choice for management of agitation | "I go through a whole mental checklist before we actually advance to [restraints and medications]. I ask myself is it appropriate to do [restraints and medications]? Have we tried other methods like trying to talk them down, those kind of things?.... Not every patient requires escalation to physical restraints. Some people will do okay if you just talk to them." - ID 21, attending |
| | Unique patient triggers and de-escalation strategies | "[There was] a patient who just wanted to stand outside his room because he'd been inside the ER for two or three days…. [I would offer] if you want to go walk, we can use the restroom on the other side [of the ED]. We can have security accompany us then just go to the furthest restroom just so you can quote, unquote, get more fresh air." - ID 10, nurse |
| Assessing threats to patient and staff safety | Patient characteristics | Age definitely plays a factor. The medications we give are not benign medications if and when we need them. So, if someone is older and agitated, you're less likely to reach for the Haldol or the Versed. You're more likely to try to physically redirect. And [redirection] does work most of the time. - ID 27, resident |
| | Prior de-escalation attempts and behavior | If it's a patient that [our staff] have a history with, who has injured someone before or basically assaulted staff, and that's why they ended up in restraints, then we're more likely to continue with restraints…because they have already proven their tendency to display violence towards staff." - ID 3, attending |
| Team collaboration | Gathering information | "Like any other resuscitation, a cardiac arrest/code or anything, you want to take everybody's input because they might be seeing things that you're not seeing. And so, I think these type of situations are like psychiatric resuscitation situations." - ID 28, resident |
| | Communicating and building consensus | "[Sometimes]…the patient's not a threat. It's like watching a child who doesn't want to stay still. They don't want to relax. They may be harder to direct, but it doesn't mean that they're a threat to elope. It doesn't mean that they're a threat to somebody's personal safety. I usually try to reiterate that to the care team like, do you feel unsafe? Or is it that you're just tired of telling patients to sit down. And most of the time, they're in agreeance and just deal with it." - ID 11, attending |
| | Coordination of restraint application | "We have a pre huddle, all the key players and the people who are going to be restraining, the nurses, the doctors. We make sure we come up with a with a plan [like] we're doing four-point violent restraints. We all agree on that. We're going to medicate the patient. What medications do we want, [which] nurse is going to go grab the medications. And we delineate roles for how we're going to handle that situation together." - ID 17, nurse |

*ED,* emergency department; *ER,* emergency room.

> I think [clinicians] do tend to get more threatened by Black men. Sometimes…when they talk bigger [it's] perceived as, oh, he's getting violent. So, I think sometimes they're perceived as more of a threat than they actually are.
>
> - ID 15, attending

According to participants, staff from diverse racial and ethnic backgrounds possess specific insights that facilitated the de-escalation of patients with similar backgrounds. The presence of racially diverse staff was cited as a mitigating factor against bias.

> Our staff is all races and genders. We do not have a primarily White staff. The nurses, the security guards, and the technicians reflect the patient population who comes in, and they oftentimes are people who I rely on to help with medical decision-making in these domains [of de-escalation]. I think [the bias] is somewhat attenuated because it actually is a diverse population of employees.
>
> - ID 24, attending

*Prior de-escalation attempts and behavior*

Staff attempted to predict a patient's threat to patient and staff safety based on prior interactions and de-escalation attempts with patients:

> I try to factor in what we know about the patient. Is this someone who just came in and we know nothing about? Or is it someone who we've seen… throughout their time in the emergency department? If they have been able to be verbally de-escalated in the past, I might be more willing to spend the time to verbally de-escalate.
>
> - ID 5, attending

Participants viewed past violent behavior as an important predictor of threats to safety:

> Sometimes patients…have actually made contact with [staff] in some way, whether it was spitting at them or trying to throw something at them…. I'm probably more likely if [the patient] has already been physical with someone to [use sedatives and restraints].
>
> - ID 25, resident

**Team Collaboration**

Interviewees described team dynamics as a crucial part of restraint decision-making. Specifically, participants took a team approach to (1) gathering information, (2) communicating and building consensus, and (3) coordinating restraint application.

*Gathering information*

Most nurses, residents, and attendings felt that the ultimate decision to use restraints was made by physicians (80%, 100%, and 83%, respectively). However, participants described the importance of team communication and consensus in the process of deciding whether to use restraints. Both physicians and nurses cited bedside staff, typically nurses and technicians, as having the most information about a patient and their behavior because of their proximity and time spent with the patient. Additionally, bedside staff were seen as more at risk for being assaulted by a patient, particularly if the decision was made not to use restraints.

> You always have to consider what the person at the bedside is seeing. I don't want to wait until one of my staff gets hit before I intervene. There are certainly times where people out of nowhere go off, but in general, we see people more slowly escalate behavior. When you start to see that and people become less redirectable, that's when you need to intervene.
>
> - ID 28, resident

*Communicating and building consensus*

Physicians described communicating their thought process to ensure everyone on the team had the shared understanding of the situation and next steps.

> Once we've tried verbally de-escalating, bargaining, [and] a show of force, but the patient is still behaving in [an unsafe way] … You verbalize that out loud. Similarly to what you do in other resuscitations or medical treatment, you say, "Look, this is what I'm seeing. I think we basically have to move down this pathway…meaning chemical sedation and physical restraint." Then you see if any staff members have objections or other suggestions.
>
> - ID 29, attending

*Coordination of restraint application*

The actual application of emergent restraints and medications was seen as a medically acute situation requiring close coordination of staff. To avoid physical injury to patient or staff, participants valued clear roles, communication, and coordination of staff members. Practices such as a pre-huddle, assigning specific members to designated limbs for restraints, and closed loop communication in the room were cited as ways of ensuring the staff members could work together quickly and efficiently.

> We do a team huddle…and gather the care team. We decide who's tying restraints, who's holding extremities, who's going to be watching the airway, who's going to grab medications, and who's going to administer medication. It's very much like a code situation for medical patients. Everyone has a role, everyone has a purpose.
>
> - ID 12, nurse

## DISCUSSION

Our qualitative study found that EPs and nurses prioritized patient-centered de-escalation, valued staff and patient safety, and close team coordination. Clinicians considered patient and team factors and institutional culture and policies when deciding when to use restraints. Our findings support prior research demonstrating that training, as well as explicit behavioral response teams, reinforce dual awareness of staff and patient safety and improve team coordination and cooperation.[13–15] These findings have implications for equipping ED staff with a standardized framework to assess and manage patient agitation as well as decreasing race and sex disparities in restraint use.

There is currently no widely adopted algorithm or pathway used by emergency clinicians to systematically assess and manage patient agitation. Wong et al developed a systems-based workplace violence and agitation care framework with five connected levels: patient; staff; team; ED microsystem; and healthcare macrosystem.[25] Our findings support and align with Wong et al's framework, suggesting its applicability across ED settings. However, most institutions rely on a fragmented, institution-specific approach drawing from individual clinician judgment, safety screening tools, clinical pathways, and behavioral response teams.[14–16,26–29] While these localized approaches may reduce restraint use and improve safety, a

standardized and unified clinical pathway could foster a broader shared mental model across emergency medicine practice.

Just as the "Hs and Ts" guide clinicians through reversible etiologies of cardiac arrest, a structured approach to agitation could help ED staff systematically assess threats and tailor responses. Our findings suggest a starting point for such a standardized approach—one that begins with assessing threat to patient and staff, prioritizes noncoercive de-escalation techniques as the first-line response, and emphasizes coordinated team-based action for pharmacologic treatment and restraint use when necessary. Any standardized approach must also account for the role of clinician and patient identities, given evidence that gender and race influence how clinicians navigate leadership and safety decisions during agitation management and that patients gendered as men are more associated with violence.[17,18,30,31]

Our findings also suggest possible mechanisms for the racial and gender disparities surrounding restraint use. First, prior research suggests increased cognitive load may make clinician judgment more susceptible to implicit racial bias.[32] In our study, participants described trying to ensure their colleagues' physical safety while also assessing whether a patient's behavior necessitated restraints. Departmental interventions such as a behavioral response team may decrease the cognitive load for clinicians. Second, staff described assessing threat to patient and staff safety as a key criterion for restraint use. While interviewees felt that patient race did not impact their own decisions, they did acknowledge that bias could impact decisions about restraint use. This suggests interviewees perceived bias in others but not themselves. It is possible that our interviewees were not subject to bias in their patient interactions, that interviewees have implicit bias that they were not aware of, or that interviewees were aware of their own bias but did not want to admit their own culpability. These observations align with psychology research showing that individuals in the United States tend to perceive Black men as threatening,[33] often overestimating their physical dimensions relative to White men of identical stature.[34]

Dedicated education about implicit racial bias and cultural awareness may be helpful. Developing explicit mechanisms to consider bias has been used in the past, such as the implementation of a "bias check" into decision-making in one emergency medicine residency, where ED staff members were asked to deliberately pause and consider whether a patient's identity was contributing to perception of threat.[35] Training staff to explicitly call out racial bias may also be helpful. Third, the use of violence-risk assessment tools may help staff identify patients who may become disruptive. However, many of these risk scores require staff to score factors such as agitation, aggression, and irritability, which are inherently subjective.[28,36,37] In fact, research has found that Black patients are more likely to have behavioral flags placed in their chart than White patients, and that Black patients with behavioral flags experience longer ED waiting times and fewer laboratory tests and imaging orders compared to White patients with behavioral flags.[38,39]

## LIMITATIONS

Our study was conducted in a single site with a high percentage of behavioral health complaints and institutional features, including a behavioral health code and a designated behavioral health patient care area, which may limit generalizability. The research site was a large urban academic ED, which may have different staff and resources than community, rural, or resource-limited EDs. We did not explore specific populations such as pediatric patients or patients with dementia. Furthermore, our study focused on agitated patients; workplace violence studies have shown ED staff experience significant assaults from visitors and families of patients.[40,41] Additionally, our participants had experienced atypically high rates of workplace violence which may have influenced their decision-making and may limit generalizability.[7,42]

Because this was a convenience sample of nurses and physicians who responded to an email invitation, there may have been selection bias in those more interested in this topic, including patient-centered care, equity, safety and threat assessment, and a team-based approach. Additionally, response rates varied substantially across professional groups, particularly among nurses, which may limit the completeness of perspectives captured. As a qualitative study, our findings rely on self-reported clinician perceptions and reflections that are subject to recall bias and social desirability bias, especially when discussing sensitive topics such as race, bias, and restraint use. Lastly, the absence of participant checking (ie, member validation) may limit confirmability of the interpretations.

## CONCLUSION

This study identified that using patient-centered strategies for de-escalation, assessing threats to patient and staff safety, and focusing on team collaboration are important factors informing restraint decision-making in the ED. We also found that staff shared a common mental model prioritizing de-escalation prior to pharmacologic agents or physical restraint. Future work should explore development and implementation of a standardized algorithm, potentially based on the mental model described, to guide responses to patient agitation and clarify mechanisms of racial disparities in restraint use and potential interventions. Future studies should include observation of ED staff behaviors, multicenter validation, and prospective evaluation.

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# Hepatitis C Care Cascade in Opioid-Dependent Emergency Department Patients

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**Introduction:** Emergency departments (ED) have become important venues for hepatitis C (HCV) screening. Similarly, EDs have had increasing engagement in the management and treatment of opioid use disorder (OUD). Persons with OUD are at disproportionate risk for acquiring HCV. We sought to assess the intersection between OUD and HCV care through observing the uptake of HCV screening and subsequent steps in the HCV care cascade in an ED-OUD cohort.

**Methods:** This retrospective cohort study analyzed patients enrolled in an ED-OUD treatment program as a convenience sample subgroup of a larger institutional ED opt-out HCV screening program conducted at a single urban site in Alabama between July 2019–June 2022. Opt-out, nonfocused HCV screening provision was standardized at triage, excluding pregnant and incarcerated individuals. Descriptive analyses were conducted to ascertain screening uptake, positive screening, confirmatory testing, linkage to HCV treatment centers, and initiation of antiviral therapy. Additional patient level demographics considered included sex, race, age, insurance status, and domicile status.

**Results:** Of the approximately 75,000 patients screened annually across the study timeframe, July 2019–June 2022, 359 patients with OUD were enrolled; enrolled participants were more likely to be male (64.9%), white (77.4%), aged 25 to 44 (73.3%), uninsured (80.5%) and housed (80.5%). Only 99 (27.6%) received an HCV antibody (Ab) screening test, 52 (52.5%) of which were positive. Thirty-three patients (63.5%) of the Ab-positive cohort were confirmed HCV viremic or 9.2% of the entire OUD cohort. Three (9.1%) of those with active viremia had documented post-ED HCV-specific care and only one was initiated on direct-acting antiviral therapy. White patients were more likely to be Ab-positive as compared to Black patients (88.5% vs 9.6%); however, Black patients were more likely to have active viremia (15.2%). Antibody-positive females had higher rates of viremia (80.0%) compared to Ab-positive males (53.1%).

**Conclusion:** Screening capture, subsequent RNA-positive linkage to care, and medication initiation rates were suboptimal, revealing opportunities for improvement across the care continuum. Incidence of active HCV viremia in the ED-OUD patient cohort is nine times higher than that in the general population and three times higher than that of the local general ED cohort. [West J Emerg Med. 2026;27(5)1393–1401.]

## INTRODUCTION

Persons with opioid use disorder (OUD) face a significantly elevated risk of contracting hepatitis C virus (HCV) due to various behavioral and systemic factors.[1] Injection drug use (IDU), particularly the sharing of needles and other paraphernalia among individuals with OUD, constitutes the primary mode of HCV transmission via direct blood-to-blood contact.[1] According to the Centers for Disease

Control and Prevention (CDC), IDU accounts for approximately two-thirds of new HCV infections in the United States (U.S.).[2] Furthermore, individuals with OUD are more likely to engage in high-risk behaviors such as unprotected sex, which can further contribute to the transmission of HCV.[3] Moreover, the structural vulnerabilities faced by individuals with OUD, such as limited access to healthcare, socioeconomic disparities, and stigma, can impede their ability to access HCV prevention, testing, and treatment services, often referred to as the hepatitis C Cascade of Care–similar to that of human immunodeficiency virus (HIV) treatment programs.[4,5] Disruptions in this series of interventions leads to a reduction in success of HCV treatment to sustained virologic response.[4]

Although the United States Preventive Services Task Force (USPSTF) recommended HCV screening and treatment in primary care settings, emergency departments (ED) have emerged as critical venues for HCV screening.[6-8] Emergency departments have the potential to reach a diverse and often underserved patient population, making them an essential component of efforts to expand access to testing and linkage to care.[6,7] This shift aligns with the World Health Organization's (WHO) goal of eliminating HCV as a public health threat by 2030, emphasizing the need for widespread screening and treatment initiatives beyond traditional healthcare settings.[9] Research indicates that a substantial proportion of individuals with HCV infection remain undiagnosed, and many of them frequently utilize emergency healthcare services.[10,11] Studies have shown that implementing routine HCV screening programs in EDs can effectively identify undiagnosed cases and link patients to appropriate care and treatment services.[10,12,13] As EDs expand their role in managing OUD by identifying individuals with OUD, initiating medication for OUD (MOUD), and linking patients to treatment, emergency physicians are uniquely positioned to address coexisting health concerns like HCV by engaging patients across the HCV care cascade.[14-16]

The HCV care cascade represents a series of sequential steps essential for effective HCV management: initial screening to identify infected individuals; confirmatory testing with HCV RNA to distinguish active from resolved infections; linkage to specialized care for treatment planning, initiation of direct-acting antiviral therapy; and sustained virologic response achievement indicating cure.[17] Each step presents potential barriers where patients may be lost to follow-up, from initial screening uptake through treatment completion. Emergency departments offer a unique opportunity to engage high-risk populations who may not access routine healthcare, potentially capturing patients early in this cascade and facilitating progression through subsequent care stages.[18] Linkage to a first appointment, however, does not ensure progression through subsequent cascade steps, and understanding attrition rates at each downstream stage is therefore critical for emergency physicians and public health officials seeking to design referral partnerships and supportive services capable of addressing the full continuum of care. For individuals with OUD who face elevated HCV risk due to IDU and often experience fragmented healthcare access, the ED encounter may represent a critical intervention point to initiate or re-engage patients in the HCV care continuum.

Prior studies have identified the ED as an important "crossroads of intersecting epidemics," namely OUD and HCV; however, a recent analysis by Lyons et al focused on this overlap that included ED visits from 2017–2018, noted that ED patients with OUD are underscreened for HCV in this setting.[19,20] The authors of this report concluded that HCV screening in EDs was uncommon among patients with OUD, including individuals who engage in IDU, even in EDs with dedicated screening initiatives. Since this prior analysis, the COVID-19 pandemic has exacerbated the opioid epidemic and the incidence of new HCV infections in the US has continued to rise.[21] Importantly, prior analyses focused primarily on screening uptake rather than the complete HCV care cascade, and none have characterized cascade completion in a non-Medicaid expansion state where structural barriers to treatment are more pronounced. To date, no studies have assessed the rates of completion for each step of the HCV care cascade among patients who are initiated on MOUD in the ED,

*Population Health Research Capsule*

What do we already know about this issue?
*Persons with opioid-use disorder (OUD) carry disproportionate hepatitis C virus (HCV) risk. Emergency departments (ED) are emerging screening venues, yet persons with OUD remain underscreened in these settings.*

What was the research question?
*What is HCV screening uptake and care cascade completion among ED patients enrolled in a medication for OUD program?*

What was the major finding of the study?
*Only 27.6% of OUD patients were HCV-screened; 9.2% had active viremia, approximately nine-fold greater than the general population.*

How does this improve population health?
*Revealing care cascade gaps in high-risk OUD populations informs targeted ED-based interventions to reduce HCV burden, notably in non-Medicaid expansion states.*

particularly in the Southeastern U.S., an often under-resourced geographic area of the U.S. Our goal was to assess the uptake of HCV screening and subsequent HCV Care Cascade among a convenience sample of ED patients with OUD who were enrolled in an ED-based MOUD program. The results of this study can help inform local public health officials into which targeted or wrap-around services may be necessary to end the HCV epidemic by 2030 as proposed by the WHO.[9]

## METHODS

### Study Design and Protocol

This retrospective cohort study is a convenience-sample subgroup analysis drawn from a previously described ED-based MOUD initiation and treatment referral program at a single site in Alabama. The program, which has been extensively described in the literature, enrolled patients presenting to the ED with opioid overdose, withdrawal, or detoxification requests who met Diagnostic and Statistical Manual of Mental Disorders (DSM-5) criteria for moderate-to-severe OUD and received treatment in the ED.[22,23] The current analysis examines HCV screening uptake and care cascade outcomes among patients enrolled in the ED-MOUD program (n = 359) during the study timeframe (July 2019–June 2022), using the ED-based universal opt-out HCV screening program as a parallel data source.[22,23]

### Emergency Department-Medication for Opioid Use Disorder Program

Patients presenting to the ED with a primary complaint of nonfatal opioid overdose, opioid withdrawal, requesting opioid detoxification, or otherwise meeting DSM-5 criteria for moderate-to-severe OUD, were considered eligible for program inclusion, following medical stabilization and clearance. Patients enrolled in the ED-MOUD program, following medical stabilization and clearance, were eligible to begin MOUD (buprenorphine/naloxone) initiation in the ED (for those with Clinical Opiate Withdrawal Scale score > 12) and/or a prescription. They were also subsequently referred for definitive OUD treatment.[23]

### Hepatitis C Virus Screening Program

Parallel to the OUD-focused program, the ED has an HCV screening and linkage program with funding provided by Frontlines of Communities in the United States (FOCUS) Program, Gilead Sciences, Inc. [PI: LAW], which supports HIV, HCV, and HBV screening and linkage to a first appointment. FOCUS partners do not use FOCUS awards for activities beyond linkage to a first appointment. The Department of Emergency Medicine [PI: LAW] is supported by a grant [1H79TI081609] from the Substance Abuse and Mental Health Services Administration (SAMHSA). This protocol has also been previously extensively described[24]; in summary, all ED patients aged 18–75 years without an HCV test result available in the electronic medical record, Cerner Health Records (Cerner, North Kansas City, MO), within the prior 12 months were eligible for HCV testing. The institution's electronic health record (EHR) is not connected to outside hospital systems, and therefore HCV test results from external institutions were not accessible and could not be used to assess eligibility for the screening program. Patients were notified of the nontargeted HCV Ab testing program by nursing staff in triage in an opt-out fashion. It is standard protocol that nursing staff ask patients during triage if they carry a diagnosis of HCV or HIV. The onus is on the patient to request not to be tested, and if not, an order will be placed for HCV and HIV screening. Additionally, those who have a positive HCV testing result in the past year were excluded from the analysis. Those with known diagnosis were then asked if they have been treated, and if so, they were not screened. Patients could decline for any reason (current infection or previously treated, uninformed on their high-risk nature, refusing blood draw, perceived associated stigma with HCV, etc). Testing was performed via a venous blood draw. Hepatitis C virus Ab screening test results were typically available within approximately one hour after venipuncture, and therefore most patients remained in the ED at the time of Ab result. If a blood specimen was not obtained, then this was considered as a missed screening opportunity. Historically, HCV screening at the institution is 20% on average.[13,25]

Patients with positive HCV Ab testing results discussed with their provider regarding the positive results, the possibility of treatment, and the linkage to care plan. Providers confirmed patients' phone numbers (as well as a secondary contact to reach patients) and provided patients packets with written instructions with more information regarding HCV screening, next steps, and further care. Following a positive HCV Ab screening, a confirmatory reflex HCV RNA confirmatory test was sent using the previously obtained blood sample with results available within 1–2 days, on average.[25] Patients were then subsequently contacted by a linkage-to-care coordinator, who calls the patient once the RNA result is available and facilitates the linkage to first appointment with an HCV treating provider, consistent with the scope of the FOCUS program funding. If after seven callback attempts at different times and days, and if there was no evidence of patient linking to care on electronic medical record review, the patient was considered to have failed to link to care. Patients attending their first appointment were considered to be a successful linkage-to-care. Pregnant and incarcerated patients were excluded from this analysis.

The institutional review board approved all study procedures, and funding agencies were not involved in study design, analysis, drafting of the manuscript, or the decision to submit for publication. STROBE (Strengthening the Reporting of Observational studies in Epidemiology) guidelines were used to conduct and compose this review.[26] In line with methodologic standards for medical review, a single author (LW) independently reviewed deidentified, aggregated

patients from Cerner Health Records that met inclusion and exclusion criteria that were pre-established and described above.[27] The single abstractor (LW), was a part of the design of the project, therefore did not require training. Additionally, the reviewer did not require abstraction forms nor monitoring, and they were aware of the hypothesis and study objective. Since only one reviewer was involved, inter-rater reliability was not applicable.[27]

### Study Setting and Population

The University of Alabama at Birmingham Medical Center is an academic tertiary care medical center located in an urban area serving a population of more than 1.1 million people. Alabama is a non-Medicaid expansion state, meaning it has not adopted the Affordable Care Act's provision allowing states to extend the Medicaid eligibility to adults earning up to 138% of the federal poverty line. This leaves a significant portion of the population uninsured (17.5%), nearly twice the rate of Medicaid expansion states, with limited options for healthcare access.[28]

### Data Collection

Research staff enrolled participants in the ED MOUD program, contingent on staff availability (typically from 09:00–00:00, seven days per week). During enrollment, they obtained and recorded demographic data, including race, sex, age, domicile status and insurance status. Domicile status was classified as "currently housed," to include private home, apartment, or trailer, versus "experiencing homelessness" (sheltered or unsheltered). Insurance status was categorized as private insurance, public insurance (Medicaid and/or Medicare), or "self-pay." Same-visit ED HIV and HCV screening uptake and results were also recorded. Electronic health record chart review was conducted to assess documented engagement in HIV or HCV treatment following ED MOUD program enrollment, with the objective of evaluating completion of post-ED follow up. Provider documentation and/or laboratory results (eg, HCV RNA quantitative levels, etc) were considered. At time of ED MOUD program enrollment, research staff also recorded participant self-reported IDU history, categorized as current/active, within the last six months, greater than six months, or never. All study data were collected and managed by research staff using Research Electronic Data Capture (REDCap), a secure, web-based data capture application.[29] The data was defined by a multiclass classification, with well-defined, categorical outcomes (eg, referral, screening, and treatment initiation, age categories, identified race, sex assigned at birth) that minimized potential bias and minimized subjectivity.

### Statistical Analysis

Descriptive statistics were utilized to compare testing uptake and outcomes by patient demographics**.** Data responses that consisted of "don't know," "declined to answer," or missing were excluded from statistical analysis. Data analysis was conducted using International Business Machines (IBM) Statistical Package for the Social Science (SPSS) for Windows, version 27 (IBM Corp., Armonk, N.Y., USA). There was no formal power analysis, as sample size was limited to patients enrolled in the ED MOUD program during the study timeframe. Given the descriptive aims of this secondary analysis, no sensitivity analyses were performed.

## RESULTS

During the study period, approximately 75,000 patients checked into the emergency department annually. Of these, 359 patients were enrolled in the ED MOUD program, and 27.6% (n = 99) received an HCV screening test compared with the average screening rate of 20% among patients without MOUD. Participants were more likely to be male (64.9%), white (77.4%), aged 25 to 44 (73.3%), uninsured (80.5%) and housed (80.5%) (Figure, Table).

While the majority (82.5%) declined to answer, 15.0% (n = 54) of participants reported IDU within six months prior to enrollment, and 9.2% (n = 33) reported active IDU. Screening uptake was low, and substantial attrition occurred at each subsequent step of the HCV care cascade. Among participants with self-reported IDU within six months of enrollment, 71.4% were not tested for HCV. Of the tested IDU subgroup, 64.3% (n = 9) were Ab positive and 28.6% (n = 4) were confirmed HCV viremic. 20.4% (n = 75) of patients were previously aware of HCV diagnosis, and none have preciously sought care. Only 18.2% (n = 6) viremic patients self-reported a previous HCV diagnosis on our questionnaire.

White patients were more likely to be Ab-positive as compared to Black patients (88.5% vs 9.6%); however, Black patients were more likely to have active viremia, representing 15.2% of RNA-positive patients despite comprising only 9.6% of Ab-positive patients. Among Ab-positive patients, females represented 38.5% of those tested, but accounted for a disproportionate amount for RNA positive cases (48.5%), suggesting higher rates of active viremia compared to Ab-positive males (80.0% vs 53.1%). Post-ED HCV-specific care was only found for three patients (9.1%) with active viremia; only one was initiated on direct-acting antiviral therapy (with no documentation of subsequent sustained virologic response).

## DISCUSSION

Screening rates in this OUD cohort were comparable (27.6%) to nontargeted testing uptake in the general ED population at this site during the study timeframe (20% of the total average ED volume).[26] Although this similarity suggests that the opt-out protocol reached patients in the MOUD protocol at similar rates to the general population, it underscores a critical gap that patients with OUD are at a disproportionately higher risk of HCV yet were screened at no greater a rate than the general population. Active HCV viremia was identified in 9.2% of the whole study cohort,

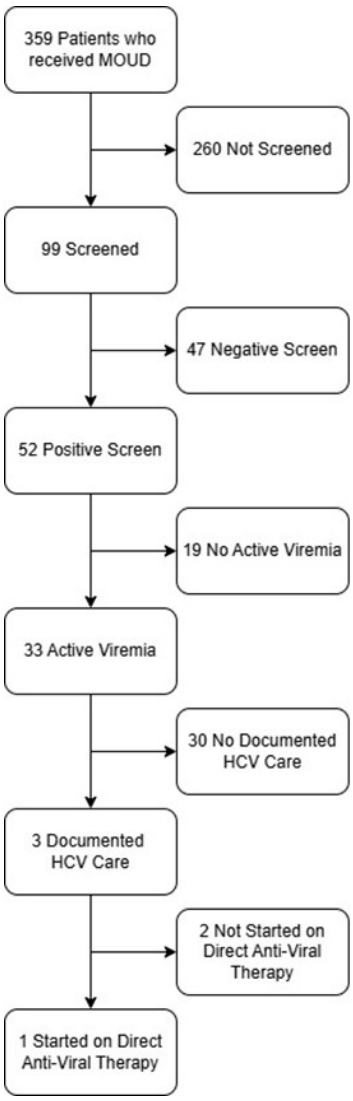


**Figure.** Sampling Flow Diagram.
Summary of patients who received medications for OUD, if they were screened, how many found to be actively viremic, how many were linked to care, and how many were started on direct-acting anti-viral therapy.
*HCV,* hepatitis C virus; *OUD,* opioid-use disorder.

approximately nine times the rate in the general population (1.0%) and three times the positivity rate of the general ED population at this site. Recurrent exposure related to substance misuse and lack of prior available treatment options likely explain this significant difference. Several barriers specific to this population may account for this failure to achieve meaningfully higher screening uptake and subsequent steps of the HCV care cascade, including HCV-related stigma, low perceived utility of testing, and structural treatment barriers.

Hepatitis C virus remains highly stigmatized, and patients who present to the ED may seek to avoid labeling or other potential perceptions when consenting to HCV testing.[30] Prior studies have demonstrated that individual awareness of HCV risk and exposure is often lacking and nearly one-third of individuals with HCV are unaware of their infection status.[31,32] Active substance misuse has previously been demonstrated to be an independent barrier to HCV treatment linkage.[24] In 2019, Jost et al published the results of qualitative interviews of persons who inject drugs (PWID), highlighting a recurrent tendency in this cohort to downplay the risk and possibility of acquiring HCV.[33] Furthermore, for PWID in particular, knowing one's HCV status may have been perceived as providing limited value.[34] Notably, during the study timeframe, Alabama Medicaid sobriety requirements mandated six months of sobriety prior to HCV treatment initiation, a policy not lifted until October 2022, potentially impacting nearly a quarter of this study's viremic cohort.[35] Furthermore, for the infected individuals who are self-pay, nearly 70% in this study, the cost of direct-acting antiviral therapy may make obtaining treatment extremely prohibitive, and limits patients' ability to access treatment.[36,37] Individual ongoing substance misuse and/or one's financial situation may make patients question the personal utility of HCV testing, despite prior demonstrations of cost-effectiveness from a health system and population health perspective.[38]

This study addresses key gaps in the existing literature. Prior analyses of HCV screening in ED-based OUD populations have focused primarily on screening uptake rather than full cascade completion.[19,20] Additionally, to our knowledge, none have characterized cascade outcomes in a non-Medicaid expansion state, where structural barriers to treatment are more pronounced.[28,35] By capturing the complete HCV cascade within this high-risk ED-based OUD cohort, this study provides a more comprehensive picture of cascade attrition in a structurally under-resourced setting.

Among patients diagnosed with HCV in the ED, 81.8% were found to be viremic, demonstrating high capture of new infections. These findings highlight the importance of the ED as a screening venue, particularly for this population, rather than in the outpatient addiction setting. While outpatient addiction medicine clinics represent a natural venue for HCV screening given their OUD-focused patient population, attendance at these clinics following ED referral is inconsistent, with studies of ED-initiated MOUD programs demonstrating that a significant proportion of patients do not follow up, making the ED encounter the most reliable and often only guaranteed point of contact for this population.[39,40] When programs have involved social work and patient care navigators for ED-based screening and treatment for similar infections, such as HIV, viral suppression rates of greater than 50% are achieved, suggesting this model may be transferable to HCV in OUD populations.[41] The ED frequently acts as the initial and main connection point to the healthcare system for individuals with OUD, as they are unable to overcome routine healthcare access limitations.[42,43] To underscore this, nearly one in five in this study were experiencing homelessness at the time of their ED visit.[44]

**Table.** Hepatitis C virus testing uptake and outcomes among emergency department medication for opioid use disorder participants.

| Demographic | All OUD Participants n = 359 n (%) | Tested n = 99 (27.6%) n (%) | HCV Ab+ n = 52 (52.5%) n (%) | HCV RNA+ n = 33 (63.5%) n (%) |
|---|---|---|---|---|
| Sex | | | | |
| Male | 233 (64.9) | 57 (57.6) | 32 (61.5) | 17 (51.5) |
| Female | 126 (35.1) | 42 (42.4) | 20 (38.5) | 16 (48.5) |
| Race ^ | | | | |
| White | 278 (77.4) | 81 (81.8) | 46 (88.5) | 28 (84.8) |
| Black | 65 (18.1) | 15 (15.2) | 5 (9.6) | 5 (15.2) |
| Other | 9 (2.5) | 2 (2.0) | 1 (1.9) | - |
| Age | | | | |
| 18-24 | 31 (8.6) | 10 (10.1) | 2 (3.8) | 1 (3.0) |
| 25-34 | 112 (31.2) | 33 (33.3) | 16 (30.8) | 10 (30.3) |
| 35-44 | 151 (42.1) | 41 (41.4) | 27 (51.9) | 17 (51.5) |
| 45-54 | 42 (11.7) | 8 (8.1) | 5 (9.6) | 3 (9.1) |
| 55-64 | 18 (5.0) | 6 (6.1) | 2 (3.8) | 2 (6.1) |
| 65-74 | 5 (1.4) | 1 (1.0) | - | - |
| Insurance * | | | | |
| Public | 54 (15.0) | 15 (15.2) | 8 (15.4) | 8 (24.2) |
| Private | 31 (8.6) | 9 (9.1) | 1 (19.2) | 1 (3.0) |
| Self-Pay | 263 (73.3) | 70 (70.7) | 41 (78.8) | 23 (69.7) |
| Domicile Status | | | | |
| Undomiciled | 69 (19.2) | 21 (21.2) | 14 (26.9) | 10 (30.3) |
| Housed | 289 (80.5) | 78 (78.8) | 38 (73.1) | 23 (69.7) |

Summary of patients who received medication for opioid use disorder in the emergency department from June 2019–June 2022, analyzed by sex, race, age, insurance status, domicile status.
*11 missing data, ^7 missing data
*Ab+,* positive antibody; *ED,* emergency department; *HCV,* hepatitis C virus; *MOUD,* medications for opioid use disorder; *OUD,* opioid use disorder; *RNA,* ribonucleic acid.

Current ED support staff such as peer navigators, who often assist with the referral to OUD treatment centers, could naturally expand their scope to include HCV education and testing encouragement prior to discharge.[45] Studies looking at post-overdose care services in the ED suggest that structured follow-up interventions improve subsequent treatment engagement, supporting the need for similarly structured HCV screening protocols within MOUD programs.[39,40] Deferring HCV screening to a clinic appointment risks losing a critical intervention opportunity in the patients who may never arrive.

Addressing these barriers in the HCV care cascade requires both system-level and patient-level interventions supported by emerging evidence in ED-OUD populations. Patients in this cohort may present to the ED with complaints that do not typically require venous blood sample as a part of their workup, making HCV screening orders less likely to be prioritized. Incorporation of an HCV fingerstick test in the future may increase testing uptake, as patients who might decline screening via venipuncture may be more willing to undergo a fingerstick blood draw based on patient preferences.[46] Additionally, despite a turnaround time of one hour, a point-of-care test will likely further increase medical professionals recommending this screening test is performed before discharge. This less-invasive, single-step method has been shown to be practical in primary care settings outside the U.S.[47] If made available in the U.S., this method may improve testing uptake in this cohort in the general ED setting. Concurrently, providing healthcare staff with education and training on the importance of HCV testing, stressing its high prevalence among individuals with OUD, and strategies for offering and encouraging testing in a nonjudgmental manner represents a key complementary intervention.[48,49]

Future studies should evaluate whether the implementation of point-of-care HCV testing within ED workflows, which would provide rapid result availability and reduced procedural burden, can meaningfully improve

screening uptake and HCV care cascade completion in this population. Additional studies considering broader, patient-targeted campaigns to reduce the perceived stigma associated with both OUD and HCV infection may help promote a supportive and non-discriminatory healthcare environment resulting in fewer patient opt-outs.[50]

Beyond screening and care cascade gaps, the present study also identified disparities in HCV outcomes across demographic subgroups that warrant attention. Although interpretation is fairly limited by small subgroups, the racial disparity correlates with prior observational studies which note Black patients are less likely than White patients to be prescribed treatment for HCV.[51] This might also reflect the recent demographic shift in the opioid epidemic which is increasingly impacting Black patients.[52] It may be that this subgroup has not had the same chronologic exposure to HCV testing or treatment referral follow-up.[52] Women have also been shown to be less likely to receive HCV treatment which this study reiterates.[53,54] These disparities underscore the important role the ED could play, as a critical intervention point for Black patients and women with OUD, given their reduced likelihood of accessing HCV care through traditional healthcare pathways. Equity-informed approaches to ED-based screening and linkage are warranted.

## LIMITATIONS

This analysis was limited to a single site and therefore, results may not be generalizable to all sites. The cohort included OUD participants enrolled in an ED-initiated treatment program and therefore excluded many patients with OUD who presented for other reasons other than overdose, withdrawal, or detoxification, introducing the potential for selection bias. However, this patient population likely represents a moderate-to-severe OUD subset of people who may inject drugs. Furthermore, since this was a retrospective observational study, the presence of other substance use disorders or high-risk behaviors beyond those captured in the medical record cannot be excluded as potential confounders. Patients with a positive HCV result in the institution's lab within the past 12 months were automatically excluded from the screening. Additionally, there is a limitation in the ability of the EHR to see HCV testing results performed at outside institutions. The modest sample size limits broader interpretation, however, it is itself reflective of the study's central finding: poor completion rates across the HCV care cascade. Future studies with larger cohorts are needed to confirm these findings. Missing data was limited to race and insurance status, which can limit generalizability, but this was secondary demographic data and does not take away from the underlying message behind the care cascade.

## CONCLUSION

Active HCV viremia was identified at rates approximately nine times that of the general population in this ED-based OUD cohort; yet, screening uptake was poor, and completion of the HCV care cascade was correspondingly low, with only three RNA-positive patients linked to care, and only one initiated direct-acting antiviral therapy. These findings highlight the gap in the HCV care cascade in this high-risk population and underscore the need for targeted interventions to improve steps of the HCV care cascade particularly in non-Medicaid expanded states. Future studies evaluating point-of-care HCV testing and peer navigator-facilitated advocacy within ED-based MOUD programs could determine if these targeted interventions can improve cascade completion in this high-risk population.

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# Changing Risk Factors in Patients Diagnosed with Human Immunodeficiency Virus

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**Introduction:** Since 2019, transmission risk factors among patients diagnosed with HIV have changed, although the trends and reasons behind them have not been fully elucidated. The objective of this study was to assess changes in HIV transmission risk factors among patients newly diagnosed with HIV to inform future targeted HIV testing programs.

**Methods:** This study site is New England's largest essential hospital and a major reporter of new HIV cases in Massachusetts. We performed a retrospective chart review of patients diagnosed with HIV infection at our medical center between January 2019 and December 2023. Demographic and clinical variables were collected and analyzed using descriptive and comparative statistics to evaluate trends in primary risk factor for HIV. Our primary outcome measure was incident HIV diagnosis with a primary risk factor of injection drug use (IDU), men who have sex with men (MSM), or heterosexual contact. A secondary outcome examined was CD4 count at the time of diagnosis.

**Results:** A total of 246 patients were newly diagnosed with HIV. Of these, 59% ($n$ = 146) reported heterosexual contact as their most likely cause of transmission, 19% ($n$ = 47) MSM, 19% IDU ($n$ = 46), and 3% ($n$ = 7) reported both MSM and IDU. Heterosexual contact increased as the predominant HIV transmission factor from 53% (24/45) in 2019 to 79% (37/47) in 2023 (risk difference, 25%; 95% CI, 6.7%-44.1%), and the percentage of diagnoses made in non-US-born patients increased from 60% (27/45) in 2019 to 83% (39/47) in 2023 (risk difference, 23%; 95% CI, 5.1%-41%). Non-US born patients had significantly lower CD4 counts at diagnosis (mean [SD] CD4 count 299 [241] cells/μL) compared to US-born counterparts (mean [SD] CD4 count 498 [309] cells/μL, $P < .001$), with a mean difference of -199 cells/μL (95% CI, -272 to -125).

**Conclusion:** The dominant risk factor for HIV transmission has changed from injection drug use/men who have sex with men to heterosexual contact in New England's largest city. Our findings associate increased HIV incidence in non-US-born immigrants at an urban essential hospital, highlighting the importance of considering this group in targeted public health efforts to avoid missing cases of HIV in similar settings. [West J Emerg Med. 2026;27(5)1402–1410.]

## INTRODUCTION

Since the onset of the HIV epidemic in the early 1980s, an estimated 91.4 million people have been infected with the virus.[1] Although the incidence of HIV in the United States had decreased by nearly 76% from 1984 to 2022,[2,3] a comprehensive understanding of the factors underlying current

HIV transmission remain unknown. The US Centers for Disease Control and Prevention (CDC) HIV Surveillance Reports stratify transmission rates nationally based on factors such as age, gender, race/ethnicity, and transmission category (including men who have sex with men [MSM] and injection drug use [IDU]); however, they do not report on HIV incidence by an individual's country of origin.[3] While these data are often difficult to obtain, it is crucial to gain a broader understanding of how HIV transmission in the United States may be associated with migration from various countries or regions of origin. It is already known that HIV transmission risk factors in non-US-born individuals differ in proportion compared to US-born counterparts. Non-US-born individuals have higher rates of reporting heterosexual contact as their primary transmission risk factor, with lower rates of MSM and IDU.[4,5] We do not know, however, whether there are temporal associations in trends between overall primary HIV transmission risk factor, foreign-born status, and disease severity within the US.

In February 2019, the US Department of Health and Human Services (HHS) published their plan, "Ending the HIV Epidemic: A Plan for America," to end the HIV epidemic by the year 2030.[6] In that plan, Suffolk County, MA, was identified as one of 48 "high burden counties" in which HHS efforts would be prioritized. Our institution, located within Suffolk County, accounts for 27% of all new HIV diagnoses in Massachusetts.[7] The objective of the current study was to assess risk factors for new HIV diagnoses among patients at an urban essential hospital in Boston, MA, as well as to elucidate trends and associations between risk factors and demographic variables including country of origin, disease severity, and comorbid diagnoses.

*Population Health Research Capsule*

What do we already know about this issue?
*HIV transmission patterns have changed over time, but evolving trends in recent years remain insufficiently described.*

What was the research question?
*How have transmission risk factors and demographics changed for incident HIV diagnoses from 2019 to 2023?*

What was the major finding of the study?
*Heterosexual transmission rose 53% to 79% (RD 25%; 95% CI, 6.7–44%; P < .05); non-US-born cases rose 60% to 83% (RD 23%; 95% CI, 5.1–41%; P < .05).*

How does this improve population health?
*Findings identify rising risk in non-US-born groups to guide targeted, culturally appropriate HIV testing and earlier diagnosis.*

## METHODS

### Setting

Our institution is a 514-bed tertiary academic medical center in Suffolk County, MA. It is New England's largest essential hospital and diagnoses more new HIV cases per year than any other institution in the state (personal communication; Johns B. Director, Division of STD Prevention and HIV Surveillance, Massachusetts Department of Public Health [MDPH], October 2, 2020). As such, this study site is uniquely poised to identify regional trends in HIV risk factors.

### Study Design and Data Collection

This study was deemed exempt by the institutional review board (IRB). It is a retrospective chart review that adheres to previously published methodological guidelines for retrospective medical record reviews.[8] Specific methods used include abstractor training, case selection criteria, variable definitions, performance monitored, medical record identified, sampling method, missing-data management plan, and IRB approval. It is a retrospective review of all patients diagnosed with incident HIV infection at our institution between January 1, 2019, and December 8, 2023. Tests are done at the request of the patient or based on physician discretion, and verbal consent is required prior to testing. Patients with a confirmed HIV diagnosis were identified via a report generated by our institution's clinical laboratory, and manual chart abstraction from both the electronic health record and the Integrated Testing and Linkage Report (created at time of HIV appointment intake) was performed for patient demographic and clinical information. We excluded from the study individuals younger than 18 years or newly diagnosed with HIV .

Demographic variables collected include age, sex, race, ethnicity, country of origin, and housing status; all variables except age were self-reported. We categorized non-US-born individuals into one of five global regions of their origin (Africa, Caribbean, Asia, Latin America, Europe) and included those born in US dependencies as non-US-born. Clinical variables of interest include the primary cause of HIV infection (IDU, MSM, heterosexual intercourse), CD4 count at the time of diagnosis (cells/µL), if available, and presence/absence at time of diagnosis of the following: syphilis; hepatitis C virus; tuberculosis; pregnancy; and psychiatric diagnoses. Patients with no CD4 count recorded at the time of diagnosis were excluded from summary statistics. Reporting of risk factors for HIV infection is required by the state for

offering government-funded HIV services. For individuals with more than one risk factor for HIV infection, the most likely primary cause of HIV infection was adjudicated by data collectors according to the MDPH algorithm, which follows the CDC hierarchical ranking method.[9] We used REDCap electronic data capture tools (hosted at CTSI 1UL1TR001430) and Excel for data collection and management.[10]

**Patient and Public Involvement**

Patients or members of the public were not involved in the design, conduct, reporting, or dissemination of our research.

**Data Analysis**

We used descriptive statistics to report the demographic and clinical characteristics of patients newly diagnosed with HIV at an urban essential hospital between January 2019 and December 2023. The Cochran-Armitage trend test was used to determine the trend of new patient HIV diagnoses per year, an ordinal variable, over a five-year time frame for each of the dichotomous demographic and clinical characteristics. Due to the small sample sizes, it was decided to conduct the statistical tests on the yearly HIV patient numbers rather than the monthly numbers. We performed chi-square tests (categorical) and two independent sample *t*-tests (continuous) to evaluate associations between the likely primary risk factor for infection and clinical characteristics of patients. Alternative nonparametric tests, including the Fisher exact test (categorical), were used when assumptions for using parametric tests were not met. Additionally, we used analysis of variance when the demographic variable (continuous) was being compared between more than two groups. To correct for multiple testing issues, the *P* values obtained from hypothesis tests were Bonferroni adjusted by the number of statistical tests performed. We analyzed data with SAS software version 9.4 (SAS Institute Inc, Cary, NC).

**RESULTS**

Between January 1, 2019, and December 8, 2023, a total of 103,759 HIV tests were administered across our institution. Of the 103,759 tests performed, 246 patients (0.24%) were identified as newly diagnosed with HIV and included in this study. Of the 7,371 tests performed in the emergency department (ED), 63 (0.85%) were identified as newly diagnosed with HIV. The frequency of new HIV diagnoses made at our institution in yearly intervals is summarized in Figure 1. Demographic and clinical characteristics of those newly diagnosed with HIV by year of diagnosis are summarized in Table 1.

The median age of the 246 patients included was 37 years (interquartile range 30-39), with 62.2% identifying as male, 63% identifying as Black, 17.9% identifying as White, 17.9% identifying as Hispanic or Latinx, and 17.9% identifying as "other" race or declining to identify their race. Other than the United States ($n$ = 94), the most represented countries of origin include Haiti ($n$ = 62), the Dominican Republic ($n$ = 12), and Cape Verde ($n$ = 9). Patients born in Haiti made up 40% of non-US-born diagnoses and 25% of all new HIV diagnoses at our institution within the study period. Of all included patients, 42% ($n$ = 103), were non-English speakers, in contrast to our institution's overall patient population, of whom 30% speak a primary language other than English.

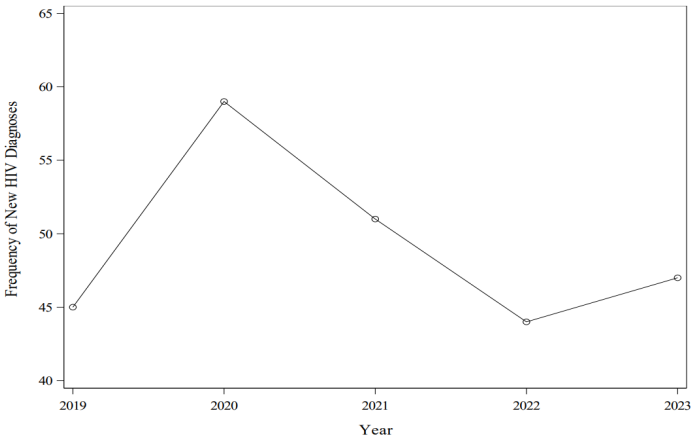


**Figure 1.** Time series plot showing frequency of new HIV diagnoses between January 1, 2019–December 8, 2023 at an urban essential hospital, by year, in a study assessing changes in transmission risk factors among patients newly diagnosed with the virus.

From the Cochran-Armitage trend tests of the study population demographics in Table 1, we observed statistically significant trends in the proportions of language ($P$ = .002), country region ($P$ = .01), risk factors ($P$ = .006), and psychiatric comorbidities ($P$ = .009) across the study years (2019–2023). We observed increasing linear trends in HIV diagnoses among unstably housed patients, non-English speakers, patients from the Caribbean, and those likely infected through heterosexual contact during the five-year study period (all $P$ values < .05). Conversely, we observed decreasing linear trends in HIV diagnoses among White patients and patients from the US, as well as those with psychiatric comorbidities, hepatitis C, and patients whose HIV transmission was likely from MSM, IDU, and MSM/IDU (all $P$ values < .05). No statistically significant linear trends were observed over the study period for age, gender, ethnicity, diagnosing department, CD4 count, or presence or absence of syphilis, tuberculosis, and pregnancy at the time of diagnosis.

Table 2 presents the clinical characteristics of the total patient sample and by the most likely cause of their HIV infection. Statistically significant associations were found between primary HIV risk factor, CD4 counts ($P$ < .001), psychiatric comorbidities ($P$ < .001), hepatitis C ($P$ < .001), and syphilis ($P$ < .001). Supplemental Table 2 indicates that

**Table 1**. Longitudinal trends in demographic and clinical characteristics of newly diagnosed HIV patients at an urban essential emergency department overall and by year of diagnosis 2019–2023 (*N* = 246).

| Characteristics | Total Sample *N* = 246 | Diagnosed 2019 *n* = 45 | Diagnosed 2020 *n* = 59 | Diagnosed 2021 *n* = 51 | Diagnosed 2022 *n* = 44 | Diagnosed 2023 *n* = 47 | *P* value |
|---|---|---|---|---|---|---|---|
| Age | | | | | | | |
| Mean (SD) | 40.02 (12.72) | 39.07 (12.77) | 38.51 (12.15) | 41.65 (13.91) | 42 (13.19) | 39.19 (11.63) | |
| Median (IQR) | 37 (30 - 49) | 37 (30 - 49) | 35 (29 - 47) | 40 (30 - 51) | 38.5 (32.5 - 50.5) | 38 (30 - 45) | >.999 |
| Min, Max | 18, 75 | 21, 68 | 21, 69 | 18, 74 | 21, 75 | 20, 69 | |
| Gender, *n* (%) | | | | | | | |
| Male | 153 (62.20) | 34 (75.56) | 37 (62.71) | 32 (62.75) | 27 (61.36) | 23 (48.94) | |
| Female | 90 (36.58) | 11 (24.44) | 22 (37.29) | 17 (33.33) | 16 (36.36) | 24 (51.06) | >.999 |
| Transgender male | 1 (0.41) | 0 (0.00) | 0 (0.00) | 1 (1.96) | 0 (0.00) | 0 (0.00) | |
| Transgender female | 2 (0.81) | 0 (0.00) | 0 (0.00) | 1 (1.96) | 1 (2.27) | 0 (0.00) | |
| Race, *n* (%) | | | | | | | |
| White | 44 (17.89) | 7 (15.56) | 20 (33.9) | 8 (15.69) | 6 (13.64) | 3 (6.38) | |
| Black | 155 (63.01) | 30 (66.67) | 26 (44.07) | 37 (72.55) | 29 (65.91) | 33 (70.21) | |
| Asian | 2 (0.81) | 0 (0.00) | 2 (3.39) | 0 (0.00) | 0 (0.00) | 0 (0.00) | .197 |
| Native Hawaiian or Other Pacific Islander | 1 (0.41) | 1 (2.22) | 0 (0.00) | 0 (0.00) | 0 (0.00) | 0 (0.00) | |
| Other | 44 (17.89) | 7 (15.56) | 11 (18.64) | 6 (11.76) | 9 (20.45) | 11 (23.40) | |
| Ethnicity, *n* (%) | | | | | | | |
| Not Hispanic or Latinx | 202 (82.11) | 37 (82.22) | 51 (86.44) | 44 (86.27) | 34 (77.27) | 36 (76.6) | >.999 |
| Hispanic or Latinx | 44 (17.89) | 8 (17.78) | 8 (13.56) | 7 (13.73) | 10 (22.73) | 11 (23.4) | |
| Language, *n* (%) | | | | | | | |
| English speaker | 143 (58.13) | 30 (66.67) | 46 (77.97) | 33 (64.71) | 19 (43.18) | 15 (31.91) | .002 |
| Non-English speaker | 103 (41.87) | 15 (33.33) | 13 (22.03) | 18 (35.29) | 25 (56.82) | 32 (68.09) | |
| Housing Status, *n* (%) | | | | | | | |
| Stable | 171 (69.51) | 35 (77.78) | 29 (49.15) | 41 (80.39) | 30 (68.18) | 36 (76.6) | |
| Not stable | 63 (25.61) | 8 (17.78) | 27 (45.76) | 6 (11.76) | 12 (27.27) | 10 (21.28) | .062 |
| Unknown | 12 (4.88) | 2 (4.44) | 3 (5.08) | 4 (7.84) | 2 (4.55) | 1 (2.13) | |
| Country Region, *n* (%) | | | | | | | |
| Asia | 2 (0.81) | 0 (0.00) | 2 (3.39) | 0 (0.00) | 0 (0.00) | 0 (0.00) | |
| Africa | 42 (17.07) | 11 (24.44) | 10 (16.95) | 8 (15.69) | 6 (13.64) | 7 (14.89) | |
| Caribbean | 83 (33.74) | 11 (24.44) | 11 (18.64) | 15 (29.41) | 21 (47.73) | 25 (53.19) | .012 |
| Latin America | 25 (10.16) | 5 (11.11) | 3 (5.08) | 4 (7.84) | 6 (13.64) | 7 (14.89) | |
| United States | 94 (38.21) | 18 (40.00) | 33 (55.93) | 24 (47.06) | 11 (25.00) | 8 (17.02) | |
| Diagnosing Department, *n* (%) | | | | | | | |
| ED | 63 (25.61) | 13 (28.89) | 14 (23.73) | 10 (19.61) | 10 (22.73) | 16 (34.04) | >.999 |
| Non-ED | 183 (74.39) | 32 (71.11) | 45 (76.27) | 41 (80.39) | 34 (77.27) | 31 (65.96) | |

patients infected with HIV primarily due to heterosexual contact or MSM have a significantly lower CD4 count at the time of diagnosis compared to those reporting IDU (mean difference = -318 cells/μL; 95% CI, -483 to -197; and mean difference = -227 cells/μL; 95% CI, -376 to -79), respectively).

With respect to other demographic characteristics, the mean CD4 count at the time of diagnosis was significantly higher among non-US-born patients compared to US-born patients (mean difference, 199 cells/μL; 95% CI, 125-272). Similarly, patients diagnosed outside the ED had significantly higher CD4 counts at diagnosis than those diagnosed in the ED (mean difference, 145 cells/μL; 95% CI, 59-230), as shown in Table 3.

**Table 1**. Continued

| Characteristics | Total Sample *N* = 246 | Diagnosed 2019 *n* = 45 | Diagnosed 2020 *n* = 59 | Diagnosed 2021 *n* = 51 | Diagnosed 2022 *n* = 44 | Diagnosed 2023 *n* = 47 | *P* value |
|---|---|---|---|---|---|---|---|
| **Clinical Characteristics** | | | | | | | |
| Most likely cause of HIV transmission, *n* (%) | | | | | | | |
| Heterosexual contact | 146 (59.35) | 24 (53.33) | 26 (44.07) | 29 (56.86) | 30 (68.18) | 37 (78.72) | .006 |
| MSM | 47 (19.11) | 14 (31.11) | 8 (13.56) | 13 (25.49) | 6 (13.64) | 6 (12.77) | |
| IDU | 46 (18.70) | 4 (8.89) | 22 (37.29) | 9 (17.65) | 7 (15.91) | 4 (8.51) | |
| MSM/IDU | 7 (2.84) | 3 (6.67) | 3 (5.08) | 0 (0.0) | 1 (2.27) | 0 (0.0) | |
| † CD4 count at time of diagnosis (cells/μL) | | | | | | | |
| Patients with available CD4 count (*n*) | 222 (90.24) | 39 (86.67) | 54 (91.53) | 46 (90.20) | 38 (86.36) | 45 (95.74) | >.999 |
| Mean (SD) | 374.51 (285.33) | 345.97 (260.64) | 405.76 (302.53) | 422.83 (293.86) | 354.97 (253.55) | 328.84 (301.31) | |
| Median (IQR) | 329.5 (152 - 539) | 306 (109 - 506) | 345 (205 - 600) | 391.5 (171 - 558) | 296 (122 - 573) | 262 (70 - 444) | |
| Min, Max | 6, 1496 | 7, 1065 | 8, 1496 | 30, 1248 | 6, 855 | 7, 1199 | |
| Not tested (*n*) | 24 | 6 | 5 | 5 | 6 | 2 | |
| Psychiatric comorbidities, *n* (%) | | | | | | | |
| Yes | 110 (44.72) | 24 (53.33) | 36 (61.02) | 22 (43.14) | 14 (31.82) | 14 (29.79) | .009 |
| No | 136 (55.28) | 21 (46.67) | 23 (38.98) | 29 (56.86) | 30 (68.18) | 33 (70.21) | |
| Hepatitis C, *n* (%) | | | | | | | |
| Yes | 55 (22.36) | 8 (17.78) | 25 (42.37) | 11 (21.57) | 8 (18.18) | 3 (6.38) | .099 |
| No | 191 (77.64) | 37 (82.22) | 34 (57.63) | 40 (78.43) | 36 (81.82) | 44 (93.62) | |
| Syphilis, *n* (%) | | | | | | | |
| Yes | 45 (18.29) | 12 (26.67) | 7 (11.86) | 10 (19.61) | 10 (22.73) | 6 (12.77) | >.999 |
| No | 201 (81.71) | 33 (73.33) | 52 (88.14) | 41 (80.39) | 34 (77.27) | 41 (87.23) | |
| Tuberculosis, *n* (%) | | | | | | | |
| Yes | 27 (10.98) | 5 (11.11) | 5 (8.47) | 6 (11.76) | 4 (9.09) | 7 (14.89) | >.999 |
| No | 219 (89.02) | 40 (88.89) | 54 (91.53) | 45 (88.24) | 40 (90.91) | 40 (85.11) | |
| Pregnant at time of diagnosis, *n* (%) | | | | | | | |
| Yes | 10 (4.07) | 1 (2.22) | 2 (3.39) | 2 (3.92) | 2 (4.55) | 3 (6.38) | >.999 |
| No | 236 (95.93) | 44 (97.78) | 57 (96.61) | 49 (96.08) | 42 (95.45) | 44 (93.62) | |

Fisher exact test performed for gender, race, housing status, country region, and transmission mode. Cochran-Armitage trend test performed for ethnicity, language, diagnosing department, psychiatric comorbidities, hepatitis C, syphilis, tuberculosis, and pregnancy at time of diagnosis. *P*-values were Bonferroni-adjusted for multiple comparisons of 15 outcomes.
†Patients with no CD4 count test were excluded from summary statistics (missing CD4 count =24)
*ED,* emergency department; *IDU*, injection drug use; *IQR,* interquartile range; *MSM,* men who have sex with men; *SD,* standard deviation.

## DISCUSSION

This study is a retrospective chart review of 246 patients with incident HIV infection from January 2019 to December 2023. Ultimately, we found that over the five-year study period, heterosexual contact increased in prominence as the predominant HIV transmission risk factor. Consequently, we noted that IDU as a primary transmission risk factor has been decreasing since 2020, as have hepatitis C codiagnoses, psychiatric comorbidities, and unstable housing status. These variables may be linked, as patients seen at our institution who inject drugs are often unstably housed, have co-occurring alcohol, substance, or opioid use disorders, and have existing hepatitis C diagnoses from IDU. It is also worth noting that CD4 count at the time of diagnosis was significantly associated with both primary transmission risk factor and housing status, with IDU and those who are unstably housed showing higher CD4 counts than average. These associations suggest that patients with IDU or unstable housing may be

**Table 2.** Clinical characteristics of newly diagnosed patients at an urban essential hospital by primary risk factor.

| Clinical Characteristics | Total Sample *N* = 246 | Heterosexual Contact *n* = 146 | MSM *n* = 47 | IDU *n* = 46 | MSM/IDU *n* = 7 | *P* value |
|---|---|---|---|---|---|---|
| † CD4 count at time of diagnosis (cells/μL) | | | | | | |
| Patients with available CD4 count (*n*) | 222 (90.24) | 131 (89.73) | 42 (89.36) | 42 (91.30) | 7 (100) | < .001 |
| Mean (SD) | 374.51 (285.33) | 285.91 (232.23) | 376.19 (234.70) | 603.55 (339.58) | 648.29 (199.19) | |
| Median (IQR) | 329.5 (152 - 539) | 245 (91 - 416) | 396.5 (226 - 502) | 579 (304 - 855) | 613 (574 – 639) | |
| Min, Max | 6, 1496 | 6, 1199 | 7, 1053 | 45, 1496 | 413, 1065 | |
| Not tested (*n*) | 24 | 15 | 5 | 4 | 0 | |
| Psychiatric comorbidities *n* (%) | | | | | | < .001 |
| Yes | 110 (44.72) | 35 (23.97) | 23 (48.94) | 45 (97.83) | 7 (100) | |
| No | 136 (55.28) | 111 (76.03) | 24 (54.06) | 1 (2.17) | 0 (0.0) | |
| Hepatitis C *n* (%) | | | | | | < .001 |
| Yes | 55 (22.36) | 3 (2.05) | 2 (4.26) | 45 (97.83) | 5 (71.43) | |
| No | 191 (77.64) | 143 (97.95) | 45 (95.74) | 1 (2.17) | 2 (28.57) | |
| Syphilis *n* (%) | | | | | | < .001 |
| Yes | 45 (18.29) | 17 (11.64) | 24 (51.06) | 3 (6.52) | 1 (14.29) | |
| No | 201 (81.71) | 129 (88.36) | 23 (48.94) | 43 (93.48) | 6 (85.71) | |
| Tuberculosis *n* (%) | | | | | | > .99 |
| Yes | 27 (10.98) | 19 (13.01) | 3 (6.38) | 5 (10.87) | 0 (0.0) | |
| No | 219 (89.02) | 127 (86.99) | 44 (93.62) | 41 (89.13) | 7 (100) | |

*P* values were Bonferroni-adjusted for multiple comparisons of five outcomes. Chi-square (categorical) and one way ANOVA (continuous) were performed.
†Patients with no CD4 count test were excluded from summary statistics (missing CD4 count, 24)
*IDU,* injection drug use; *IQR,* interquartile range; *MSM,* men who have sex with men; *MSM/IDU,* men who have sex with men and injection drug use; *SD,* standard deviation.

diagnosed with HIV closer to the time of infection than other high-risk groups, which may be due to greater use of the ED among patients with these risk factors; however, further studies are needed to understand the reasons for these associations.

It is striking that although only 7.1% of HIV tests at our institution were performed in the ED, 25.6% of the diagnoses of the virus were made in the ED, and the CD4 counts of individuals diagnosed in the ED were significantly lower than those diagnosed elsewhere in the institution. A high prevalence of HIV in ED patients is consistent with prior literature, and a major reason why multiple guidelines across the US have, since 2006, recommend ED HIV screening as a major component of ending the HIV epidemic.[11-13]

As seen in Figure 3, non-US-born individuals now make up 75% and 83% of new HIV infections diagnosed in 2022 and 2023, respectively, which is a statistically significant trend by year. We found that there has also been a statistically significant association between language and year, with non-English speakers now making up most new HIV cases, which may be associated with the increase in diagnoses among non-US-born patients. While foreign-born status is not a transmission risk factor for HIV, it is an illuminating piece of context that can inform future HIV prevention efforts.

When comparing our results to trends reported by the MDPH Bureau of Infectious Disease and Laboratory Sciences from 2019 to 2021, we find that our data align by foreign-born status, but not gender, race, or risk factor.[14] The MDPH reports a lower incidence among women, Black non-Hispanic individuals, and people reporting heterosexual transmission than we found at our institution. This trend may be in part due to the fact that our institution is considered an essential hospital—meaning we provide care to a high volume of uninsured and vulnerable patients, regardless of their ability to pay or immigration status. Previous studies have demonstrated that heterosexual contact as an HIV transmission risk factor is higher in non-US-born individuals than their US-born counterparts, as well as higher transmission among women, which may account for the trends present at our institution.[4,5]

The CDC's National HIV Surveillance System (NHSS)

**Table 3.** Pairwise comparisons of the secondary outcome CD4 cell count at time of diagnosis by demographic characteristics in a study assessing changes in transmission risk factors among patients newly diagnosed with HIV.

| Pairwise Comparisons of Demographic Characteristics | Difference between mean CD4 cell count (cells/μL) | Adjusted 95% confidence interval for difference between two mean CD4 cell counts (cells/μL) | *P* value* |
|---|---|---|---|
| Country of origin | | | |
| Non-US-born – US-born Patients | 198.8 | (125.4, 272.2) | .001 |
| Diagnosing department | | | |
| Non-ED patient – ED patient | 144.5 | (59.0, 230.0) | .005 |
| Housing status | | | |
| Not stable – Stable | 164.0 | (61.3, 266.8) | .003 |
| Not stable – Unknown | 200.8 | (-51.3, 452.8) | > .99 |
| Stable – Unknown | 36.7 | (-205.5, 279.0) | > .99 |

**P* values were Bonferroni-adjusted for multiple pairwise comparisons (five comparisons).
*ED,* emergency department.

reports demographic characteristics and transmission risk category from data collected by local health jurisdictions.[3] When examining the most recent of these reports, which includes HIV incidence among individuals 13 years of age and above from 2018 to 2022, we found both similarities and differences compared to our results. The NHSS reports a significant 12% decrease in male diagnoses from 2018 to 2022, compared to our finding, which was not statistically significant; and that male diagnoses decreased by 27% from 2019 to 2023 ( $P$ =.107). The NHSS did not find a significant increase in female diagnoses, and used sex assigned at birth rather than current gender identity. The NHSS also found a significant 10% decrease in HIV incidence for those reporting MSM as their only transmission risk factor between 2018 and 2022, with no change detected for those reporting IDU or heterosexual contact. The NHSS does not report HIV incidence by US- versus non-US-born status. These similarities and differences may be due to our limited sample size or the patient population specific to our institution. However, it is possible that while the trends demonstrated here regarding transmission among non-US-born individuals may be a national trend, they cannot be compared to nationally reported data because these variables are not collected.

It is important to note that this study is particularly relevant to other urban HIV epicenters where there has been a recent immigration boom, including Denver, CO, Chicago, IL, and New York City, NY. These states had a 540% increase, 540% increase, and 1020% increase, respectively, in US Customs and Border Protection encounters from 2021 to 2023,.[15] Thus, further research investigating HIV transmission risk factors should be conducted in other priority jurisdictions outlined by the Ending HIV Epidemic Initiative, and leaders of public health interventions should consider focusing their efforts on these areas.

The increase in HIV incidence among non-US born individuals has occurred against the backdrop of limited opportunities for HIV detection, treatment and prevention upon arrival in the US. Prior to 2010, HIV testing was mandatory for immigrants at the time of entry to the US as part of their immigration examination. Criticisms of the ban soon mounted, with opponents noting that HIV is not transmissible via casual contact and that at the time, the US had more known cases of HIV than any other country. The removal of the ban in effect in early 2010 had far-reaching positive effects ranging from decreasing the stigma faced by those with HIV to allowing for their safer travel, since they no longer had to fear being deported if medications were found during the immigration process. However, lifting mandatory HIV entrance testing removed a critical touchpoint for new migrants to receive testing and linkage to care.[16]

While it is difficult to quantify the impact of no longer mandating HIV entrance testing, HIV incidence in the US decreased by 10.3% in the four years following the policy change, which may reflect lower rates of detection among immigrants arriving to the US.[17] Furthermore, recently arrived immigrants may face ongoing socioeconomic barriers to healthcare access that may preclude earlier entry to HIV care along the route of migration as well as in the US.[18] When examining existing barriers to testing among immigrants, studies suggest that many immigrants express fear that testing positive for HIV will result in deportation, with some citing the former HIV travel ban as a key contributor to their hesitancy to test.[19]

Non-US-born patients had significantly lower CD4 counts at the time of diagnosis compared to their US-born counterparts. This trend may be associated with a delay between HIV infection and testing for non-US-born patients, potentially due to the lengthy establishment of care upon arrival to the US. However, several studies suggest that many non-US-born

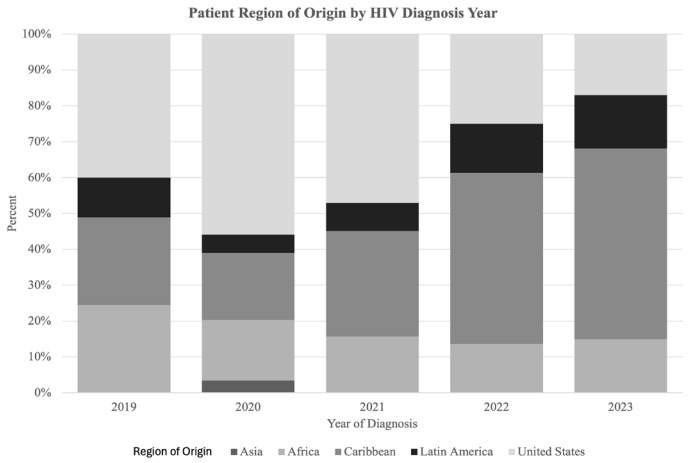


**Figure 2.** Region of origin of patients diagnosed with HIV by diagnosing year in a study on the changing trends in risk factors among patients diagnosed with the virus. Those born in US dependencies are not categorized as US-born, but rather as their geographic location. There was a 21% increase in non-US-born patients newly diagnosed with HIV between 2019 and 2022 ($P$ = .01).

individuals acquire HIV after immigrating to the US.[20,21] As suggested by Harawa et al, it is difficult to accurately characterize the time at which immigrants are infected, as many travel back and forth between their country of origin and the US. Among foreign-born Black men, lack of familiarity with the US healthcare system, low risk perception, and a lack of testing services advertised in their native language may contribute to their decreased likelihood of receiving HIV screening.[22]

## LIMITATIONS

This study was performed at a single-site urban essential hospital and, therefore, results may not be generalizable to other institutions or geographic areas. Additionally, data collection was done through a retrospective chart review. Not all variables, particularly co-occurring diagnoses and housing status, were available for each patient, especially those who had recently immigrated and had not established care in the US prior to HIV diagnosis. Many of these patients were also not tested for the co-occurring diagnoses of interest at the time of HIV screening. Unfortunately, we lack data regarding where non-ED diagnoses were made in our institution, which may affect the proportions of transmission risk factors and other variables presented here. Due to our small sample size, the presence of psychiatric comorbidities was documented as a broad category rather than individual diagnoses, sinces we would be less likely to draw any associations. Furthermore, we do not know whether the psychiatric comorbidities documented in each patient's chart were active diagnoses at the time of HIV testing and diagnosis.

With the exception of MSM co-occurring with IDU, only one primary risk factor for HIV infection was documented per patient and was determined according to an algorithm outlined by the MDPH for HIV data collection. However, transmission risk factors are not mutually exclusive. Furthermore, risk factors are self-reported and, thus, may also be affected by one's country of origin, as lingering stigmas against MSM and IDU from their home country and the U.S. may influence their willingness to disclose either as their primary risk factor. Moreover, data were not consistently available about the country of origin of our institution's overall patient population, making conclusions about the proportionality of HIV infection by country of origin difficult to ascertain. Finally, there is no universal opt-out HIV screening program at our institution. Patients are tested at their request or based on physician discretion, which requires verbal consent prior to testing; thus, there may be patients at this institution who had incident HIV during the study period and were not included in the current analyses.

## CONCLUSION

Our study may suggest that incident HIV diagnoses among non-US-born immigrants reporting heterosexual contact have become a primary HIV transmission demographic, which has not been fully explored before. Our findings suggest that targeted public health efforts be directed at non-US-born immigrants, particularly those from Latin America and the Caribbean. Increased testing among these groups is a must; however, we must be careful not to stigmatize them further. Therefore, culturally and linguistically relevant immigration education, testing, and linkage-to-care outreach efforts should be prioritized.

One final point of advocacy is for universal opt-out HIV testing. The CDC currently recommends routine opt-out HIV screening, as it mitigates stigma associated with testing, facilitates earlier diagnosis in overlooked groups, and ultimately decreases chances of transmission.[23] However, each state has its own laws governing HIV testing; in Massachusetts, separate verbal informed consent is required prior to initiating HIV testing. Language barriers and stigma may, therefore, have a greater impact on testing acceptance in Massachusetts than in other states.[24] Should universal HIV opt-out testing become available across healthcare settings, stigma about HIV testing and transmission of HIV among the high-risk populations outlined in this paper may be greatly reduced. Future research should be aimed at investigating these emerging trends in HIV risk factors across multiple study sites and geographic locations.

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# Emergency Department Evaluation and Care of Hepatic Encephalopathy: ACEP Expert Panel Recommendations

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**Introduction:** Patients with hepatic encephalopathy frequently visit the emergency department, and these visits are expected to rise in the coming years due to an increased prevalence of liver disease in the United States. Accordingly, we sought to define a comprehensive and efficient approach for emergency physicians to evaluate, treat, and determine the optimal disposition of patients presenting with possible or confirmed hepatic encephalopathy and its complications.

**Methods:** We reached consensus recommendations through a structured literature review and a modified Delphi technique, informing an expert panel of academic and community emergency physicians convened by the American College of Emergency Physicians.

**Results:** We created the assess, look, treat, evaluate risk, reassess, disposition (ALTERD) framework as a digital point-of-care tool to support clinicians in guiding key bedside steps involved in the diagnosis and care of patients across the spectrum of hepatic encephalopathy.

**Conclusion:** A collaborative expert panel process can create an emergency department-focused, easily accessible, and comprehensive digital tool to complement workflows and improve the care of a vulnerable and growing patient population. [West J Emerg Med. 2026;27(5)1411–1419.]

## INTRODUCTION

Chronic liver disease affects approximately 2.6% of the population in the United States (U.S.), with prevalence expected to rise.[1,2] Metabolic dysfunction-associated steatotic liver disease increased from 20.0% (1988-1994) to 31.9% (2013-2016).[3] While recent breakthroughs in hepatitis C treatment have been introduced, the ongoing opioid crisis associated with injection drug use has allowed it to remain a leading cause of liver disease in the U.S., with over 67,000 new cases in 2022.[4] Physicians are increasingly likely to encounter patients with chronic liver disease. This trend underscores the need for effective screening tools to prompt further evaluation, such as the serum-based fibrosis-4 (FIB-4) index.[5] Hepatic encephalopathy (HE) is a severe cirrhosis complication affecting approximately 202,000 U.S. adults, with high recurrence risk, frequent readmissions, and poor survival.[6,7] Hepatic encephalopathy is characterized predominantly by alterations in personality, consciousness,

cognition, and motor function. Its manifestation may not be clinically obvious, and multiple detection tools contribute to variation in reported incidence and prevalence.[8] Impaired hepatic ammonia metabolism and portal hypertension shunt ammonia-rich portal blood into the systemic circulation, where it crosses the blood-brain barrier and is converted to glutamine, causing cerebral dysfunction.[9]

Given the current and anticipated burden of liver disease in the U.S., efforts should be focused on more effective identification and treatment in key settings, such as the emergency department (ED). Overt HE occurs in 30-40% of cirrhosis patients during their clinical course.[10] Hepatic encephalopathy is broadly classified as either minimal or covert (ie, with normal mental status and neurologic exam but with psychometric testing abnormalities detected on tests such as the Psychometric Hepatic Encephalopathy Score, which is out of scope for most ED visits) or overt (ie, with neurologic and neuropsychiatric abnormalities).[11,12] The West Haven criteria (WHC) for the diagnosis of HE is found in the American College of Emergency Physicians (ACEP) HE point-of-care tool, which grades HE from subtle cognitive impairment to coma (Table 1).[13] Minimal HE or covert HE occurs in 20%-80% of patients with cirrhosis.[14,15] Overt episodes of HE are debilitating, can occur without warning, render the patient incapable of self-care, and frequently result in hospitalization. The likelihood of developing HE correlates with the severity of liver disease.[10]

*Population Health Research Capsule*

What do we already know about this issue?
*Hepatic encephalopathy is a common, high-risk emergency department (ED) presentation, but diagnosis and management vary, and ED-specific guidance has been limited.*

What was the research question?
*How should ED clinicians evaluate, treat, and determine disposition for hepatic encephalopathy?*

What was the major finding of the study?
*An expert panel developed the ALTERD bedside framework for ED hepatic encephalopathy care.*

How does this improve population health?
*A standardized ED tool supports earlier recognition, consistent care, appropriate disposition, and improved transitions for patients with hepatic encephalopathy.*

**Table 1.** The West Haven Criteria differentiate hepatic encephalopathy from subtle cognitive impairment to coma.[13]

| Type of HE | Grade | Description |
|---|---|---|
| Covert | Minimal | No clinical evidence of mental changes<br>Psychometric or neuropsychological testing may detect abnormalities |
| | 1 | Altered sleep rhythm<br>Euphoria or anxiety<br>Impairment of addition or subtraction<br>Shortened attention span<br>Trivial lack of awareness |
| Overt | 2 | Asterixis<br>Disorientation for time<br>Dyspraxia<br>Inappropriate behavior<br>Lethargy or apathy<br>Obvious personality change |
| | 3 | Bizarre behavior<br>Confused<br>Gross disorientation<br>Responsive to stimuli<br>Somnolence to semistupor |
| | 4 | Coma |

*HE*, hepatic encephalopathy.

Distinguishing HE from other conditions in the ED setting can be challenging, leading to underdiagnosis. Common differential diagnoses include medication adverse effects, electrolyte disorders (hypoglycemia, hyponatremia, hypercalcemia), uremia, sepsis, central nervous system infection, nonconvulsive epilepsy, psychiatric disorders, alcohol intoxication or withdrawal, hypercapnia, and intracranial bleeding or stroke.[16] Undertreatment contributes to recurrence, despite evidence demonstrating that the rifaximin with or without lactulose regimen is cost-effective approximately 99% of the time for preventing recurrence.[17,18] Given HE's increasing prevalence and challenging clinical presentations, we developed a consensus-based bedside decision tool to help emergency physicians assess and manage patients with suspected or confirmed HE within typical ED workflows.

## METHODS

### Study Design and Setting

Between July and December 2021, the ACEP convened an expert panel on HE. We conducted a structured literature review, serving as a rapid evidence assessment that balanced the rigor of a systematic review with a more focused scope to guide and support the panel's recommendations. We searched PubMed and included English-language sources

with full text available using the keywords "hepatic encephalopathy." Panel chairs reviewed abstracts with an emphasis on recency (eg, within five years), relevance to ED clinical care, journal impact factor, study design, and specialty society affiliations and guidelines. Additionally, they reviewed the references of highly relevant papers to identify and include foundational sources most closely related to the topic. The panel chairs circulated final full-length selections among the entire group for subsequent inclusion as supporting evidence for the proposed tool content. We employed a modified Delphi technique to achieve consensus via virtual panel meetings.[19] Panel chairs assigned major sections to pairs of panelists, who drafted proposed content based on the literature review. In four rounds of subsequent voting across the entire panel, including comments with suggested edits, the content was iterated until a majority consensus of over 50% was reached.

### Selection of Participants

The panel consisted of a multidisciplinary group of clinicians from diverse geographical areas and practice settings. The ACEP staff selected the co-chairs (ABJ and SCT), who then selected the panelists. Selection criteria included direct clinical experience in evaluating and managing the target patient population in the ED setting, and the final panel consisted of three academic emergency physicians, two community emergency physicians, one ED pharmacist, one hepatologist, one case manager, and one hospitalist. Though an unrestricted educational grant from Salix Pharmaceuticals to ACEP offset project management expenses, including honorariums, there was no industry involvement in designing, developing, or editing the work product.

### Interventions

We conducted four rounds of structured voting; for each round, the chairs presented the initial voting results and facilitated extensive discussion during virtual meetings. The fourth round involved one additional survey of panelist comments and votes. The chairs modified the recommendations based on the discussion and voting from the previous rounds. The final panel recommendations represent consensus and majority opinions. This project relied on publicly available sources and was framed as a quality improvement project exempt from our institutional review board's oversight.

## RESULTS

We developed the acronym ALTERD to communicate the six main steps for diagnosing ED patients with confirmed or suspected HE: assess, look, treat, evaluate risk, reassess, disposition. In Figure 1, we show the tool's menu page, which features each of these steps along with supporting evidence and acknowledgments. Clicking each one reveals additional detail in bullet-point format, facilitating rapid referencing and usability.

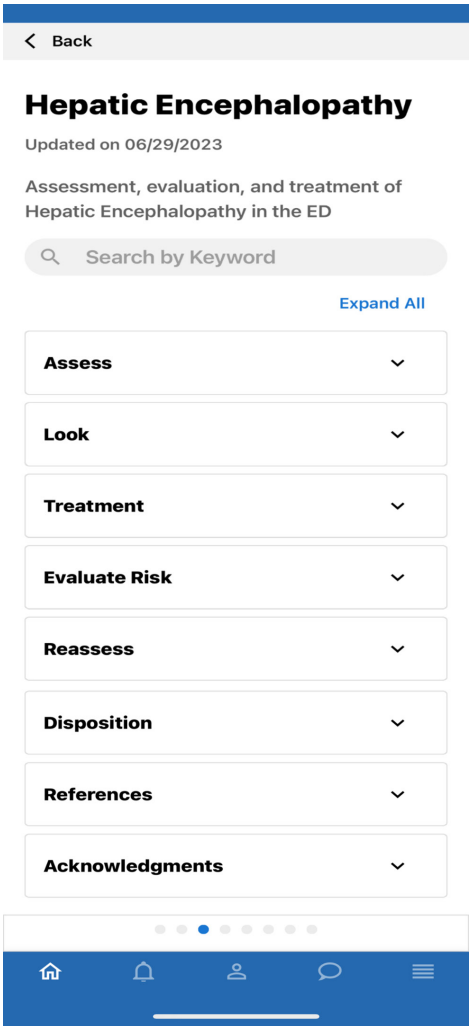


**Figure 1.** Screenshot of the American College of Emergency Physicians point-of-care tool for hepatic encephalopathy. Access the tool by opening the ACEP application, logging in with your ACEP credentials, selecting "Point-of-Care" in the upper left, and then choosing "Hepatic Encephalopathy" from the list.

The ALTERD tool has been available since June 2023 on the ACEP website without a paywall. It is also available via the ACEP smartphone application on the Apple App Store or Google Play Store at no cost to current ACEP members in the "Point-of-Care" section. It is intended to be accessed in real time during an ED visit, providing clinicians with fast, helpful guidance. The website for this tool has had 412 visitors, and the application has had 355 users access it since its inception.

### Assess

The assessment begins with the chief complaint and initial history. Consider the diagnosis of HE in any patient presenting with altered mental status, particularly those with known liver disease. Due to acute delirium, obtain collateral information from family, caregivers, emergency medical services, or

nursing home staff. Inquire about previous liver disease, alcohol use, recent procedures (eg, transjugular intrahepatic portosystemic shunt), nonadherence to lactulose/rifaximin, benzodiazepine or opioid use, diuretics, valproic acid, and infection symptoms. Investigate recent high-protein dietary loads and changes in bowel movements, including diarrhea, constipation, or bleeding.[16]

**Look**

Diagnosing overt HE requires excluding alternative causes of altered mental status. Key physical exam findings in patients with liver disease are illustrated in Figure 2. The laboratory and diagnostic testing evaluation expected to be most helpful is illustrated in Table 2. While blood ammonia levels are commonly used, high levels alone add little diagnostic, staging, or prognostic value in HE patients with chronic liver disease.[8] Repetitive ammonia measurements are neither predictive nor cost-effective. Although HE patients typically have elevated serum ammonia levels, the severity of HE does not correlate with these levels beyond a certain threshold.[20]

**Treatment**

Table 3 correlates WHC scores with treatment regimens. Besides supportive care, identifying and treating precipitating factors is essential; nearly 90% of patients improve when these factors are corrected, thereby preventing recurrence and readmissions.[21] Common precipitants include infections (eg, spontaneous bacterial peritonitis, urinary tract infections), gastrointestinal bleeding, electrolyte abnormalities, acute kidney injury, hypovolemia, sedating medications or intoxication, and portal vein thrombosis.[16]

Acute overt HE treatment includes reducing nitrogenous gut load via lactulose and rifaximin. Treatment goals are to induce remission by purging colonic bacterial contents and to maintain remission with secondary prophylaxis, given the high risk of recurrence. Lactulose, a nonabsorbable disaccharide, acidifies the gastrointestinal (GI) tract and inhibits ammonia production by coliform bacteria.[22,23] Rifaximin, a semisynthetic nonsystemic antibiotic, decreases intestinal ammonia production and absorption by altering GI flora and is almost wholly excreted unchanged in feces. Studies show rifaximin equals or exceeds lactulose efficacy, with international guidelines supporting its use (GRADE 1, A, 1) as add-on therapy to lactulose for overt HE recurrence prevention.[24–27] Polyethylene glycol (PEG) is an osmotic laxative that acts as a fecal cleanser, removing fecal nitrogen, and can be added in more severe cases.[28] Additional treatments less commonly encountered in the ED but supported by evidence include intravenous L-ornithine L-aspartate (LOLA), oral branched-chain amino acids, and zinc.[24]

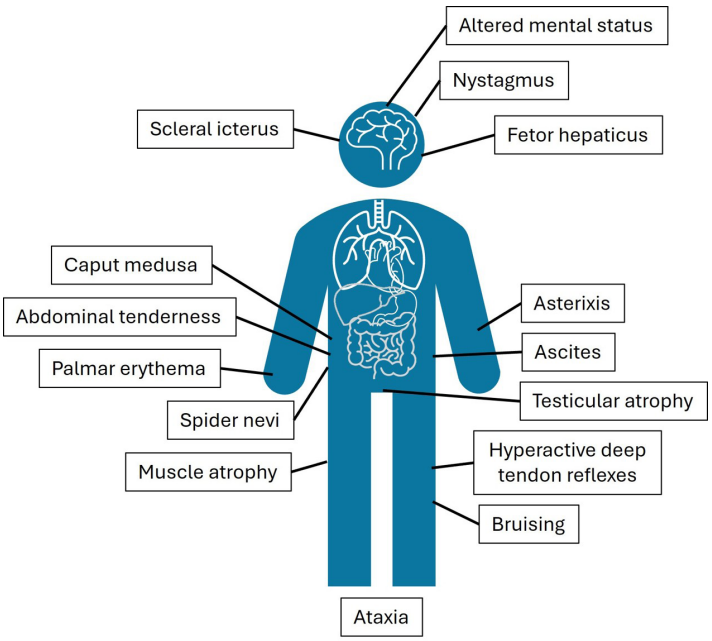


**Figure 2.** Signs and symptoms to look for during the physical examination in hepatic encephalopathy.
Illustration of the physical manifestations of chronic liver disease found in the ACEP point-of-care tool for hepatic encephalopathy. *ACEP,* American College of Emergency Physicians.

**Evaluate Risk**

Patients may have dynamic exams during ED evaluation, requiring serial assessments. Emergency physicians should document appropriate WHC scores. Trends in mental status, vital signs, and laboratory values clarify patient trajectory and treatment response. Some patients with overt HE requiring hospitalization may be suitable for either floor or intensive care unit (ICU) admission. Hard ICU indications typically include intubation with mechanical ventilation, vasopressor support, frequent blood sugar and other electrolyte monitoring, and similar interventions deemed out of scope for inpatient floor care. Clear communication with consultants regarding their current status and decompensation potential is critical.

**Reassess**

The broad diagnostic workup for overt HE typically spans hours and requires multiple reassessments. Diagnostic results refine the differential diagnosis and exclude alternative causes. This period allows reviewing vital sign trends, reassessing mental status, and detecting dynamic exam findings. For anticipated discharges, subsequent evaluations provide opportunities to screen for social determinants impeding outpatient treatment and follow-up. Engage case managers, social workers, or community health workers for vulnerable patients when available, or use asynchronous post-discharge referral systems during off-hours.

**Disposition**

Once HE is confirmed, select the appropriate disposition

**Table 2.** Laboratory testing recommended for patients with suspected hepatic encephalopathy.

| Test | Comments |
|---|---|
| Ammonia level | • Up to 40% of patients with HE may have a normal ammonia level |
| Blood alcohol level | • Perform if indicated |
| BMP | • Assess for metabolic disarray, especially hyponatremia, hypokalemia, hypoglycemia, and acute renal failure |
| CBC | • Assess for evidence of associated infection, acute blood loss |
| Diagnostic paracentesis to evaluate for SBP | • Up to 10% of patients with overt HE also have SBP |
| Drug levels<br>• Acetaminophen<br>• Digoxin<br>• Salicylates<br>• Valproic acid | • Based on history or medication list |
| LFTs | • Trend versus historical values, if available |
| Consider lumbar puncture | • If meningitis is suspected without contraindications (eg, coagulopathy) |
| PT/INR | • May be abnormal due to impaired hepatic synthetic function of coagulation factors |
| Radiology<br>• Consider right upper quadrant ultrasound (with Doppler)<br>• Consider noncontrast head CT | <br>• Assess for portal vein thrombosis<br>• Assess for intracranial hemorrhage |
| Toxicology screen | • Perform if indicated* |

Diagnostic testing considerations for the patient with chronic liver disease in the emergency department presenting with altered mental status found in the ACEP Point-of-Care tool for Hepatic Encephalopathy.
*ACEP,* American College of Emergency Physicians; *BMP,* basic metabolic panel; *CBC,* complete blood count; *CT,* computed tomography; *HE,* hepatic encephalopathy; *LFTs,* liver function tests; *PT/INR,* prothrombin time/International normalized ratio; *SBP,* spontaneous bacterial peritonitis.
*Urine drug screen is only warranted if the cause for presentation is unclear, and results will change emergency department treatment.

and treatment that match the patient's needs. In Figure 3, we provide suggested language for documentation that can easily be added to the medical decision-making section of a note to memorialize these actions. We correlate the range of disposition options to the severity of HE presentation in Table 3. Among patients with covert HE detected during an unrelated ED visit, they should be discharged home and scheduled for outpatient follow-up. If the patient does not have a primary care physician, local referral processes should be used. Patients with covert HE related to the ED chief complaint can also be discharged home, but with a specialty gastroenterology/hepatology referral. For discharged patients, see Figure 3 for an example handout to include with the after-visit summary. Consider an observation status hospitalization among patients with an established history of HE presenting with mild HE symptoms but without a safe discharge plan. Consider starting lactulose and rifaximin in the ED for treatment and prevention of recurrence, correcting metabolic disturbances, and a gastroenterology consult.

Patients with overt HE will require treatment with lactulose and rifaximin, followed by inpatient hospitalization on a hospital medicine service with a gastroenterology consult. These patients will have a WHC score of 2-3, indicating they will be arousable and redirectable, with minimal or moderate metabolic derangement or complications. Lastly, some patients with overt HE will require medical ICU hospitalization. Such patients will have a WHC score of 4 and will be obtunded and/or have severe metabolic disarray or complication. They will be unlikely to take medications by mouth, which may require alternative treatment strategies, such as rectal lactulose and/or extemporaneously compounded rifaximin or lactulose administered via gastric tube in addition to correction of metabolic abnormalities and resuscitation of other associated complications.[29]

A gastroenterology consult in the ED would be helpful for this population, along with other specialists as needed. Finally, regardless of patient disposition, engaging case management to ascertain prescription drug benefit coverage for rifaximin and/or patient assistance programs will prevent delays in initiation and gaps in treatment and, in turn, increase treatment retention to avoid rehospitalizations and other adverse outcomes associated with recurrent HE.[30]

## DISCUSSION

Standardized approaches to HE diagnosis and management are crucial for improving efficiency, achieving

**Table 3.** Summary of hepatic encephalopathy treatment and disposition recommendations by patient diagnosis.

| Patient Diagnosis | Disposition and Treatment Recommendation | Target Patient |
|---|---|---|
| Covert HE unrelated to the reason for visit<br>Discharge home | • Discharge home with PCP follow-up within 14 days<br>• If no PCP, use local processes for PCP and/or gastroenterology referral | • WHC grade 1, no metabolic disarray or complications |
| Covert HE related to the reason for visit<br>Discharge home | • Discharge home with gastroenterology/hepatology specialist follow-up within 7 days, if available<br>• Consider discharge prescription for rifaximin 550mg BID<br>• If limited specialty clinic follow-up, consider gastroenterology consultation | • WHC grade 1, no metabolic disarray or complications |
| Observation or inpatient hospitalization | • Lactulose 30-45 mL (20-30 g) orally every 1-2 hours until mental status improves<br>• Consider rifaximin 550 mg BID to prevent recurrence<br>• Correct metabolic disturbances, CIWA for patients with alcohol use disorder<br>• ED observation protocol should include:<br>- Explicit inclusion/exclusion criteria<br>- Typical observation interventions<br>- Endpoints for discharge with an outpatient follow-up plan versus inpatient admission<br>• Recommend gastroenterology consult, if available<br>• At discharge, recommend follow-up with gastroenterology/hepatology clinic within 3-5 days, if available | • WHC grade 1 with barriers to follow-up, or<br>• WHC grade 2 with near-normal mental status and/or mild metabolic disarray or complications with anticipated length of stay less than two midnights |
| Overt HE<br>Inpatient hospitalization | • Administer lactulose 30-45 mL (20-30 g) orally or through nasogastric tube† every 1-2 hours until mental status improvement<br>• Consider adding rifaximin 550 mg BID to prevent recurrence<br>• Recommend gastroenterology consult, if available | • WHC grade 2-3, arousable and redirectable, minimal or moderate metabolic disarray or complications |
| Overt HE<br>ICU hospitalization | • If the patient is intubated, administer lactulose 30-45 mL (20-30 g) via nasogastric tube every 1-2 hours until mental status improvement<br>• If not intubated, administer lactulose 200 g rectally hourly until improvement in mental status<br>• PEG-3350 4 L can be administered via nasogastric tube as adjunctive therapy<br>• Consider adding rifaximin 550 mg BID once the patient can take medications orally to prevent recurrence<br>• Recommend gastroenterology consult, if available | • WHC grade 4, obtundation, and severe metabolic disarray or complication |

Treatment and disposition recommendations for the emergency department patient with hepatic encephalopathy according to the degree of illness found in the ACEP point-of-care tool for hepatic encephalopathy
*ACEP,* American College of Emergency Physicians; *CIWA,* Clinical Institute Withdrawal Assessment for Alcohol; *BID,* twice daily; *HE,* hepatic encephalopathy; *PCP,* primary care physician; *WHC,* West Haven criteria.

better outcomes, and ensuring appropriate ED care transitions. Our multidisciplinary expert panel developed stepwise guidance for emergency physicians approaching ED patients with HE. This ED-focused framework provides interventions for all patients with altered mental status and is accessible via the ACEP website and point-of-care app.

The ACEP has created and distributed point-of-care tools for nearly a decade, currently supporting 30 clinical conditions frequently encountered in the ED. These tools reach wide audiences through the. following: 1) free accessibility without paywalls (mobile application requires ACEP membership); and 2) easy-to-use formats (eg, high-yield checklists) leveraged at the bedside to facilitate data collection, orders, and result interpretation. As smartphones have become ubiquitous in EDs, handheld electronic clinical-decision support and just-in-time training are increasingly available and accepted.[31] Artificial intelligence-enabled tools will likely further impact clinical decision support, with point-of-care content informing next-generation digital tools improving HE diagnosis and treatment.[32]

Nonspecific chief complaints, incomplete or inaccurate histories, and underlying liver disease necessitate broad differential diagnoses and extensive testing, increasing ED length of stay and evaluation complexity. The broad presentation range and rapid mental status fluctuations further complicate diagnosis. Patients may seek care for undiagnosed

I have considered multiple high-risk, life-threatening etiologies of acute mental status change in this patient through various laboratory and imaging tests during the ED evaluation, including, but not limited to, infections complicated by sepsis, such as pneumonia, urinary tract infection, spontaneous bacterial peritonitis, and meningitis. Electrolyte abnormalities such as hyponatremia and hypoglycemia. Neurologic emergencies such as intracranial hemorrhage, ischemic stroke, and seizure. Toxic ingestions such as alcohol and other drug intoxication or withdrawal, including poisoning such as acetaminophen, salicylate, and others, and I have made a diagnosis of Hepatic Encephalopathy (ICD-10 K76.82). As a result, I have chosen a disposition of (SELECT ONE/DROPDOWN: admission or discharge) appropriate for this patient with the following treatment plan and therapies initiated (SELECT ONE OR MORE/DROPDOWN: lactulose, rifaximin).

**HEPATIC ENCEPHALOPATHY ED SAMPLE DISCHARGE INSTRUCTIONS**

Hepatic Encephalopathy (HE) is a condition that causes confusion and other problems with thinking. It can also cause changes in mood, poor sleep, and unusual body movements. Most people who get HE have a type of liver disease called cirrhosis, and things like infection, bleeding in the stomach, or constipation can be the cause. HE can cause memory loss, confusion, mood changes, difficulty speaking or writing, unusual movements of the hands, arms, legs, and trouble sleeping or sleeping too much.

**DISCHARGE INSTRUCTIONS FOR PATIENT AND CAREGIVER**

Please be sure to follow these directions carefully:

1. Schedule an appointment with your Primary doctor in ___ days
2. Schedule an appointment with your GI doctor in ___ days
3. Fill your prescriptions and take all medications as prescribed
4. Review medications with both patient and caregiver, making a note of any changes
5. Drink plenty of fluids
6. Eat frequent small meals throughout the day with a high carbohydrate snack at bedtime
7. Prevent falls or other injuries: remove loose rugs from the floor, use handrails when walking stairs, use a shower chair when bathing, keep pathways and walkways clear of clutter both inside and out
8. Patients and caregivers should be aware of signs of worsening hepatic encephalopathy:
   a. Confusion
   b. Disorientation
   c. Agitation
9. Your doctor may advise against driving. HE may increase your risk of having an accident while driving a car. Your doctor may not allow you to drive until you have more testing or may limit your driving to short distances in daylight hours only

**Figure 3.** Sample dot phrase and emergency department discharge instructions for patients with hepatic encephalopathy. Example documentation exhibits to assist with the clinical note and discharge instructions provided to patients with hepatic encephalopathy in the emergency department, found in the ACEP point-of-care tool for hepatic encephalopathy.
*ACEP,* American College of Emergency Physicians.

or undertreated HE consequences like infections, trauma, or medication errors. Emergency department pressures, including hallway care, inpatient boarding, and staffing shortages, challenge comprehensive exams and thorough histories, making collateral information needed for correct diagnosis difficult to obtain. These factors increase the risk of delayed or missed HE diagnosis. Despite these challenges, rapid identification and management of HE in the ED is essential, given the considerable mortality associated with altered mental status and high-grade HE among cirrhosis patients being cared for in this care setting.[34]

Looking ahead, further breakthroughs to reduce the prevalence of liver disease, along with tools to aid both the diagnosis and treatment of HE, are needed. Rapid, inexpensive diagnostic aids with high sensitivity and specificity, designed for use in the ED setting, would be a welcome addition to current testing approaches. Additionally, accessible treatments that rapidly correct HE, with regimens that maintain remission and achieve high compliance rates, would be ideal. The timing of treatment initiation is an important variable to optimize; for existing treatments with clear efficacy, studies are needed to demonstrate differences in patient outcomes between ED and inpatient care. For example, evidence supporting improved patient outcomes with rifaximin initiation within the typical timeframe of an ED visit (eg, within the first 6-8 hours of ED arrival) is needed.

## LIMITATIONS

Our approach had several limitations. First, we did not conduct a systematic literature review or report our findings

in accordance with PRISMA standards.[35] Our point-of-care tool should not be considered a clinical practice guideline; therefore, we did not apply the Appraisal of Guidelines Research and Evaluation (AGREE) reporting checklist.[36] Additionally, this expert panel's recommendations differ from those of ACEP clinical policies, which the ACEP Clinical Policies Committee develops through a separate process. Accordingly, grading the evidence and tying it to the strength of panel recommendations was out of scope for this project. Recommendations for HE grading and treatment were best supported by the literature, whereas other aspects of clinical care less likely to be explicitly studied, such as differential diagnosis and disposition destination, were consensus based.

Second, a common criticism of expert panel recommendations is that they are overrepresented by urban, academic physicians, which risks making them irrelevant to clinicians practicing in different settings. While we assembled a panel of U.S. clinicians from academic and community settings, as well as urban and rural settings, the panel selection process may not have resulted in panelists representative of the entire country, and it limits generalizability outside U.S. ED settings. This tool is not intended to represent a legal standard of care for emergency physicians. The ACEP recognizes the importance of the individual physician's judgment and patient preferences. Lastly, several panelists reported financial relationships with entities relevant to HE, which may have introduced bias.

## CONCLUSION

The ACEP developed an evidence-based tool to evaluate and treat patients presenting to the ED with suspected or confirmed HE, with a focus on seamless integration into typical ED workflows. Emergency physicians should expect to encounter these patients more frequently over time as the population of patients with liver disease rises. Increased awareness of the spectrum of presentations, diagnostic criteria, and treatment options for HE is needed. Electronic tools such as the ACEP point-of-care apps are a valuable resource for rapid, accurate guidance. Further research is needed to answer key questions that could clarify the importance of timing specific treatments during the ED visit and aid clinicians in diagnosing HE more rapidly and accurately.

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# Reevaluating the Role and Timing of Fever in Acute Cholecystitis

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**Introduction:** Acute cholecystitis is diagnosed based on clinical and diagnostic findings. Fever is commonly considered a sign of systemic inflammation in acute cholecystitis, although its diagnostic performance may vary depending on the timing of presentation. This study analyzed the prevalence of fever as a diagnostic parameter for acute cholecystitis, according to the symptom onset at the time of medical consultation (≤ 24 hours versus > 24 hours), and its potential association with both medical and surgical complications.

**Methods:** We conducted a retrospective cohort study in two urban, tertiary care emergency departments (ED) between March 2023 and June 2024. Adult patients (≥ 18 years) with clinically diagnosed acute cholecystitis were included. Presentations were categorized by time since symptom onset: early (≤ 24 hours) or late (> 24 hours). Fever was defined as axillary temperature > 37.5 °C at home or at ED arrival. The primary outcome was the sensitivity of fever for the diagnosis of acute cholecystitis, stratified by early versus late presentation. Secondary outcomes included the sensitivity of other inflammatory markers and the association between fever and medical or surgical complications. The association between fever and complications was evaluated using a penalized logistic regression model (Firth method) to account for the low number of outcome events.

**Results:** A total of 207 cases of acute cholecystitis were included in the analysis: 108 early presenters; and 99 late presenters. Fever was present in 4.6% (95% CI, 1.5–10.4) of early presenters and 20.2% (95% CI, 12.8–29.4) in late presenters, with an overall sensitivity of 12.1% (95% CI, 8.0–17.2). Medical and/or surgical complications were low in this cohort (n = 15, 7.2%), but more frequent in patients with fever, regardless of time onset of symptom (28% versus 4.5%, $P < .001$), yielding an adjusted odds ratio of 6.64 (95% CI, 1.42-31.21; $P = .02$) after adjusting for leukocyte count, C-reactive protein levels, and age.

**Conclusion:** Fever is an uncommon sign of acute cholecystitis, especially in early presentations, but may indicate a higher risk for complications when present. These findings underscore the need to reconsider the role of fever in current diagnostic criteria and suggest further validation of its use as a predictor of complications in prospective studies. [West J Emerg Med. 2026;27(5)1420–1427.]

## INTRODUCTION

Acute cholecystitis is an acute inflammatory condition of the gallbladder, most often caused by obstruction of the cystic duct by gallstones or biliary sludge (90-95% of cases).[1] In the United States, 10-15% of adults have gallstones, while the estimated prevalence in the Chilean population is 13.3% in

men, and 36.7% in women.[2,3] Acute cholecystitis cases account for up to 10% of all patients with abdominal pain.[4]

The progression from cholelithiasis to acute cholecystitis and its complications depends on the degree and duration of ductal obstruction. This progression is classically described in three stages.[2] In the initial stage (days 2 to 4), obstruction of the cystic duct causes increased intraluminal pressure and impairs lymphatic drainage; this, combined with bile supersaturation, triggers inflammation, which is reflected as edema and congestion of the gallbladder wall, often observed as wall thickening on imaging. The second stage (days 3 to 5) involves worsening inflammation, which can progress to necrosis, hemorrhage, and potential perforation that may lead to peritonitis. The third stage (day 6 onward) is marked by increase of necrotic tissue, leukocyte infiltration, and infection. Only about 10-30% of acute cholecystitis cases develop secondary infection, underscoring the primary role of obstruction rather than infection in early acute cholecystitis.[5,6]

The diagnosis of acute cholecystitis combines clinical, laboratory, and imaging findings, formalized in the Tokyo Guidelines, updated in 2013 and again revised in 2018.[7] These guidelines define a "suspected diagnosis" of acute cholecystitis as the presence of a local sign of inflammation (Murphy sign, or pain, tenderness, and/or mass in the right upper quadrant) plus a systemic sign of inflammation (fever, elevated C-reactive protein, and/or leukocytosis). A "definitive diagnosis" requires compatible imaging findings, where common imaging modalities include ultrasound, computed tomography (CT), magnetic resonance (MRI) and magnetic resonance cholangiopancreatography (MRCP). Leukocytosis > 18,000/µL is also a marker of moderate severity by these guidelines. Although the derivation study conducted in Japan reported high diagnostic accuracy (sensitivity 92.1%, specificity 93.3%), subsequent studies have shown reduced diagnostic performance in clinical settings, with sensitivities between 83-85% and specificities between 37-50%.[8,9]

*Population Health Research Capsule*

What do we already know about this issue?
*Fever is part of the Tokyo Guidelines criteria for acute cholecystitis, but recent studies suggest its diagnostic value may be limited.*

What was the research question?
*Does fever sensitivity for diagnosing acute cholecystitis vary with time from symptom onset?*

What was the major finding of the study?
*Fever sensitivity: 4.6% early vs 20.2% late presenters (> 24 hours of symptoms); aOR for complications 6.64 (95% CI, 1.42-31.21; P = .02).*

How does this improve population health?
*Recognizing the low sensitivity of fever in early acute cholecystitis may reduce diagnostic delays and help identify patients at risk for complications.*

**Importance**

Traditionally, the clinical suspicion of acute cholecystitis relies on the presence of local clinical signs (right upper quadrant pain, nausea, vomiting), along with the presence of fever. This framework has shaped expectations of systemic inflammation as a diagnostic marker, which may reduce the likelihood of early detection of this condition, whose management is essentially surgical, thereby increasing patient morbidity and mortality. Given that acute cholecystitis is primarily an obstructive rather than infectious condition in its initial stages, it may be possible that the lower rates of systemic inflammation observed today result from patients in many settings seeking care earlier than when the Tokyo criteria were originally derived. Exploring this possibility is timely, as it raises questions about the role of systemic inflammation markers in acute cholecystitis diagnosis and severity grading and whether patients presenting earlier in the disease course have different inflammatory profiles than those presenting later.

Although fever is not part of the Tokyo criteria for acute cholecystitis severity, systemic inflammation markers, such as leukocytosis > 18,000/µL, are included as criteria for moderate severity (Grade II).[7] Since fever often accompanies elevated leukocyte counts in inflammatory processes, it may be logical to consider fever as a supplementary indicator of severity. A few studies have described the association between fever and surgical complications or difficult laparoscopic cholecystectomy.[10–12]

**Goals of This investigation**

The aim of this study was to determine the prevalence of fever as a diagnostic parameter for acute cholecystitis in a population with a high incidence of the condition, according to the symptom onset at the time of medical consultation (≤ 24 hours versus > 24 hours), and its potential association with both medical and surgical complications.

## METHODS

**Study Design and Setting**

This was a retrospective cohort study conducted in two emergency departments (ED) of two Chilean urban, tertiary academic hospitals. The study spanned from March 2023 to June 2024. This study was approved by the ethics review board of the participating center and conducted in accordance with local legal and institutional requirements, as well as generally accepted ethical principles including the Declaration of Helsinki, the Belmont Report, and the Nuremberg Code.

**Selection of Participants**

Participants included all patients older than 18 years who were consecutively admitted to the hospital from the ED with a clinical diagnosis of acute cholecystitis determined by the treating physician and based on the patient's clinical presentation and imaging findings in accordance with the Tokyo criteria. Presentations were categorized as "early" if symptom onset occurred within 24 hours prior to arrival to the ED and "late" if symptom onset occurred longer than 24 hours before arrival. The cut point of 24 hours was based on a prior unpublished quality improvement project that described the timing of consultation in the ED for patients diagnosed with acute cholecystitis. In that study, more than half of patients visited the ED before 24 hours of symptoms onset, representing a relevant group of patients that need assessment and risk stratification in the ED. This cut-point also fits with our hypothesis that as early as 24 hours after symptoms onset, obstruction is what leads the clinical scenario and not inflammation.

Screening for inclusion was based on ED discharge diagnoses of acute cholecystitis, biliary colic, cholelithiasis, acute abdomen, sepsis, or septic shock. Including acute abdomen and sepsis/shock ensured inclusion of severe cases with biliary etiology that might otherwise be overlooked on initial evaluation. Exclusion criteria included patients with a final diagnosis other than acute cholecystitis at hospital discharge, those without abdominal pain on presentation and those without a documented time of symptom onset. The cohort aimed to reflect a wide range of disease severity among patients with acute cholecystitis. For the primary outcome the gold standard for the final diagnosis of acute cholecystitis was established by histopathological analysis of the resected gallbladder specimen.

**Interventions**

In Chile, cholelithiasis and gallbladder cancer are prevalent, making cholecystectomy the standard of care for patients with symptomatic cholelithiasis, regardless of presentation.[13,14] Medical management is rarely employed, except in cases where proportional care is deemed appropriate due to patient comorbidities or clinical limitations. Thus, all patients followed diagnosis and management according to hospital and national protocols, considering patient stability and clinical judgment of the surgical team on shift.

**Measurements**

We collected data from the electronic health record (EHR) including patient demographics, clinical history, physical examination findings, laboratory values, and imaging results. Fever was defined as either a reported history of fever at home or an axillary temperature > 37.5 °C recorded in the ED. This temperature cutoff was selected based on the lowest temperature reported in the literature for evaluating inflammatory criteria in the diagnosis of acute cholecystitis.[15,16] While this cutoff does not align with the threshold established by the Infectious Diseases Society of America, which is a temperature higher than 38.3 °C, it increases sensitivity and allows for comparison with data published in the field.[17] Additionally, we report alternative cutoffs to broaden the scope of our analysis. Temperature measurements were not standardized due to the retrospective design of the study; axillary temperature was used as it was the most consistently documented method in both prehospital and ED settings. Data on antipyretic use were not systematically recorded in the medical records and were therefore not included in the analysis.

Laboratory data, including C-reactive protein (CRP) and white blood cell (WBC) counts, were categorized as normal based on local laboratory cutoffs (CRP < 0.5 mg/dL, WBC < 11,000/μL). These parameters were measured upon presentation and documented in the EHR. Data abstraction procedures followed methodological recommendations for retrospective medical record review studies as outlined by Worster and Bledsoe.[18] These included the use of predefined inclusion and exclusion criteria, standardized data collection with operational definitions specified a priori, and trained reviewers who abstracted data from the EHR.

**Outcomes**

The primary outcome was the sensitivity of fever for the diagnosis of acute cholecystitis, stratified by early versus late presentation. Sensitivity was defined as the proportion of patients with histopathologically confirmed acute cholecystitis who presented with fever. Secondary outcomes included the sensitivity of other inflammatory markers in early and late presenters and the association between fever and surgical or medical complications. Medical complications were defined as sepsis, septic shock, need for vasopressors, or death, while surgical complications included empyema, gangrene, perforation, need for open conversion, need for drainages, and partial cholecystectomy. For the purposes of this study, clinically diagnosed acute cholecystitis was defined as a final hospital discharge diagnosis established by the treating team based on clinical presentation and compatible imaging findings (ultrasound, CT, or MRI), in accordance with the Tokyo criteria.

**Analysis**

Sample-size calculations were based on an estimated sensitivity of 30% in late-presenting patients, reflecting findings from recent literature on fever rates in acute cholecystitis.[8] For early presenting patients, fever was expected to have a sensitivity of 10%, based on a prior unpublished quality improvement project of patients diagnosed with acute cholecystitis at the ED. This required a sample of 89 patients per group (total 178) to detect a 20% difference with 90% power. Statistical analyses for the primary and secondary outcomes included chi-square tests for categorical variables and Student *t* test or Mann-Whitney-Wilcoxon tests for continuous variables based on distribution. A parsimonious multivariable

model was prespecified based on clinical reasoning, including fever as the primary exposure and age and C-reactive protein (CRP) as covariates. Given the limited number of outcome events, variables were restricted to minimize overfitting, and a penalized likelihood logistic regression model (Firth method) was used to reduce small-sample bias. Age and CRP were analyzed as scaled continuous variables (per decade increase and per 10 mg/dL increase, respectively) to improve interpretability.

A complete-case analysis was conducted, and observations with missing data were excluded from the regression models. Analyses were performed using Stata 17 (StataCorp).

## RESULTS

### Main Results

*Characteristics of Study Subjects*

A total of 94,763 patient encounters were screened for diagnoses of acute cholecystitis, biliary colic, cholelithiasis, acute abdomen, and sepsis at the time of admission at the ED or transfer to the ward, yielding 419 eligible records. We excluded 212 encounters (Figure).

Of the included cohort of 207 patients with clinically diagnosed acute cholecystitis, 108 (52.2%) presented within 24 hours of symptom onset (early presentation), and 99 (47.8%) after 24 hours (late presentation). The cohort was 55% female overall, with 58% female in the early presentation group and 52% in the late presentation group ($P = .35$). The median age of the total cohort was 53 years (interquartile range [IQR] 39-64), with a median of 50 years (IQR 38-63) in the early presentation group and 56 years (IQR 42-68) in the late presentation group ($P = .03$). Of those presenting late, 32% presented between 24 and 48 hours of symptoms onset; 21% between 48 and 72 hours, 18% from 72 to 96 hours, and 29% after 96 hours. The median duration of symptoms in the early group was 8.5 hours (IQR 5-18) compared to 72 hours (IQR 48-144) in the late group ($P < .001$). Acute cholecystitis was clinically confirmed with ultrasound in 82% of cases, with CT in 14.5% of cases, and with MRI/MRCP in 2.9% of cases. A total of 141 patients (68%) had histologically confirmed acute cholecystitis, while the remaining 32% of cases had signs of chronic cholecystitis. We found that 55% of early presenters and 81% of late presenters had histologically confirmed acute cholecystitis. Table 1 provides an overview of the clinical characteristics of the analyzed cohort.

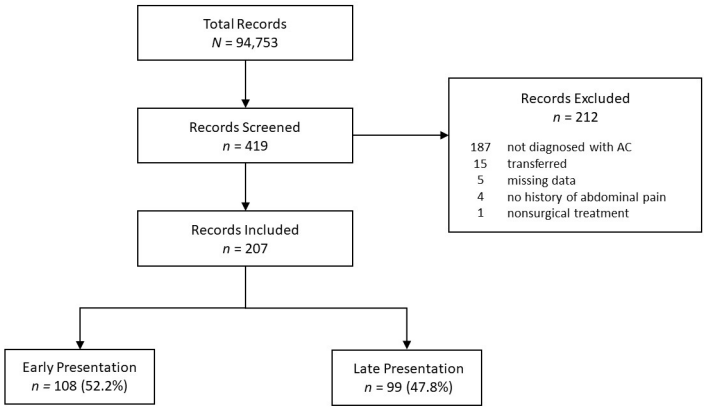


**Figure.** Study flowchart for a retrospective cohort of 207 patients with acute cholecystitis in a study to determine the prevalence of fever as a diagnostic parameter for the disease.
Early presentation: within 24 hours of symptom onset. Late presentation after 24 hours.
*AC,* acute cholecystitis.

### Fever and Clinical Characteristics

The mean axillary temperature on ED arrival was 36.4 °C (0.4). Across all fever cutoffs, including history of fever at home, fever was more prevalent among late-presenting patients. The prevalence of history of fever and/or temperature higher than 37.5 °C in the ED in the early presentation group was 4.6% and 20.2% among late presenters. The clinical description of patients with fever in comparison with patients without is described in Table 2.

### Sensitivity of Tokyo Criteria

The sensitivity of the Tokyo criteria, including fever by early and late presenters is shown in Table 3. Temperature higher than 37.5 °C at ED arrival plus history of fever at home had a sensitivity of 12.1% (95% CI, 8.0–17.2), with lower sensitivity in early presenters (4.6% [95% CI, 1.5–10.4]) compared to late presenters (20.2% [95% CI, 12.8–29.4]). Fever, defined as higher than 38 °C in axillary temperature in the ED, had a sensitivity of 1.5% [95% CI, 0.3-4.3] overall in this cohort, with a 0% (exact 95% CI, 0.0–3.4) for early presenter and 3% (95% CI, 0.6–8.5) in late presenters.

### Complications

Fifteen patients experienced complications. Two patients presented with medical complications, one of whom had fever in the ED. Patients with fever, defined as history of fever at home and/or axillary temperature higher than 37.5 °C ($n = 25$), had higher rates of surgical complications (24.0% in febrile versus 3.9% in afebrile patients; odds ratio [OR] 4.81; 95% CI, 1.03-22.37; $P < .001$). Among the group of patients with a temperature higher than 38 °C, one required vasopressors for sepsis, another had concurrent choledocholithiasis requiring a laparoscopic rendezvous procedure, and a third developed a hepatic abscess requiring drainage.

In the complete cohort, a history of fever and/or an axillary temperature higher than 37.5 °C (12.1%, $n = 25$) was significantly associated with complications in a penalized logistic regression model. The adjusted OR for complications associated with fever was 6.64 (95% CI, 1.42-31.21; $P = .02$) adjusted for CRP (modeled per 10 mg/dL increase) and age

**Table 1.** Clinical characteristics, laboratory findings, and imaging results of patients with clinically diagnosed acute cholecystitis, stratified by time from symptom onset.

| | Total (*N* = 207) | Early Presentation (*n* = 108, 52.2%) | Late Presentation (*n* = 99, 47.8%) | Group comparison |
|---|---|---|---|---|
| Clinical variables | | | | |
| RUQ pain, *n* (%) | 162 (78.3%) | 77 (71.3%) | 85 (85.9%) | *P* = .01 |
| Murphy sign, *n* (%) | 74 (35.8%) | 30 (27.8%) | 44 (44.4%) | *P* = .02 |
| Hx of fever at home, *n* (%) | 17 (8.2%) | 3 (2.8 %) | 14 (14.1 %) | *P* < .001 |
| Temperature (°C), mean (SD) | 36.4 (0.5) | 36.3 (0.4) | 36.6 (0.5) | *P* < .001 |
| Temperature > 37.5 °C, *n* (%) | 9 (4.3%) | 2 (1.9%) | 7 (7.1%) | *P* = .07 |
| Temperature ≥ 37.8 °C, *n* (%) | 6 (2.9%) | 1 (0.9%) | 5 (5.1%) | *P* = .08 |
| Temperature ≥ 38 °C, *n* (%) | 3 (1.4%) | 0 (0%) | 3 (3.0%) | *P* = .07 |
| Hx + Temperature ≥ 37.5 °C, *n* (%) | 25 (12.1%) | 5 (4.6%) | 20 (20.2%) | *P* < .001 |
| Hx + ≥ Temperature ≥ 37.8 °C, *n* (%) | 22 (10.6%) | 4 (3.7%) | 18 (18.2%) | *P* < .001 |
| Hx + Temperature ≥ 38 °C, *n* (%) | 19 (9.2%) | 3 (2.8%) | 16 (16.2%) | *P* < .001 |
| Laboratory | | | | |
| CRP (mg/dL), median | 1.3 [0.3-10.6] | 0.4 [0.2-1.0] | 10.1 [2.5-18.4] | *P* < .001 |
| CRP ≥ 0.5 (mg/dL) | 144 (69.6%) | 52 (48.1%) | 92 (92.9%) | *P* < .001 |
| WBC (x$10^3$/μL), mean (SD) | 11.6 (4.1) | 11.5 (4.4) | 11.6 (3.8) | *P* = .90 |
| WBC ≥ 11.0 (x$10^3$/μL), *n* (%) | 114 (55.1%) | 57 (52.8%) | 57 (57.6%) | *P* = .49 |
| Imaging | | | | |
| Abdominal ultrasonography, *n* (%) | 166 (80.2%) | 95 (88.0%) | 71 (71.7%) | |
| Abdomen-pelvis contrasted CT, *n* (%) | 30 (14.5%) | 10 (9.3%) | 20 (20.2%) | |
| MRI, *n* (%) | 6 (2.9%) | 2 (1.9%) | 4 (4.0%) | |

Temperature was defined as the axillary temperature at ED arrival.
*CRP,* C-reactive protein; *CT,* computed tomography; *Hx,* history of; *MRI,* magnetic resonance imaging; *RUQ,* right upper quadrant; *SD,* standard deviation; *WBC,* white blood cell count.

(modeled per decade increase) (Table 4). C-reactive protein was independently associated with complications (aOR 2.26 per 10 mg/dL increase; 95% CI, 1.24–4.11; *P* = .01), as was age (aOR 3.03 per 10-year increase; 95% CI, 1.63–5.63; *P* < .001). In subgroup analyses, the aOR for complications associated with fever was 20.5 (95% CI, 0.54–777.34; *P* = .10) among early presenters and 4.38 (95% CI, 0.80–23.86, *P* = .09) among late presenters.

## DISCUSSION

### Interpretation

Our findings align with studies by Naidu et al and Jain et al, which demonstrate limited sensitivity of fever as a diagnostic criterion for acute cholecystitis.[8,9] Notably, the sensitivity of fever varies significantly depending on the timing of symptom onset—only reaching 1.9% (95% CI, 0.2-6.8) in early presentations and 7.1% (95% CI, 2.9-14.1) in late presentations when considering 37.5 °C as the cutpoint. These findings suggest that systemic inflammatory signs may not be reliably present in the initial phase of disease.

Leukocytosis and CRP were more frequently abnormal than fever; however, they also demonstrated only moderate sensitivity in early presentations. Together, these observations highlight the potential limitations of relying on systemic inflammatory markers as diagnostic signals in the hyperacute phase of acute cholecystitis. From a prognostic perspective, fever was associated with complications after adjustment for age and CRP (OR 6.64; 95% CI, 1.42–31.21). C-reactive protein (modeled per 10 mg/dL increase) and age (per decade increase) were also independently associated with complications. However, the confidence intervals were wide, reflecting the limited number of outcome events, and preclude definitive conclusions regarding the magnitude of effect.

### Summary of Main Findings

In this retrospective cohort of patients with clinically diagnosed acute cholecystitis, fever was uncommon at presentation—even at lower rates than those reported in the literature—and demonstrated very low sensitivity as a diagnostic criterion (histological confirmation), particularly among patients presenting within 24 hours of symptom onset.[8,19] Even when combining measured temperature and

**Table 2.** Clinical characteristics of patients with clinically diagnosed acute cholecystitis stratified by the presence of fever.

| | Fever (*n* = 25, 12.1%) | No fever (*n* = 182, 87.9%) | Group comparison |
|---|---|---|---|
| Clinical variables | | | |
| Age (years), mean (SD) | 56 (15) | 51.8 (16) | *P* = .21 |
| Female, *n* (%) | 11 (44%) | 102 (56%) | *P* = .25 |
| Time of symptom onset (hours), median [IQR] | 48 [48-72] | 24 [6-72] | *P* < .001 |
| Temperature (°C), mean (SD) | 37 (0.14) | 36 (0.02) | *P* < .001 |
| Laboratory | | | |
| CRP (mg/dL), mean (SD) | 19.4 (12.9) | 5.4 (8.2) | *P* < .001 |
| WBC (x$10^3$/μL), mean (SD) | 13 (4.6) | 11 (4) | *P* = .03 |
| Diagnosis and complications | | | |
| Medical complications, *n* (%) | 1 (4%) | 1 (0.5%) | *P* = .10 |
| Surgical complications, *n* (%) | 6 (24%) | 7 (3.8%) | *P* < .001 |
| Death, *n* (%) | 1 (4%) | 0 (0%) | *P* < .001 |

Fever defined as history of fever at home or axillary temperature at ED arrival > 37.5°C.
*CRP,* C-reactive protein; *ED,* emergency department; *SD,* standard deviation; *WBC,* white blood cell count.

history of fever at home, overall sensitivity remained limited. Although fever was infrequent, it was associated with complications after adjustment for age and CRP using a penalized likelihood logistic regression model. Given the small number of outcome events, these findings should be interpreted cautiously and considered exploratory.

### Comparison to Previous Studies

Although this study was not powered to evaluate the predictive value of fever as a marker of severity in acute cholecystitis, the presence of fever may serve as a specific marker for severe disease and could complement other systemic inflammation indicators. An axillary temperature higher than 37.5 °C or a patient-reported history of fever was independently associated with complications after adjusting for CRP and age in a penalized logistic regression model. Since the number of complications was small in our study, it may be necessary to explore these results in a larger study. Nonetheless, to our knowledge, the 207 patients included here represent one of the largest samples specifically examining fever characteristics in relation to clinical outcomes in acute cholecystitis, which strengthens the precision and reliability of the descriptive estimates across different stages of symptom onset.

### Strengths

Strengths of this study include histopathologic confirmation of acute cholecystitis, detailed characterization of symptom timing, and the use of penalized logistic regression

**Table 3.** Sensitivity of Tokyo diagnostic criteria for acute cholecystitis by time of symptom onset in a retrospective cohort study of patients with clinically diagnosed acute cholecystitis.

| | Early presenters | Late Presenters | Total |
|---|---|---|---|
| RUQ pain | 71.3% [62.0–79.3] | 85.9% [77.7–91.8] | 78.3% [72.4–83.3] |
| Murphy sign | 27.8% [19.7–37.2] | 44.4% [34.6–54.6] | 35.7% [29.3–42.6] |
| T > 37.5°C | 1.9% [0.2–6.8] | 7.1% [2.9–14.1] | 4.4% [2.0–8.1] |
| Hx + T > 37.5°C | 4.6% [1.5–10.4] | 20.2% [12.8–29.4] | 12.1% [8.0–17.2] |
| T ≥ 38°C | 0.0% [0–3.4] | 3.0% [0.6–8.5] | 1.5% [0.3–4.3] |
| Hx + T ≥ 38°C | 2.8% [0.6–8.0] | 16.2% [9.6–25.0] | 9.2% [5.6–14.0] |
| CRP ≥ 0.5 (mg/dL) | 48.2% [38.5–58.1] | 92.9% [85.9–97.1] | 69.6% [63.0–75.6] |
| WBC ≥11.0 (x103/μL) | 52.8% [43.0–62.5] | 57.6% [47.3–67.4] | 55.1% [48.1–62.0] |

Temperature was defined as the axillary temperature at ED arrival.
*CRP,* C-reactive protein; *Hx,* history of; *RUQ,* right upper quadrant; *WBC,* white blood cell count.

**Table 4.** Penalized logistic regression model of risk factors for complications in patients with acute cholecystitis, adjusted for age and C-reactive protein, in a retrospective cohort study of cases of acute cholecystitis.

| Variable | Odds ratio | 95% CI | *P* value |
|---|---|---|---|
| Fever | 6.64 | 1.42 – 31.21 | .02 |
| CRP (per 10 mg/dL increase) | 2.26 | 1.24 – 4.11 | .01 |
| Age (per 10-year increase) | 3.03 | 1.63 - 5.63 | < .001 |

Fever defined as history of fever at home or axillary temperature at ED arrival > 37.5 °C.
*CRP,* C-reactive protein; *ED,* emergency department.

to mitigate small-sample bias. The stratification by timing of presentation provides clinically interpretable insights into early versus later manifestations of systemic inflammation.

### Clinical implications

From an ED perspective, these findings suggest that the absence of fever should not be used to exclude acute cholecystitis, particularly in patients presenting early in the course of disease. In this setting, reliance on fever as a diagnostic criterion may delay diagnosis and imaging. Instead, clinical suspicion should be guided primarily by local signs and symptoms, with inflammatory markers providing complementary but limited diagnostic support.

In patients presenting with fever and clinically diagnosed acute cholecystitis, alternative diagnoses such as cholangitis, pyelonephritis, or other infectious sources should be reconsidered. Alternatively, the presence of fever may indicate that the patient is at elevated risk for medical and surgical complications from acute cholecystitis, alerting the emergency physician, which may evaluate appropriate management strategies, including prompt surgical consultation and possible disposition to a higher level of care.

### Research Implications

Future research should prospectively evaluate fever as a predictor of complications in larger, multicenter cohorts. Studies incorporating continuous temperature monitoring and longitudinal inflammatory markers may better characterize the temporal relationship between fever onset and disease progression in acute cholecystitis.

## LIMITATIONS

This was a retrospective two-center study, which may limit generalizability. The high prevalence of cholelithiasis in the Chilean population may influence disease presentation and diagnostic practices. The number of complications was small, limiting statistical power and resulting in wide confidence intervals, particularly in subgroup analyses. Although we adjusted for age and CRP, residual confounding remains possible. We were unable to account for additional physiologic parameters such as blood pressure, shock index, markers of organ dysfunction, or other laboratory indicators that may influence risk stratification. Additionally, history of fever at home was self-reported and may be subject to recall bias. However, this information remains relevant to real-world clinical decision-making and risk stratification.

Prior studies have shown that self-reported fever may have moderate diagnostic value in identifying infectious conditions, like pneumoniae and influenza and is frequently used as part of initial clinical assessment in the emergency department.[20,21] Kass Hout et al found a moderate agreement between measured and self-reported fever (*k,* 0.423; 95% CI, 0.420-0.425).[22] In this context, patient-reported fever may serve as a complementary clinical signal that reflects early systemic inflammatory response, but it should be interpreted cautiously and in conjunction with other clinical and laboratory findings.

We stratified patients using a 24-hour threshold from symptom onset to distinguish early from later clinical presentations. This cutoff was selected to reflect a clinically meaningful window in emergency care decision-making and to approximate the early inflammatory phase of disease evolution. However, inflammatory progression is inherently continuous, and dichotomization may oversimplify the biological process.

## CONCLUSION

In this retrospective cohort, fever demonstrated low sensitivity as a diagnostic sign of acute cholecystitis, particularly in early presentations. Although an association with complications was observed after adjustment for age and C-reactive protein, the limited number of outcome events and study design preclude firm conclusions regarding its prognostic value. These findings suggest that fever has limited diagnostic utility in early acute cholecystitis and may warrant further investigation as a potential marker of severity in larger prospective studies.

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# Impact of a Decision-Support Interface on Mental Workload and Stress in Prehospital Stroke Triage: A Randomized Crossover Trial

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**Introduction:** Prehospital triage challenges often lead to suboptimal choices and delayed treatment for stroke patients. The objective of the study was to evaluate whether a decision-support interface to assist in stroke triage to an appropriate hospital could reduce emergency medical technicians' (EMT) mental workload.

**Methods:** This randomized crossover study was conducted between February and March 2025. Each participant completed two 12-minute simulated trials in randomized order: current dispatch orders without decision support and a decision-support interface. We assessed mental workload—the mental effort required to make hospital transport decisions under time pressure during prehospital stroke triage—using heart rate variability (HRV) metrics and the National Aeronautics and Space Administration Task Load Index (NASA-TLX). System usability was assessed using the System Usability Scale. The primary outcome was the root mean square of successive differences for each participant after completing the two trials. The secondary outcomes included the differences of NASA-TLX, System Usability Scale, and other heart rate variability parameters, including mean R-R interval (meanRR), mean heart rate, percentage of successive R-R intervals that differ by more than 50 milliseconds, low-frequency power (LF), high-frequency (HF) power, and the LF/HF ratio. Subgroup analyses examined differences by sex, education, age, and years of service.

**Results:** A total of 35 emergency medical technician (EMT)-intermediate participants (mean age, 27.5 [5.3] years) completed the study. For the primary outcome, the root mean square of successive differences increased significantly (28.1 [13.0] vs 32.4 [13.6] milliseconds; mean difference, 4.3 milliseconds [95% CI, 1.57–6.99]; $P < .01$), indicating reduced mental workload when the participants used the decision-support interface. For the secondary outcomes, mean heart rate (77.5 [8.6] vs 73.8 [10.6], $P < .01$) decreased, mean R (784.2 [89.5] vs 808.9 [87.3], $P < .01$) increased, and HF power (370.1 [291.7] versus 482.6 [433.9], $P = .02$) increased, suggesting reduced mental workload when the participants used the decision-support interface. The mental demand scores in NASA-TLX decreased from 62.5 (14.6) to 35.5 (17.0). Emergency medical technicians with 1.0–1.5 years of service reported higher System Usability Scale scores than those with 1.5–3.0 years (84.4 versus 71.3, P = .02), and 82.9% of participants rated the system as acceptable (System Usability Scale score ≥ 70).

**Conclusion:** This study demonstrated that integrating a web-based decision-support interface effectively reduces mental workload and psychological stress among EMTs in stroke triage. [West J Emerg Med. 2026;27(5)1428–1435.]

## INTRODUCTION

According to the World Health Organization, stroke was the second leading cause of death globally in 2019, accounting for 11% of all deaths, following ischemic heart disease at 16%.[1] Given its substantial global burden, optimizing timely access to effective stroke interventions remains a critical public health priority. Ischemic strokes constitute approximately 87% of all stroke cases, highlighting their substantial clinical importance.[2] Much research focuses on acute ischemic stroke (AIS) patients, including scenarios both with and without large vessel occlusion. After intravenous thrombolysis was found to improve outcomes in patients with ischemic stroke, endovascular thrombectomy was also proven to be beneficial for patients with large vessel occlusion.[3] Patients with AIS have better outcomes if the time is reduced between onset and receiving treatment to reperfuse the brain tissues.[4,5]

To minimize the time window from stroke onset to treatment for AIS patients, the decision-making process for hospital transport must also consider additional factors such as transport time, door-to-treatment duration, and necessary diagnostic testing.[6] However, not all hospitals were equipped to provide endovascular thrombectomy, and interhospital transfer caused significant delays between the time patients were last seen normal and the initiation of endovascular thrombectomy, which was associated with poor outcomes.[7] Therefore, it is recommended that prehospital personnel use screening tools to identify patients with large vessel occlusion and transport them directly to hospitals capable of performing endovascular thrombectomy.[8]

In our city, emergency medical technicians (EMT) employ the Cincinnati Prehospital Stroke Scale and the Gaze-Face-Arm-Speech-Time (G-FAST) test to identify patients suspected of having a stroke, including those with a potential large vessel occlusion.[9] While dispatch systems offer predefined transport routes before EMTs arrive at the scene, they do not consider real-time patient conditions or treatment eligibility, potentially resulting in suboptimal hospital selection, resource concentration at tertiary centers, and treatment delays. To address this challenge, decision-support interfaces may support more accurate triage decisions by integrating real-time clinical and transport information into clear, actionable guidance for EMTs.

Although interface design and decision-support tools have been widely applied in other domains, few studies have investigated their role in reducing the specific decision-making burden on EMTs during stroke triage, which represents a significant gap in current research on prehospital care. This study aims to evaluate a hospital selection interface developed from historical stroke registry data, designed to support EMTs in selecting the most appropriate hospital for suspected stroke patients.[10] Unlike studies focusing solely on interface usability, our objective was to assess whether an integrated system—comprising a predictive model, user interface, and field validation—could reduce the mental demands associated with hospital selection. By linking EMTs' mental workload reduction to emergent stroke transport system, our goal was to provide empirical evidence on improving real-world decision-making efficiency and resource distribution in stroke emergency care.

*Population Health Research Capsule*

What do we already know about this issue?
*Prehospital stroke triage is complex and may increase emergency medical technicians' (EMT) mental workload, potentially leading to treatment delays.*

What was the research question?
*We sought to determine whether a decision-support interface reduces EMTs' mental workload during stroke triage.*

What was the major finding of the study?
*The root mean square of successive differences increased by 4.3 milliseconds (95% CI, 1.57–6.99; P < .01) with decision support, indicating lower workload.*

How does this improve population health?
*Decision-support tools that reduce EMTs' mental workload may improve stroke triage and facilitate timely access to appropriate care.*

## METHODS

### Study Design

This randomized crossover study adopted a within-subject design with two experimental conditions to evaluate the impact of a digital decision-support interface on prehospital stroke transport decision-making. The study was conducted and reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines.[11] To mitigate potential order effects, participants were randomly assigned to one of two trial sequences using a Latin square design. Each participant completed both trial conditions—Trial A (current dispatch orders) and Trial B (the proposed decision-support interface). Objective physiological indicators and subjective workload assessments were collected to evaluate participants' mental workload and user experience.

In both trials, participants were presented with a decision-making test sheet based on standard operating procedures followed by EMTs when managing suspected stroke cases.

Each test involved eight simulated patient scenarios, with participants assessing one patient at a time in sequence. They proceeded to the next scenario only after completing a decision for the current case, continuing this process until the 12-minute time limit was reached. For each case, decisions were made based on the provided G-FAST score and relevant patient data. To minimize potential learning effects, each scenario varied in terms of location, symptom-onset time, and G-FAST results. The simulation environment and presentation format were held constant across both trials; only patient-specific variables differed. A video simulation was shown once before the first trial to establish contextual understanding.

**Study Setting and Participants**

This study was conducted between February and March 2025. The experimental setting replicated real-world prehospital stroke triage scenarios using standardized patient cases, verbal instructions, and audio distractions to simulate decision-making under pressure. All participants were certified EMTs with prior training in stroke management. The emergency medical service (EMS) system from which participants were recruited is operated by the city's fire department and comprises a mixed one-tier and two-tier system, including 41 basic life support units and four advanced life support units. There are approximately 1,200 EMTs in the city. [12] During the study period, approximately 12% were EMT-paramedics, while the remainder were EMT-intermediates. The EMT-intermediates receive 280 hours of training, whereas EMT-paramedics undergo 1,280 hours of training. Most patients with suspected stroke were managed by EMT-intermediates.[13]

According to internal evaluations conducted by the fire department, EMTs with less than three years of field experience tend to have higher error rates, with decision-making performance improving markedly after the third year. Based on this empirical observation, we recruited EMTs with fewer than three years of service to focus on early-career personnel. Participants were recruited via announcements and screened for eligibility, including no history of arrhythmia or cardiac-related medication use. All procedures were approved by the research ethics committee of National Tsing Hua University (IRB No. 11310HE165), and written informed consent was obtained from all participants.

**System Overview and Interface Design**

The decision-support system evaluated in this study was developed based on a previously proposed risk-averse optimization model for prehospital stroke triage.[10] The model estimates outcome probabilities for potential hospital destinations by accounting for transport time, treatment capabilities (intravenous thrombolysis/endovascular thrombectomy), and individual patient characteristics. Building on this model, we implemented a user-oriented interface designed to support EMTs in time-sensitive decision-making tasks.

To support novice EMTs who often overlook critical steps under pressure, the interface was designed as a single-page, stepwise workflow. Users are guided through a structured, checklist-style input process that includes G-FAST items, symptom-onset time, and location. Based on the predicted probability of the patient receiving appropriate treatment, the system then dynamically ranks hospital options. The results are displayed with geolocation and visualized treatment time distributions, incorporating eligibility for thrombolytic therapy, transport duration, and hospital capabilities.

Unlike current dispatch forms, the interface integrates clinical decision factors and presents them with visual cues and outcome probabilities. This presentation strategy was intended both to enhance usability and to increase trust in the system's recommendations by making its logic transparent.

**Outcome Measures**

In this study, mental workload was defined as the mental effort required to process clinical information and make hospital transport decisions under time pressure during prehospital stroke triage. We evaluated mental workload during prehospital stroke decision-making, assessed objectively through heart rate variability (HRV) and subjectively via the National Aeronautics and Space Administration Task Load Index (NASA-TLX). The HRV parameters, established indicators of autonomic regulation and mental workload,[14,15] included root mean square of successive differences, mean R-R interval (mean RR), mean heart rate (mHR), percentage of successive R-R intervals that differ by more than 50 milliseconds (pNN50), low-frequency power (LF), high-frequency power (HF), and LF/HF ratio. We used root mean square of successive differences as the primary outcome and other HRV parameters as secondary outcomes. The NASA-TLX evaluated six workload dimensions: mental demand; physical demand; temporal demand; performance; effort; and frustration.[16] In addition to NASA-TLX, the secondary outcomes included system usability, measured using the System Usability Scale, a validated instrument widely applied to assess perceived usability of digital interfaces.[17]

**Measurements Tools**

Physiological signals were recorded using the Polar H10 chest-strap sensor (Polar Electro Oy, Kempele, Finland), a validated device transmitting mean RR via Bluetooth. The RR interval is the time between two consecutive R-waves on an electrocardiogram (ECG). This device has demonstrated high accuracy and consistency compared to ECG in both resting and exercise conditions.[18] The RR intervals were recorded continuously throughout each trial, and HRV metrics were calculated from a 5-minute segment beginning with the second patient scenario using standard time-domain and frequency-domain algorithms.[19]

Subjective workload was measured using the NASA-TLX, a validated multidimensional tool that includes six dimensions rated from 0 to 100 in this study. A pairwise

comparison matrix determined the weighting of each dimension, generating a weighted overall workload score after each trial.[16]

System usability was assessed post-experiment using the System Usability Scale questionnaire. Participants rated their experience with the decision-support interface on a five-point Likert scale, resulting in scores ranging from 0 to 100, with higher scores indicating superior usability. According to the scale's interpretive guidelines, scores below approximately 50 are considered not acceptable and correspond to an "F" grade, often described as *poor* or *worst imaginable* usability. Scores between 50 and 70 fall within a marginal acceptability range (grades D–C), typically interpreted as *"okay"* usability. Scores above 70 are generally regarded as acceptable, with values between 70 and 80 corresponding to "good" usability (grade C–B). Scores exceeding 80 indicate excellent usability, and those above 90 are associated with "best imaginable" systems (grade A), reflecting outstanding user experience and strong usability performance.[20] The questionnaire was administered once, upon completion of both trials, with participants instructed to evaluate only their experience using the interface, independent of trial order.

### Sample Size Estimation

We hypothesized that the root mean square of successive differences would be significantly higher in Trial B (the proposed decision-support interface) than in Trial A (current dispatch orders), reflecting reduced mental workload. Based on a two-tailed $\alpha = 0.05$, $\beta = 0.2$ (power of 80%) and an expected effect size of $r = 0.5$, a sample size of 32 was estimated for the Wilcoxon signed-rank test. To allow for possible data exclusion, we recruited 35 participants. No interim analyses or early stopping criteria were applied during the study.

### Statistical Analysis

This study aimed to compare participants' physiological responses and subjective workload with and without the use of the proposed decision-support interface. Paired analyses were conducted to compare HRV and NASA-TLX scores between the two trial conditions. For normally distributed data, paired *t*-tests were used; otherwise, the Wilcoxon signed-rank test was applied. The Shapiro–Wilk test was used to assess the normality of score distributions and their differences. To examine associations between physiological and subjective workload measures, we used the Pearson correlation for normally distributed data and Spearman correlation for non-normal data. The System Usability Scale score, collected only after the decision-support condition, was summarized descriptively.

We conducted subgroup analyses to explore the influence of sex, education level, age, and years of service on usability and workload outcomes. These categories were derived based on the distribution of the collected sample and were not prespecified. The analyses were exploratory and aimed to inform future implementation strategies. All statistical analyses were performed using Minilab (version 3.13; Minitab, LLC., State College, PA) and Python (version 18.1; Python Software Foundation, Wilmington, DE). Results were reported as mean (standard deviation) or median (Q1–Q3), depending on data distribution. A two-tailed *P* value of < .05 was considered statistically significant.

## RESULTS

We initially identified 46 potential participants, of whom 35 EMT-intermediate-certified personnel completed informed consent and participated. Participants were randomized into two groups: Trial A first (current dispatch orders, $n = 18$) or Trial B first (the proposed decision-support interface, $n = 17$). All participants completed both trials, and no dropouts or adverse events occurred (Figure).

Participant demographics included 31 males and four females. A total of 21 participants held a university degree (4-year independent college) and 14 held a college degree (2-to-5-year community college). The mean age was 27.5 (5.34) years. The average years of service was 1.33 (0.81) years (Table 1).

Paired analyses revealed significant differences in multiple HRV indicators between Trial A and Trial B, indicating reduced mental workload during proposed interface use. Specifically, the root mean square of successive differences increased significantly from 28.11 (13.01) milliseconds in Trial A to 32.40 (13.57) milliseconds in Trial

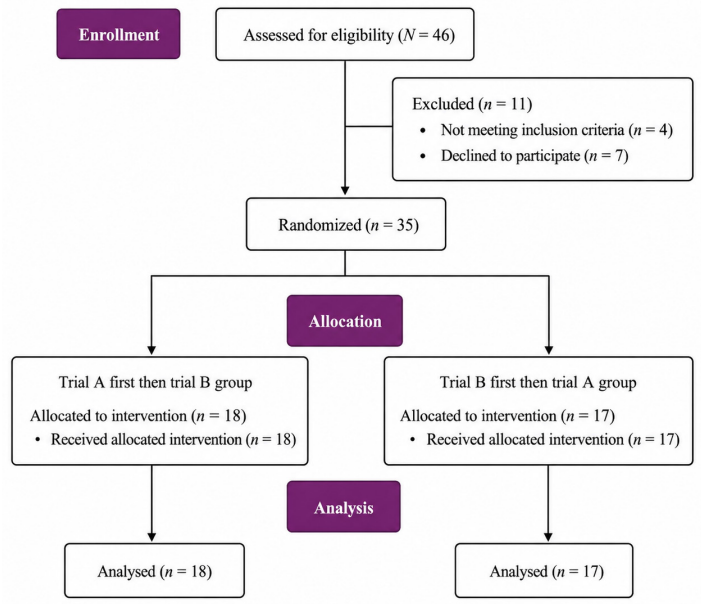


**Figure.** Flow diagram of study participants in a randomized crossover study of a decision-support interface for prehospital stroke triage among emergency medical technicians.
Trial A: current dispatch orders; Trial B: the proposed decision-support interface.

**Table 1.** Characteristics of participants in a randomized crossover study of a decision-support interface for prehospital stroke triage among emergency medical technicians.

| | *n* | Percentage |
|---|---|---|
| Sex | | |
| Male | 31 | 89 % |
| Female | 4 | 11 % |
| Education level | | |
| University | 21 | 60 % |
| College | 14 | 40 % |
| Age | | |
| 20 – 25 | 14 | 40 % |
| 26 – 30 | 12 | 34 % |
| 31 – 35 | 5 | 14 % |
| 36 – 39 | 4 | 11 % |
| Years of Service | | |
| <1 | 10 | 29 % |
| 1 – 2 | 20 | 57 % |
| 2 – 3 | 5 | 14 % |
| Total | 35 | 100 % |

B (mean difference 4.28; 95% CI, 1.57–6.99; $Z = 3.26$, $P < .01$), representing the primary outcome. The mean RR increased (784.19 [89.46] vs 808.94 [87.34]; mean difference 24.75; 95% CI, 11.71–37.79; $Z = 3.21$, $P < .01$), while mHR decreased (77.46 [8.61] vs 73.79 [10.62]; mean difference −3.67; 95% CI, −6.43 to −0.90; $Z = -3.38$, $P < .01$), and HF increased (370.10 [291.66] to 482.57 [433.87]; mean difference 112.46; 95% CI, 15.35–209.57; $Z = 2.43$, $P = .02$) all showed significant changes in the expected direction. In contrast, pNN50 (11.39 [11.79] vs 13.45 [13.95]; mean difference 2.06; 95% CI, −0.48 to 4.61; $Z = 1.48$, $P = .14$), LF (686.84 [577.52] vs 850.76 [733.76]; mean difference 163.92; 95% CI, 8.97–318.87; $Z = 1.76$, $P = .08$), and LF/HF ratio (2.33 [1.35] vs 2.16 [1.25]; mean difference −0.17; 95% CI, −0.59 to 0.25; $Z = -1.36$, $P = .17$) did not reach significance (Table 2). Low-frequency power values increased slightly, but the trend was inconsistent with other HRV parameters.

The total NASA-TLX score, measured on a 0–100 scale, did not significantly deviate from normality, as assessed by the Shapiro–Wilk test ($P > .05$). A paired-sample *t*-test revealed a significant reduction in subjective workload when using the decision-support interface. The mean NASA-TLX score decreased from 62.54 (14.61) in Trial A to 35.45 (16.97) in Trial B, representing an average reduction of 26.04 points (95% CI, −34.23 to −20.02; standard deviation (SD) = 22.07), which was statistically significant ($t = -6.98$, $P < .01$).

Subgroup analyses were conducted to explore the potential influence of participant characteristics—sex, education level, age, and years of service—on usability and workload outcomes. These categories were derived from the actual distribution of the sample and not prespecified prior to data collection. No significant sex differences were found in HRV or NASA-TLX scores. However, this finding should be interpreted cautiously because the small number of female participants may have limited the statistical power to detect sex-related differences. Participants with a university degree showed a significantly larger decrease in LF/HF ratio compared to those with a college degree ($P = .05$). Younger participants (aged 20–26) exhibited significantly greater reductions in mHR ($P = .03$), LF ($P = .02$), and LF/HF ($P = .03$), indicating stronger autonomic responses (Supplementary Table 1). Differences by years of service were non-significant, though small-to-moderate effect sizes were observed in the root mean square of successive differences and LF.

**Table 2.** Differences in heart rate variability indicators between Trial A and Trial B in a randomized crossover study evaluating a decision-support interface for prehospital stroke triage among emergency medical technicians.

| | Trial A Mean (SD) | Trial B Mean (SD) | *Z* value | *P* value | Expected Trend | Observed Trend |
|---|---|---|---|---|---|---|
| RMSSD | 28.11 (13.01) | 32.40 (13.57) | 3.26 | < .01 | ↑ | ✓ |
| mRR | 784.19 (89.46) | 808.94 (87.34) | 3.21 | < .01 | ↓ | ✓ |
| mHR | 77.46 (8.61) | 73.79 (10.62) | -3.38 | < .01 | ↑ | ✓ |
| pNN50 | 11.39 (11.79) | 13.45 (13.95) | 1.48 | .14 | ↑ | ✓ |
| LF | 686.84 (577.52) | 850.76 (733.76) | 1.76 | .08 | ↓ | x |
| HF | 370.10 (291.66) | 482.57 (433.87) | 2.43 | .02 | ↑ | ✓ |
| LF/HF | 2.33 (1.35) | 2.16 (1.25) | -1.36 | .17 | ↓ | ✓ |

✓ indicates consistency with the expected trend under reduced mental workload; ✗ indicates inconsistency.
*HF*, high-frequency power; *LF*, low-frequency power; *mHR*, mean heart rate; *mRR*, mean R–R interval; *pNN50*, percentage of successive R–R intervals differing by more than 50 milliseconds; *RMSSD*, root mean square of successive differences; *SD,* standard deviation.

For NASA-TLX, no subgroup differences reached statistical significance, suggesting consistent workload reduction across demographic groups (Supplementary Table 2). Two-way repeated measures analysis of variance revealed no significant trial order effects for any HRV or NASA-TLX outcome (all $P > .05$) (Supplementary Table 3). Correlation analyses showed that changes in the root mean square of successive differences, mean RR, mHR, and LF were significantly associated with reductions in NASA-TLX scores (all $P < .05$), supporting the validity of physiological indicators (Supplementary Table 4).

System usability was assessed using the System Usability Scale scoring range from 0-100, with higher scores indicating better perceived usability. In this study the scale was administered only after completion of the decision-support condition. The mean score was 78.07 (16.76), and the median was 80 (interquartile range [IQR], 72.50–90.00), indicating generally positive user perceptions. Based on the System Usability Score grading scale, 9 participants rated the system in the A range (90–100), 10 rated it in the B or C range (70–89), 1 rated it in the D range (60–69), and 5 gave it an F rating (<60), suggesting limited usability concerns (Table 3).

Subgroup analyses examined potential differences in System Usability Scale scores across demographic subgroups. Shapiro–Wilk tests indicated non-normal distributions for sex and education, leading to Mann–Whitney U tests, while age and years of service were analyzed using independent *t*-tests. The System Usability Scale scores did not significantly differ by sex, age, or education level. However, participants with 1.0–1.5 years of service reported significantly higher scores than those with 1.5–3.0 years ($t = 2.43$, $P = .02$), suggesting that less experienced EMTs perceived the system as more usable (Supplementary Table 5).

## DISCUSSION

In this study, use of the decision-support interface for hospital selection was associated with significantly reduced mental workload among EMTs, as reflected by improvements in both physiological and subjective measures. The primary HRV outcome, root mean square of successive differences, increased significantly during interface use, suggesting reduced physiologic strain and improved beat-to-beat variability. Increased mean RR and decreased mHR were also observed, consistent with reduced physiologic demand during decision-making. These physiologic findings were consistent with subjective workload results, as NASA-TLX scores demonstrated a substantial reduction in perceived workload during interface use.

In the frequency domain, both LF and HF power increased while the LF/HF ratio decreased. However, LF interpretation remains complex because LF is influenced by multiple physiologic mechanisms and does not exclusively reflect sympathetic activity.[21] Therefore, these findings should be interpreted cautiously as supportive evidence of altered autonomic regulation rather than definitive indicators of sympathetic or parasympathetic dominance. Given the simulation-based design and absence of controlled respiratory measurements, causal physiologic interpretations cannot be definitively established.

Overall, the consistency between HRV and NASA-TLX findings suggests that the decision-support interface may help reduce cognitive burden during prehospital stroke triage by simplifying hospital selection and presenting treatment-related information in a structured format. In addition, significant correlations between changes in HRV parameters and NASA-TLX scores further support the convergent validity of these physiologic and subjective workload measures.

These results support previous research showing that real-time decision support can help mitigate mental burden and reduce errors in high-stakes prehospital environments.[22] In our simulation-based study, use of the decision-support interface was associated with reduced mental workload and concurrent changes in HRV measures among EMTs during stroke triage.

**Table 3.** System Usability Scale score range and statistics results in a randomized crossover study evaluating a decision-support interface for prehospital stroke triage among emergency medical technicians.

| Grade Scale | Score Range | *n* | Percentage | Mean (SD) | Median (IQR) |
|---|---|---|---|---|---|
| A | 90 – 100 | 9 | 25.71% | 96.11 (4.17) | 95 (92.5 – 100) |
| B | 80 – 89 | 10 | 28.57% | 83.25 (3.13) | 83.75 (80 – 85.63) |
| C | 70 – 79 | 10 | 28.57% | 74.75 (1.85) | 75 (72.5 – 75.63) |
| D | 60 – 69 | 1 | 2.86% | 60.00 | 60 (* – *) |
| F | 0 – 59 | 5 | 14.29% | 45.50 (9.42) | 47.5 (37.5 – 52.5) |
| Total | 0 – 100 | 35 | 100% | 78.07 (16.76) | 80 (72.50 – 90.00) |

System Usability Scale scores were interpreted according to established guidelines: <50 = not acceptable (F), 50–69 = marginal (D–C), 70–79 = good (C), 80–89 = excellent (B), and ≥90 = best imaginable (A).
*IQR*, interquartile range; *SD*, standard deviation.

Usability scores were generally positive (mean System Usability Scale score = 78.10), indicating that the interface design met the practical needs of EMTs in hospital selection scenarios. This is consistent with prior findings that well-designed interfaces—those that align with real-world workflows—are crucial for adoption and effectiveness in emergency settings.[23] Subgroup analysis further revealed that EMTs with shorter field experience (1.0–1.5 years) reported significantly higher scores than those with 1.5–3.0 years of service ($t = 2.43$, $P = .02$), suggesting greater openness to technological tools among early-career personnel. This finding is consistent with broader patterns in healthcare technology adoption, where tenure and familiarity with legacy systems can dampen receptiveness to innovation.[24]

## LIMITATIONS

There are some limitations to this study. First, the decision-support model was built on retrospective data and may not fully reflect complex on-scene decisions. Second, participants were drawn from only one EMS in an urban area with high hospital density, which may limit generalizability to rural regions. Third, the study focused on EMTs with fewer than three years of service to better evaluate mental workload during stroke triage among less experienced personnel; therefore, the findings may not be fully generalizable to more experienced EMTs. In addition, the relatively modest sample size may limit generalizability; however, the randomized crossover design enabled within-subject comparisons that may reduce interindividual variability. Finally, although both objective and subjective indicators were used, potential interindividual variability and context-specific factors (eg, team dynamics) were not fully captured.

Despite these limitations, this study provides preliminary evidence that decision-support interfaces may help reduce mental burden during prehospital stroke triage. Future research should evaluate human–system interactions, integrate these tools into operational dispatch systems, and assess their performance across diverse clinical environments, including rural settings.

## CONCLUSION

This study demonstrated that integrating a web-based decision-support interface effectively reduces mental workload and psychological stress among EMTs during prehospital stroke hospital selection. Both physiological and subjective measures confirmed decreased mental workload and increased parasympathetic activity, indicating reduced stress and improved autonomic balance. The positive user experience further supports the feasibility of implementing such tools in real-world emergency settings. Future studies should validate system effectiveness under operational EMS conditions and explore integration pathways that support adaptive modeling, human–artificial intelligence interaction, and deployment in diverse healthcare environments.

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# Acute Headache Management and Emergency Department Throughput: A Multicenter Retrospective Analysis

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**Introduction:** Headache is a common presentation to the emergency department (ED), requiring both accurate diagnosis and efficient management. Although consensus guidelines exist, real-world treatment practices and their associations with operational outcomes remain variable. We evaluated the association between acute headache management strategies—including medications, diagnostic imaging, and consultations—and ED length of stay (LOS), using both unadjusted and multivariable-adjusted analyses.

**Methods:** We conducted a multicenter retrospective observational study using data from 79,527 adult ED encounters for headache across 22 EDs in the southwestern and upper Midwestern United States between 2018 and 2024. The primary outcome was ED LOS. Secondary outcomes included LOS differences associated with medication classes, imaging modalities, procedures, and specialty consultations. Length of stay differences by treatment strategy were compared using Mann-Whitney U testing. We performed multivariable linear regression and quantile regression (median) adjusting for age, sex, Emergency Severity Index level, disposition, imaging, procedures, consultations, site, and year. Encounters were classified by headache type (primary, secondary, or unspecified) using discharge diagnosis codes, and stratified analyses were performed.

**Results:** Primary headache encounters comprised 19.4% of the cohort ($n$ = 15,413), secondary headache 14.0% ($n$ = 11,147), and unspecified headache 66.6% ($n$ = 52,967). The overall median LOS was 183 minutes (interquartile range [IQR], 119–276). In unadjusted analyses, nonsteroidal anti-inflammatory drug (NSAID) (median 180 vs 185 minutes; $P$ = .42) and triptan administration (177 vs 183 minutes; $P$ = .49) were not associated with longer LOS. In contrast, antiseizure medications (+136 minutes; $P$ < .001), intravenous magnesium (+101 minutes; P < .001), opioids (+89 minutes; $P$ < .001), and benzodiazepines (+72 minutes; $P$ < .001) were associated with the longest LOS. In multivariable-adjusted analysis ($R^2$ = .40), antiseizure medications (adjusted coefficient +85.1 min; 95% CI, 76.0–94.3), admission (+71.1 minutes; 95% CI, 68.3–73.8), and magnetic resonance imaging (+125.9 minutes; 95% CI, 119.8–131.9) were most strongly associated with longer LOS. Stratified analyses showed primary headaches had shorter median LOS (153 minutes; IQR, 105–224) than secondary (204 minutes; IQR, 126–317) or unspecified headaches (189 minutes; IQR, 123–282), with consistent medication–LOS associations across subgroups (Kruskal-Wallis H = 1,476.85, $P$ < .001; all pairwise comparisons $P$ < .001 after Bonferroni correction).

**Conclusion:** In this multicenter retrospective study, most pharmacologic and diagnostic interventions—aside from NSAIDs and triptans—were associated with longer ED LOS, even after adjusting for patient and clinical covariates. These associations likely reflect both direct treatment effects and confounding by indication. Prospective studies are needed to evaluate whether standardized protocols can improve ED throughput while maintaining care quality. [West J Emerg Med. 2026;27(5)1436–1446.]

## INTRODUCTION

Headache is a common complaint in the emergency department (ED), accounting for over three million annual visits in the United States alone.[1] In 2008, headache comprised the chief complaint of 2.4% of ED visits and was the secondary complaint in 4.4% of ED visits.[1] For emergency physicians, the challenge lies in rapidly distinguishing life-threatening or time-sensitive secondary causes of headache from primary headache disorders while also delivering effective symptomatic relief and ensuring efficient patient throughput.[2]

Evidence-based management of primary headache disorders, including migraines, tension-type, and cluster headaches, relies on pharmacologic therapies that alleviate pain and reduce recurrence.[2,3] However, red-flag features raise concern for secondary headache, which should prompt further evaluation.[4]

Practices for management of headache in the ED are extrapolated from the migraine literature.[5] Despite consensus guidelines from organizations such as the American Headache Society (AHS) and the American College of Emergency Physicians (ACEP), variability in prescribing practices remains substantial.[3,6] Medications such as metoclopramide, prochlorperazine, and sumatriptan have demonstrated consistent efficacy and are recommended as first-line agents for acute migraine management.[3] Furthermore, adjunctive use of dexamethasone has been associated with reduced recurrence rates, while intravenous (IV) acetaminophen has shown promise in enhancing pain control and possibly reducing the use of opioid rescue medications.[7,8] However, adoption of these practices is heterogeneous and heavily influenced by clinician preference, institutional culture, and workflow efficiency. Notably, a survey of subspecialty headache neurologists found that a minority were satisfied with headache management of their patients in the ED.[9]

While prior studies have examined individual aspects of ED headache management, comprehensive multicenter data evaluating the association between diverse treatment strategies and ED throughput remain limited, particularly in the United States.[10-12] Our study aim was to evaluate, at multicenter scale, the association between different headache management strategies and ED length of stay (LOS) using both unadjusted comparisons and multivariable-adjusted analyses.

*Population Health Research Capsule*

What do we already know about this issue?
*Headache is a common emergency department (ED) chief complaint, but real-world associations between treatment choice and length of stay vary widely.*

What was the research question?
*Do specific acute headache treatments increase ED length of stay (LOS), after adjusting for patient and clinical factors?*

What was the major finding of the study?
*Antiseizure medications added 85 minutes to ED LOS (95% CI, 76-94 min; P < .001) vs nonsteroidal anti-inflammatory drugs and triptans (no association).*

How does this improve population health?
*Identifying which acute headache treatments increase LOS can guide protocols that improve ED throughput without compromising care.*

## METHODS

### Study Design and Setting

We conducted a retrospective observational study using data extracted from the electronic health record (EHR) (Epic Systems) across multiple EDs. These included the three tertiary care sites in Phoenix, Arizona, Jacksonville, Florida, and Rochester, Minnesota, as well as 19 community hospitals spanning Minnesota and Wisconsin. This study was deemed exempt by the institutional review board. This study adheres to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

### Study Population

Data extraction was performed from the Clarity reporting database via structured query language through the institution's unified data pool. Initially, 2,906,593 ED encounters across all sites were identified between January 1, 2018–December 31, 2024. After excluding pediatric patients (< age 18), 2,481,384 adult encounters remained. Headache-related visits were identified by querying both structured diagnosis fields and reason-for-visit entries. Encounters were included if the reason for visit matched "Migraine" or "Headache," or if they carried diagnoses matching headache-related terms including "headache," "migraine," "subarachnoid," "intracerebral hemorrhage," "intracranial hemorrhage," "subdural," "epidural," "hematoma," "meningitis," "encephalitis," "venous thrombosis," "arteritis," "hypertensive encephalopathy," "intracranial hypertension," "pseudotumor," "intracranial hypotension," or "CSF leak." This methodology ensured the comprehensive inclusion of primary headache disorders as well as secondary neurological conditions presenting with headache symptoms. We excluded visits reporting trauma on computed tomography (CT) imaging indication or with a diagnosis linked to trauma and EHR test patients. The initial cohort comprised 79,770 patient encounters.

### Headache Classification

Encounters were classified into three groups based on discharge diagnosis codes (DX_NAME): (1) primary headache (migraine, tension-type, cluster, benign headache, and related diagnoses; *n* = 15,413); (2) secondary headache (intracranial hemorrhage, subdural hematoma, subarachnoid hemorrhage, stroke, meningitis, encephalitis, sinusitis, concussion, head injury, COVID-19, and other secondary etiologies; *n* = 11,147); and (3) unspecified headache (headache unspecified, headache not otherwise specified, and diagnoses without clear primary or secondary classification; *n* = 52,967). This stratification was performed to address the potential confounding introduced by diagnostic heterogeneity.

### Outcome Measures

The primary outcome was ED LOS, defined as the time from ED arrival to ED departure. Encounters with LOS ≤ 0 minutes (*n* = 44) or > 1,440 minutes (24 hours; *n* = 199) were excluded, yielding an analytic sample of 79,527 encounters. Sensitivity analyses using a 720-minute (12-hour) threshold were also performed.

### Data Collection

Clinical and demographic information—including Emergency Severity Index (ESI), age, sex, race, ethnicity, LOS, and disposition—was extracted from encounter-level tables. Medication administration was restricted to active orders administered during the ED stay, operationalized by requiring that the medication order start time fell between the arrival and departure times. Imaging, consultations, and procedures, including CT, magnetic resonance imaging (MRI), neurology consultation, nerve blocks, and lumbar punctures, were filtered as completed between arrival and disposition time to ensure they reflected the emergency workup.

### Statistical Analysis

Descriptive statistics were reported as medians with interquartile ranges (IQR) for continuous variables and frequencies with percentages for categorical variables. We compared LOS distributions for each medication using the Mann-Whitney *U* test. A two-sided *P* value < .05 was considered statistically significant.

Multivariable linear regression (ordinary least squares) was performed with LOS as the dependent variable. Covariates included all 13 medication classes (binary), patient age, sex, ESI level (categorical; reference, ESI 3), disposition (discharged vs admitted/observed/transferred), CT performed, MRI performed, neurology consultation, lumbar puncture, site (categorical, 22 sites), and year. Quantile regression at the median (q = 0.50) was also performed to provide estimates robust to the skewed LOS distribution.

We performed stratified analyses by headache type (primary, secondary, unspecified), including both Mann-Whitney *U* tests and multivariable regression within the primary headache subgroup. Sensitivity analyses included the following: (1) restricting to discharged patients only; and (2) using a 720-minute LOS exclusion threshold. Analyses were performed using Python 3 with pandas, SciPy, and statsmodels.

### Missing Data

Emergency Severity Index values were missing for 2,839 encounters (3.6%) in the analytic sample; these were excluded from regression analyses (regression *n* = 76,688). All other variables had complete data.

## RESULTS

### Study Population

After excluding encounters with LOS ≤ 0 or > 1,440 minutes (n = 243), the analytic sample comprised 79,527 encounters. Demographic information is summarized in Table 1. Patients of female sex comprised 66.4% of the cohort. The mean age was 48.0 years (SD 19.8), and median age was 45.0 years. By headache classification, 15,413 (19.4%) had primary headache diagnoses, 11,147 (14.0%) had secondary headache diagnoses, and 52,967 (66.6%) had unspecified headache diagnoses.

**Table 1.** Patient demographics in a study evaluating the association between acute headache management strategies and length of stay in the emergency department.

| Characteristic | Total patients (%) (*N* = 79,770) |
|---|---|
| Age, Years | |
| Mean (SD) | 48.04 (19.81) |
| Median (IQR) | 45.00 (32) |
| Biologic Sex, *n* (%) | |
| Male | 26,753 (33.54%) |
| Female | 53,003 (66.44%) |
| Nonbinary | 7 (0.01%) |
| Unknown | 7 (0.01%) |
| Race, *n* (%) | |
| American Indian or Alaska Native | 670 (0.84%) |
| Asian | 1,824 (2.29%) |
| Black or African American | 5,835 (7.31%) |
| Native Hawaiian or Pacific Islander | 217 (0.27%) |
| White | 68,197 (85.49%) |
| Unknown or not reported | 3,027 (3.79%) |
| Ethnicity, *n* (%) | |
| Hispanic or Latino | 6,265 (7.85%) |
| Not Hispanic or Latino | 71,877 (90.11%) |
| Unknown or not reported | 1,628 (2.04%) |

*IQR,* interquartile range; *SD,* standard deviation.

**Medication Use Trends**

Medication administration patterns over the seven-year period are shown in Table 2. Intravenous fluids (43–48%), nonsteroidal anti-inflammatory drugs (NSAID) (37–42%), and dopamine antagonists (27–31%) consistently ranked as the most frequently administered treatments. Antiseizure medications were the least frequently administered (0.26–1.50%), along with IV magnesium (0.73–2.60%) and triptans (1.23–2.06%).

Annual use trends (Figure 1) demonstrated relative stability for most medications. Notable trends included the following: Acetaminophen use increased from 14.8% to 29.1%; IV magnesium grew from 0.73% to 2.60%; and antiseizure medication administration increased nearly six-fold from 0.26% to 1.50%. Opioid administration remained stable (11.2–11.7%). Diphenhydramine use declined from 31.0% to 26.7%.

Medication use differed substantially by headache type: Primary headache encounters had higher rates of dopamine antagonists (50.1% vs 9.8% secondary), NSAIDs (64.2% vs 14.1%), diphenhydramine (52.5% vs 7.6%), and triptans (4.1% vs 0.2%), while secondary headache encounters had higher rates of opioids (20.0% vs 6.4%), acetaminophen

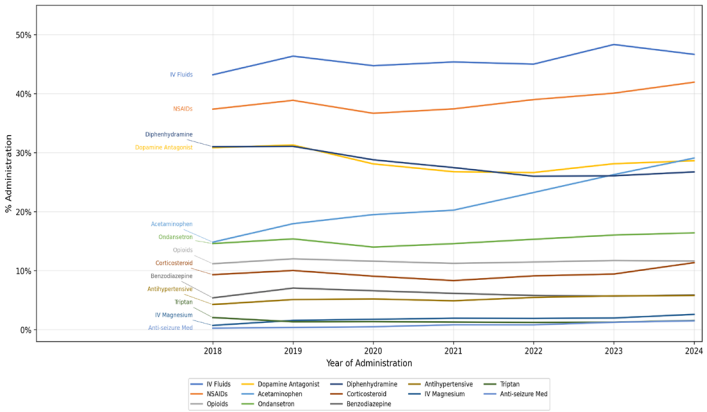



**Figure 1.** Annual use trends stratified by medication class over the seven-year study period.

**Table 2.** Trends in medication administration (2018–2024) in a study evaluating the association between acute headache management strategies and length of stay in the emergency department.

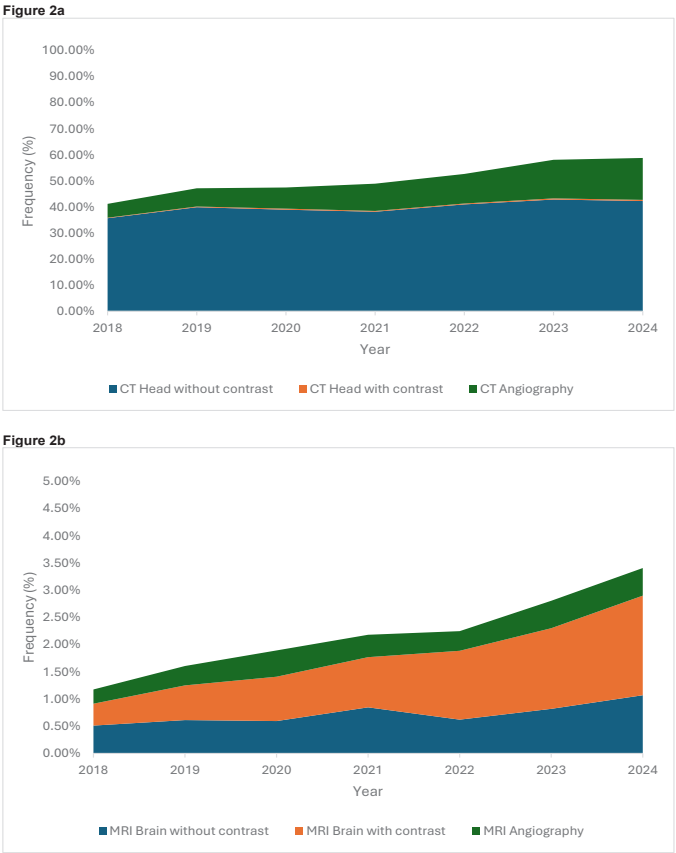
| Medication Category | 2018 (*n* = 9,187) | 2019 (*n* = 11,755) | 2020 (*n* = 9,925) | 2021 (*n* = 11,918) | 2022 (*n* = 11,917) | 2023 (*n* = 12,076) | 2024 (*n* = 12,992) | Total (%) |
|---|---|---|---|---|---|---|---|---|
| IV Fluids | 3,969 (43.20%) | 5,450 (46.36%) | 4,441 (44.75%) | 5,408 (45.38%) | 5,364 (45.01%) | 5,837 (48.34%) | 6,062 (46.66%) | 36,531 (45.59%) |
| NSAIDs | 3,434 (37.38%) | 4,569 (38.87%) | 3,640 (36.68%) | 4,460 (37.42%) | 4,647 (38.99%) | 4,841 (40.09%) | 5,449 (41.94%) | 31,040 (37.48%) |
| Dopamine Antagonists | 2,834 (30.85%) | 3,679 (31.30%) | 2,789 (28.10%) | 3,190 (26.77%) | 3,174 (26.63%) | 3,397 (28.13%) | 3,720 (28.63%) | 22,783 (28.42%) |
| Diphenhydramine | 2,850 (31.02%) | 3,653 (31.08%) | 2,858 (28.80%) | 3,274 (27.47%) | 3,099 (26.00%) | 3,150 (26.08%) | 3,474 (26.74%) | 22,358 (27.90%) |
| Acetaminophen | 1,363 (14.84%) | 2,112 (17.97%) | 1,936 (19.51%) | 2,414 (20.26%) | 2,771 (23.25%) | 3,174 (26.28%) | 3,779 (29.09%) | 17,549 (21.89%) |
| Ondansetron | 1,341 (14.60%) | 1,809 (15.39%) | 1,390 (14.01%) | 1,738 (14.58%) | 1,826 (15.32%) | 1,937 (16.04%) | 2,132 (16.41%) | 12,173 (15.19%) |
| Opioids | 1,027 (11.18%) | 1,412 (12.01%) | 1,152 (11.61%) | 1,340 (11.24%) | 1,367 (11.47%) | 1,416 (11.73%) | 1,513 (11.65%) | 9,227 (11.83%) |
| Corticosteroids | 857 (9.33%) | 1,179 (10.03%) | 900 (9.07%) | 992 (8.32%) | 1,087 (9.12%) | 1,139 (9.43%) | 1,476 (11.36%) | 7,630 (9.52%) |
| Benzodiazepines | 496 (5.40%) | 829 (7.05%) | 655 (6.60%) | 734 (6.16%) | 691 (5.80%) | 687 (5.69%) | 763 (5.87%) | 4,855 (6.06%) |
| Antihypertensives | 392 (4.27%) | 600 (5.10%) | 517 (5.21%) | 584 (4.90%) | 652 (5.47%) | 692 (5.73%) | 752 (5.79%) | 4,189 (5.23%) |
| Magnesium | 67 (0.73%) | 185 (1.57%) | 175 (1.76%) | 231 (1.94%) | 228 (1.91%) | 239 (1.98%) | 338 (2.60%) | 1,463 (1.83%) |
| Triptans | 189 (2.06%) | 158 (1.34%) | 136 (1.37%) | 154 (1.29%) | 147 (1.23%) | 154 (1.28%) | 202 (1.55%) | 1,140 (1.42%) |
| Antiseizure medications | 24 (0.26%) | 44 (0.37%) | 49 (0.49%) | 99 (0.83%) | 98 (0.82%) | 152 (1.26%) | 195 (1.50%) | 661 (0.82%) |

*IV,* intravenous; *NSAID,* nonsteroidal anti-inflammatory drug.

**Table 3.** Imaging studies and procedures performed (2018–2024) in a study evaluating the association between acute headache management strategies and length of stay in the emergency department.

| Year | CT (Any) | MRI | Lumbar puncture | Nerve blocks | Neurology consultation |
|---|---|---|---|---|---|
| 2018 (*n* = 9,187) | 3,477 (37.8%) | 87 (0.9%) | 107 (1.2%) | 6 (0.1%) | 214 (2.3%) |
| 2019 (*n* = 11,755) | 5,044 (42.9%) | 157 (1.3%) | 190 (1.6%) | 18 (0.2%) | 597 (5.1%) |
| 2020 (*n* = 9,925) | 4,234 (42.7%) | 150 (1.5%) | 153 (1.5%) | 20 (0.2%) | 554 (5.6%) |
| 2021 (*n* = 11,918) | 5,145 (43.2%) | 224 (1.9%) | 159 (1.3%) | 19 (0.2%) | 646 (5.4%) |
| 2022 (*n* = 11,917) | 5,546 (46.5%) | 235 (2.0%) | 142 (1.2%) | 10 (0.1%) | 661 (5.5%) |
| 2023 (*n* = 12,076) | 6,143 (50.9%) | 292 (2.4%) | 145 (1.2%) | 16 (0.1%) | 715 (5.9%) |
| 2024 (*n* = 12,992) | 6,646 (51.2%) | 383 (2.9%) | 139 (1.1%) | 30 (0.2%) | 896 (6.9%) |
| Total (%) | 36,235 (45.42%) | 1,528 (1.92%) | 1,035 (1.30%) | 119 (0.15%) | 4,283 (5.37%) |

*CT,* computed tomography; *MRI,* magnetic resonance imaging.




**Figures 2a–b.** Trends in CT use (Figure 2a) and MRI use (Figure 2b) over the seven-year study period. Note the vertical axis for Figure 2b has a maximum of 5%, given the low frequency of use in our emergency department, in a study of emergency department evaluation and management of headache from 2018–2024.

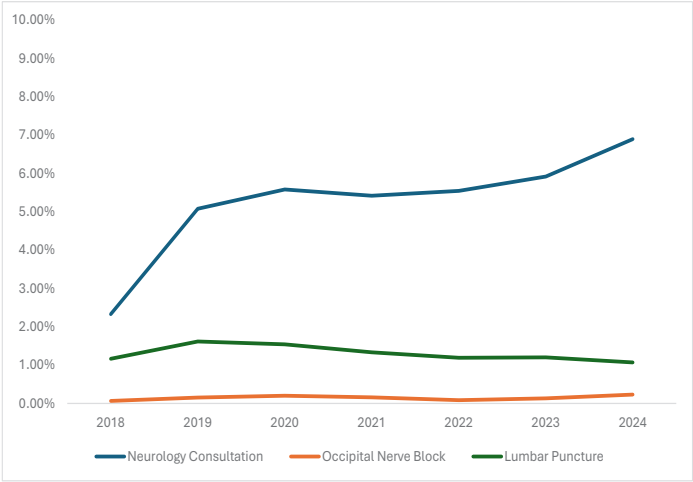



**Figure 3.** Trends in lumbar puncture, nerve block, and inpatient neurology consultation over the seven-year study period, in a study of emergency department evaluation and management of headache from 2018–2024.

(26.5% vs 13.4%), antihypertensives (15.6% vs 1.0%), and antiseizure medications (3.2% vs 0.2%).

## Imaging and Procedural Trends

A summary of imaging studies, lumbar punctures, nerve blocks, and neurology consultations is shown in Table 3. Computed tomography use rose from 37.9% in 2018 to 51.2% in 2024. Magnetic resonance imaging use increased from 0.95% to 2.95%. Lumbar puncture rates remained stable (~1.2%). Neurology consultations increased three-fold, from 2.3% in 2018 to 6.9% in 2024.

## Length of Stay: Unadjusted Medication Associations

The overall median LOS was 183 minutes (interquartile range [IQR], 119–276). For encounters without any medication, imaging, procedure, or consultation, the baseline median LOS was 106 minutes (IQR, 62–172). Table 4 presents the corrected Mann-Whitney *U* test results comparing median LOS by medication. Administration of NSAIDs (median 180 vs 185 minutes; difference, −5 min; $P = .42$) and triptans (177 vs 183 min; difference, −6 minutes; $P = .49$) were not

associated with longer LOS. Diphenhydramine showed a statistically significant but clinically negligible difference (182 vs 183 minutes; difference, −1 minute; $P < .001$), likely driven by the large sample size.

Antiseizure medications were associated with the greatest LOS difference (+136 minutes; median 318 vs 182 minutes; $P < .001$), followed by IV magnesium (+101 minutes; $P < .001$), opioids (+89 minutes; $P < .001$), benzodiazepines (+72 minutes; $P < .001$), antihypertensives (+69 minutes; $P < .001$), and acetaminophen (+68 minutes; $P < .001$). Detailed results including IQR for each comparison are presented in Table 4.

**Length of Stay: Multivariable-Adjusted Analysis**

The multivariable ordinary least squares regression model ($N = 76{,}688$; $R^2 = .40$) is presented in Table 5. After adjusting for age, sex, ESI, disposition, imaging, procedures, consultations, site, and year, the medications most strongly associated with longer LOS were antiseizure medications (+85.1 minutes; 95% CI, 76.0–94.3; $P < .001$), acetaminophen (+40.9 minutes; 95% CI, 38.8–42.9; $P < .001$), benzodiazepines (+38.6 minutes; 95% CI, 35.1–42.1; $P < .001$), and opioids (+37.5 minutes; 95% CI, 34.7–40.2; $P < .001$).

Triptans showed a notable adjusted association (+34.6 minutes; 95% CI, 27.8–41.4; $P < .001$), which contrasts with the unadjusted null finding and likely reflects residual confounding: triptan recipients tend to be less acutely ill (fewer CT, lower admission rates), and adjusting for these factors unmasks the time associated with triptan administration itself. Nonsteroidal anti-inflammatory drugs showed a small but significant adjusted association (+4.7 minutes; 95% CI, 2.7–6.7; $P < .001$). Diphenhydramine was not independently associated with LOS after adjustment (+1.3 minutes; 95% CI, −0.9 to 3.5; $P = .25$).

Among nonmedication covariates, hospital admission was associated with +71.1 minutes (95% CI, 68.3–73.8), lumbar puncture with +153.5 minutes (95% CI, 146.2–160.8), MRI with +125.9 minutes (95% CI, 119.8–131.9), CT with +44.2 minutes (95% CI, 42.4–46.0), and neurology consultation with +41.2 minutes (95% CI, 37.3–45.1).

Quantile regression at the median (pseudo $R^2 = .27$) confirmed similar patterns: antiseizure medications (+40.2 minutes), IV fluids (+31.3 minutes), opioids (+29.7 minutes), IV magnesium (+28.3 minutes), and acetaminophen (+27.4 minutes) had the largest adjusted median effects. Diphenhydramine showed a small significant median effect (+2.8 minutes; $P < .001$) but was of negligible clinical magnitude.

**Length of Stay: Imaging and Procedures**

Median LOS for imaging and procedures are summarized in Table 6. Patients without imaging, procedures, or consultation had a median LOS of 145 minutes. Computed tomography imaging was associated with a median of 228 minutes, MRI with 348–399 minutes, lumbar puncture with 444 minutes, and neurology consultation with 293 minutes. The association between imaging use and LOS is expected, as

**Table 4.** Unadjusted associations between medication administration and emergency department length of stay.

| Medication | *n* given | Median LOS given (IQR) | *n* not given | Median LOS not given (IQR) | Difference (min) | *P* value |
|---|---|---|---|---|---|---|
| Antiseizure medications | 632 | 318 (213–499) | 78,895 | 182 (119–274) | +136 | < .001 |
| IV magnesium | 1,458 | 282 (213–389) | 78,069 | 181 (118–273) | +101 | < .001 |
| Opioids | 9,167 | 263 (178–383) | 70,360 | 174 (114–261) | +89 | < .001 |
| Benzodiazepines | 4,807 | 251 (172–376) | 74,720 | 179 (117–269) | +72 | < .001 |
| Antihypertensives | 4,105 | 249 (161–372) | 75,422 | 180 (117–270) | +69 | < .001 |
| Acetaminophen | 17,421 | 238 (159–355) | 62,106 | 170 (112–255) | +68 | < .001 |
| IV fluids | 36,444 | 207 (146–299) | 43,083 | 159 (96–254) | +48 | < .001 |
| Ondansetron | 12,110 | 219 (145–331) | 67,417 | 177 (115–266) | +42 | < .001 |
| Corticosteroids | 7,598 | 208 (141–311) | 71,929 | 180 (117–272) | +28 | < .001 |
| Dopamine antagonists | 22,731 | 196 (133–291) | 56,796 | 178 (113–270) | +18 | < .001 |
| Diphenhydramine | 22,315 | 182 (126–266) | 57,212 | 183 (116–280) | −1 | < .001 |
| NSAIDs | 31,001 | 180 (124–263) | 48,526 | 185 (115–284) | −5 | .42 |
| Triptans | 1,136 | 177 (113–280) | 78,391 | 183 (119–276) | −6 | .49 |

Results of the Mann-Whitney U test comparing emergency department (ED) length of stay (LOS) by medication administration status. Median LOS with interquartile range (IQR) is shown for encounters where the medication was given versus not given. Difference is the median LOS when given minus the median LOS when not given. A positive difference indicates longer LOS when the medication was administered. Analytic sample: $N = 79{,}527$ encounters with LOS > 0 and at most 1,440 minutes, in a study of ED management of headache from 2018–2024.
*IQR*, interquartile range; *IV*, intravenous; *LOS*, length of stay; *min*, minutes; *NSAID*, nonsteroidal anti-inflammatory drug.

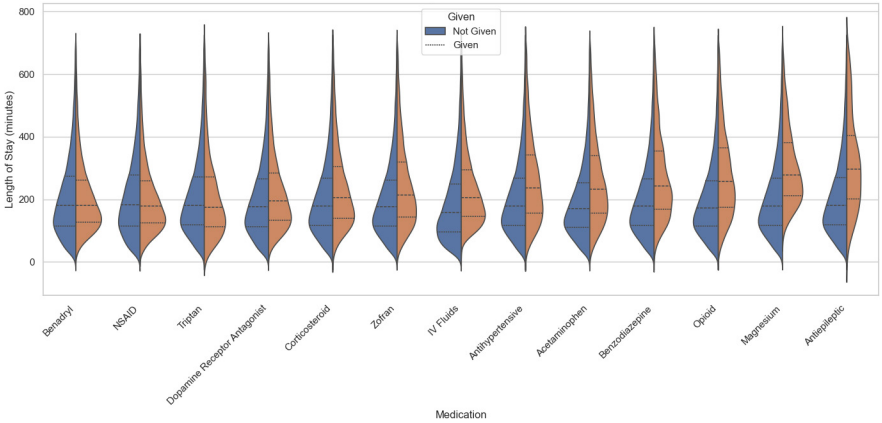



**Figure 4.** Violin plot of the distribution of length of stay, stratified by whether the medication was given (orange) or not given (blue), in a study of emergency department management of headache from 2018–2024.

**Table 5.** Multivariable-adjusted associations between emergency department interventions and length of stay.

| Panel A: Medication coefficients | | | | | | |
|---|---|---|---|---|---|---|
| Variable | OLS Coefficient (min) | 95% CI | *P* value | QR Coefficient (min) | 95% CI | *P* value |
| Antiseizure medications | +85.1 | 76.0, 94.3 | < .001 | +40.2 | 33.1, 47.3 | < .001 |
| Acetaminophen | +40.9 | 38.8, 42.9 | < .001 | +27.4 | 25.8, 28.9 | < .001 |
| Benzodiazepines | +38.6 | 35.1, 42.1 | < .001 | +26.6 | 23.9, 29.3 | < .001 |
| Opioids | +37.5 | 34.7, 40.2 | < .001 | +29.7 | 27.6, 31.9 | < .001 |
| Triptans | +34.6 | 27.8, 41.4 | < .001 | +22.0 | 16.8, 27.3 | < .001 |
| IV Magnesium | +32.4 | 26.1, 38.6 | < .001 | +28.3 | 23.5, 33.2 | < .001 |
| IV Fluids | +30.3 | 28.3, 32.3 | < .001 | +31.3 | 29.7, 32.8 | < .001 |
| Antihypertensives | +28.2 | 24.3, 32.2 | < .001 | +11.9 | 8.9, 15.0 | < .001 |
| Ondansetron | +15.1 | 12.7, 17.5 | < .001 | +13.3 | 11.5, 15.2 | < .001 |
| Corticosteroids | +13.9 | 11.0, 16.7 | < .001 | +10.4 | 8.2, 12.6 | < .001 |
| Dopamine antagonists | +13.2 | 11.1, 15.4 | < .001 | +8.4 | 6.8, 10.1 | < .001 |
| NSAIDs | +4.7 | 2.7, 6.7 | < .001 | +4.2 | 2.7, 5.8 | < .001 |
| Diphenhydramine | +1.3 | −0.9, 3.5 | .252 | +2.8 | 1.1, 4.5 | .001 |

| Panel B: Other covariates | | | |
|---|---|---|---|
| Variable | OLS Coefficient (min) | 95% CI | *P* value |
| Lumbar puncture | +153.5 | 146.2, 160.8 | < .001 |
| MRI performed | +125.9 | 119.8, 131.9 | < .001 |
| Admitted/observed | +71.1 | 68.3, 73.8 | < .001 |
| CT Performed | +44.2 | 42.4, 46.0 | < .001 |
| Neurology consultation | +41.2 | 37.3, 45.1 | < .001 |
| Female sex | +3.5 | 1.7, 5.3 | < .001 |
| Age (per year) | +0.6 | 0.6, 0.7 | < .001 |
| ESI 1 (vs ESI 3) | −151.1 | −158.2, −144.1 | < .001 |
| ESI 2 (vs ESI 3) | −28.8 | −31.5, −26.0 | < .001 |
| ESI 4 (vs ESI 3) | −15.2 | −17.7, −12.7 | < .001 |
| ESI 5 (vs ESI 3) | −25.2 | −35.3, −15.2 | < .001 |

*CT,* computed tomography; *ED,* emergency department; *ESI,* Emergency Severity Index; *min,* minutes; *MRI,* magnetic resonance imaging; *OLS,* ordinary least squares; *QR,* quantile regression.

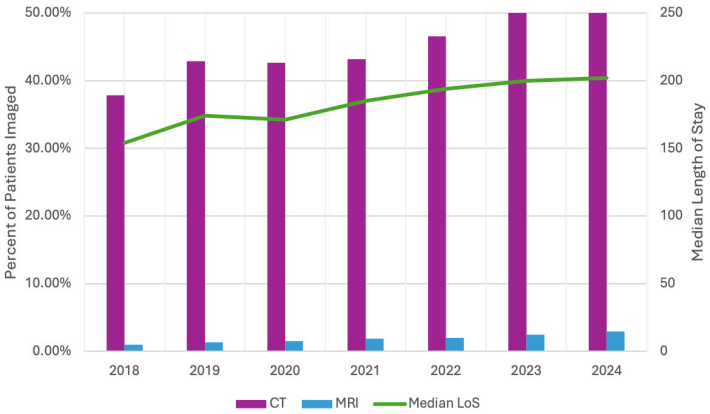



**Figure 5.** Bar–line chart depicting the correlation between computed tomography and magnetic resonance imaging and median length of stay, in a study of emergency department evaluation and management of headache from 2018–2024. *CT,* computed tomography; *LOS,* length of stay; *MRI,* magnetic resonance imaging.

imaging inherently adds to the ED workup duration.

### Stratified Analysis by Headache Type

Primary headache encounters (*n* = 15,413) had a median LOS of 153 minutes (IQR, 105–224), compared with 204 minutes (IQR, 126–317) for secondary headaches (*n* = 11,147) and 189 minutes (IQR, 123–282) for unspecified headaches (*n* = 52,967). Within the primary headache subgroup, the direction and rank order of medication–LOS associations were generally consistent with the full cohort. Intravenous magnesium (+96 min), opioids (+68 minutes), benzodiazepines (+65 minutes), and acetaminophen (+62 minutes) remained the medications most strongly associated with longer LOS. Nonsteroidal anti-inflammatory drugs (+5 minutes; $P < .001$) and triptans (+7 minutes; $P = .09$) were not associated with clinically meaningful differences.

In the multivariable regression restricted to primary headaches (n = 14,634; $R^2 = .47$), opioids (+33.6 minutes; 95% CI, 28.0–39.2), triptans (+30.9 minutes; 95% CI, 24.3–37.6), IV magnesium (+30.2 minutes; 95% CI, 22.3–38.0), and acetaminophen (+30.3 minutes; 95% CI, 26.3–34.3) were the strongest independent medication predictors. Nonsteroidal anti-inflammatory drugs were not significant (−0.5 minutes; $P = .74$). Antiseizure medications were not significant in this subgroup (+10.4 minutes; $P = .50$), likely due to very small numbers (*n* = 29). Full stratified results are provided in the Supplemental Tables.

**Table 6.** Median length of stay stratified by imaging, procedures, and neurology consultation, in a study of emergency department evaluation and management of headache from 2018–2024.

| Procedure/imaging | Median LOS (min) | Number of patients |
|---|---|---|
| No Imaging, procedure, or consult | 145 | 43,081 |
| CT imaging only | 228 | 35,161 |
| MRI imaging only | 348 | 454 |
| CT and MRI imaging | 414 | 1,074 |
| Nerve block | 338 | 119 |
| Lumbar Puncture (LP) | 444 | 1,035 |
| Neurology consultation | 293 | 4,283 |
| MRI and neurology consultation | 426 | 594 |

*CT,* computed tomography; *LOS,* length of stay; min, minutes; *MRI,* magnetic resonance imaging.

### Sensitivity Analyses

Results were robust across sensitivity analyses. When restricted to discharged patients only (*n* = 64,559; median LOS 170 minutes), the rank order of medication–LOS associations was preserved, with antiseizure medications (+124 minutes), IV magnesium (+91 minutes), and opioids (+68 minutes) remaining the top three. When using a 720-minute (12-hour) LOS exclusion threshold (*n* = 78,612), results were virtually identical to the primary analysis.

## DISCUSSION

Our analytic sample of 79,527 adult ED encounters for headache across 22 EDs over a seven-year period represents, to our knowledge, the largest reported cohort evaluating headache management and ED LOS. The overall median LOS of 183 minutes falls within the range reported in prior published cohorts (186–381 minutes).[10-13] Our findings are also broadly consistent with a nonpeer-reviewed ACEP Research Forum abstract by Wang, which reported that route of administration and drug class were each correlated with LOS in primary-headache ED visits in a single-institution cohort.[14] The convergence of medication–LOS associations across that independent single-institution dataset and our multicenter cohort strengthens the inference that these patterns are not artifacts of any single institution's case-mix or operational model. We found that most pharmacologic interventions, aside from NSAIDs and triptans, were associated with longer LOS in both unadjusted and multivariable-adjusted analyses. Importantly, our cohort included a heterogeneous mix of primary headaches (19.4%), secondary headaches (14.0%), and unspecified headache diagnoses (66.6%), which influences the interpretation of these findings.

### Medication–Length of Stay Associations

The most commonly administered therapies—IV fluids, NSAIDs, and dopamine antagonists—largely align with current consensus guidelines.[3,13,15] Nonsteroidal anti-

inflammatory drug administration was not associated with longer LOS in unadjusted analysis and showed only a small adjusted association (+4.7 minutes), consistent with their role as first-line agents for acute headache. Dopamine antagonists showed a modest unadjusted association (+18 minutes) that attenuated in the adjusted model (+13.2 minutes), supporting their use as efficient first-line therapy. Randomized trials have demonstrated that prochlorperazine with diphenhydramine results in sustained headache relief with less likelihood of headache recurrence within 48 hours compared to hydromorphone[16] and faster reduction in pain intensity compared to sumatriptan.[17]

Diphenhydramine, often co-administered with dopamine antagonists, showed no clinically meaningful unadjusted difference (−1 minute) and was not significant after adjustment (+1.3 minutes; $P = .25$). This is consistent with evidence suggesting that diphenhydramine does not significantly impact headache outcomes.[18,19]

Antiseizure medications, opioids, benzodiazepines, and IV magnesium were associated with the longest LOS in both unadjusted and adjusted analyses. However, these associations must be interpreted cautiously. Patients receiving these medications likely represent more severe or refractory presentations requiring treatment escalation, and thus these medications may serve as markers of clinical complexity rather than independent drivers of prolonged stays. This interpretation is supported by the observation that admission status—a proxy for clinical severity—was independently associated with +71.1 minutes of LOS in the adjusted model.

Opioid use remained stable over the study period (11.2–11.7%), which compares favorably to national datasets from 2010 reporting opioid use in 49–59% of headache-related ED visits.[20,21] Both the AHS and ACEP guidelines recommend against routine opioid use for acute headache.[3,6] Similarly, benzodiazepine use remained stable at approximately 6%, and current guidelines recommend against their use for acute headache treatment.[3,6]

### Imaging and Consultations

Diagnostic testing and consultations were associated with progressively longer LOS, as expected given the inherent time required for these evaluations. Computed tomography use rose from 37.9% to 51.2% over the study period, a trend consistent with broader patterns of increasing neuroimaging use.[6,13,22,23] Notably, higher imaging and consultation rates may be clinically appropriate, particularly among the 14% of encounters with secondary headache diagnoses (hemorrhage, stroke, meningitis), where advanced workup is indicated.

An important contextual factor was the West Nile virus outbreak in Maricopa County, Arizona, between May and December 2021, which likely increased lumbar puncture, neuroimaging, and neurology consultation rates during that period.[24]

### Stratified Findings

Primary headache encounters had shorter median LOS (153 minutes) and higher rates of guideline-concordant medications (dopamine antagonists 50.1%, NSAIDs 64.2%), while secondary headache encounters had longer LOS (204 minutes) and higher rates of opioids (20.0%), antihypertensives (15.6%), and antiseizure medications (3.2%). These differences underscore the importance of stratification when interpreting LOS associations in a diagnostically heterogeneous cohort.

### Adjusted vs. Unadjusted Results

The multivariable model ($R^2 = .40$) explained a substantial proportion of LOS variability and provides a more accurate picture of independent medication–LOS associations. Several notable differences emerged between unadjusted and adjusted results: triptans showed no unadjusted difference but a significant adjusted association (+34.6 minutes), likely reflecting that triptan recipients are selected lower acuity patients whose shorter raw LOS masks the actual time associated with administration. Conversely, the large unadjusted associations for opioids and antiseizure medications attenuated in the adjusted model (from +89 to +37.5 minutes for opioids; from +136 to +85.1 minutes for antiseizure medications), confirming substantial confounding by indication.

### Future Directions

Prospective studies and quality improvement initiatives evaluating standardized headache management protocols are needed to determine whether observed LOS differences can be reduced while maintaining or improving patient-centered outcomes including pain relief, recurrence rates, and patient satisfaction—not only operational throughput.

## LIMITATIONS

This study has several important limitations. First, the retrospective observational design precludes causal inference. Observed associations between medications and LOS may reflect confounding by indication: Patients with more severe or refractory headaches receive more interventions and independently have longer stays. While multivariable adjustment mitigates this bias, unmeasured confounders (eg, pain severity, comorbidities, prior ED visits) may persist. Second, our cohort includes a heterogeneous mix of primary headache, secondary headache, and diagnostically unspecified encounters. Although we performed stratified analyses, the large proportion of unspecified diagnoses (66.6%) limits the precision of headache-type classification. Medication and imaging patterns that appear discordant with primary headache guidelines may be clinically appropriate for secondary or undifferentiated headache presentations.

Third, potential timing bias exists: Medications administered later in the ED course (eg, as rescue therapy or

after failed initial treatment) will inherently be associated with longer LOS, even if they do not independently prolong the stay. Medication timing data (time to first medication) were not available in our dataset. Fourth, we did not adjust for ED crowding, boarding, or staffing levels, which are known to affect LOS independently of clinical factors. Fifth, confounding variables including patient acuity beyond ESI, comorbid conditions, and concurrent treatments were not fully adjusted for. Medications may serve as proxies for more complex clinical presentations. Additionally, we did not examine whether patients were established with outpatient neurology consultants with existing care plans.

Finally, due to the nonrandomized nature of medication administration, observed associations may not accurately reflect causal relationships. However, the multicenter design, large sample size, seven-year study period, and the addition of multivariable-adjusted analyses enhance the validity and applicability of our findings.

## CONCLUSION

In this multicenter retrospective study of 79,527 ED headache encounters, most pharmacologic interventions—aside from NSAIDs and triptans—were associated with longer LOS in both unadjusted and multivariable-adjusted analyses. These associations likely reflect a combination of direct treatment effects and confounding by indication. Prospective studies evaluating standardized headache management protocols and their effects on both operational and patient-centered outcomes are needed.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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# Impact of Ultrasound-Guided Peripheral Intravenous Training on Central Line Placement in the Emergency Department

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**Introduction**: Central venous catheters are placed in the emergency department (ED) when difficult peripheral access limits care or when critical medications require central access because of their sclerotic nature or incompatibility with other drugs. Ultrasound-guided peripheral intravenous (IV) access offers a less invasive alternative. We evaluated whether implementation of a structured ultrasound-guided peripheral intravenous training program for ED nurses and technicians was associated with changes in ED central venous catheter use.

**Methods**: We performed a retrospective chart review at our 50-bed academic community ED, which holds a Level II trauma designation. This center has an ED census of 80,000 patients per year, a 4:1 nursing to patient ratio with an admission rate of 20-25% with expected monthly variation. A structured ultrasound-guided peripheral IV curriculum for nurses and technicians launched in November 2023. The primary endpoint was annual ED central venous catheter placement count, identified through procedure documentation in the electronic health record. Training that was conducted for nurses and clinical technicians consisted of three hours of didactic and hands-on training, followed by a period of procedural supervision. We compared the baseline year 2022 with the first two full post-implementation years, 2024 and 2025. The analysis was descriptive.

**Results**: Central venous catheter placements in the ED decreased from 387 in 2022 to 275 in 2024 and 218 in 2025, corresponding to absolute reductions of 112 placements (28.9%) and 169 placements (43.7%), respectively. By the end of 2025, 33 nurses and ED technicians had completed training and competency sign-off.

**Conclusion**: Implementation of a structured ultrasound-guided peripheral IV training program for nurses and technicians was associated with fewer ED central venous catheter placements at our institution. These findings support further multicenter evaluation using patient-level outcomes and visit-adjusted rates. [West J Emerg Med. 2026;27(5)1447–1451.]

## INTRODUCTION

Establishing vascular access is fundamental to emergency care. In patients with difficult intravenous (IV) access, repeated failed peripheral attempts can lead to escalation to physician-performed ultrasound-guided peripheral IV (USPIV) placement or, in selected cases, central venous catheter (CVC) placement. Although CVCs can be critical to patient care, it is invasive and carries meaningful mechanical, infectious, and thrombotic risk.[1,2]

Ultrasound-guided peripheral IV placement improves

vascular access success in difficult-access patients and can provide an alternative to more invasive access strategies.[4] Prior studies have also shown that nurse- and technician-performed USPIV can be taught successfully in emergency and hospital settings.[5–8] At our institution, difficult-access escalation historically depended on clinician availability and operator comfort with bedside ultrasound. Expanding USPIV capability to nurses and technicians offered a plausible systems-level mechanism to reduce avoidable CVC placement for access alone. The objective of this study was to investigate whether an association between implementation of a structured USPIV training and competency program for emergency department (ED) nurses and technicians and subsequent ED CVC placement counts existed.

*Population Health Research Capsule*

What do we already know about this issue?
*Ultrasound-guided peripheral intravenous (USPIV) placement can improve access in difficult-IV patients and may reduce use of more invasive vascular access.*

What was the research question?
*Was nurse/technician USPIV training associated with fewer emergency department (ED) central lines?*

What was the major finding of the study?
*Placememt of central lines in the ED fell 43.7% after training: 387 in 2022 vs 218 in 2025.*

How does this improve population health?
*Expanding frontline USPIV may reduce invasive central line use, thereby lowering complication risks and potentially saving about $136,000 annually.*

## METHODS

We performed a retrospective chart review at our 50-bed academic community hospital with Level II trauma designation and an annual ED census of approximately 80,000 visits. The investigation was designed as an operational quality-improvement evaluation of a vascular access training initiative rather than a hypothesis-testing study.

The USPIV training program launched in November 2023. The curriculum included didactic instruction, simulation, supervised bedside scanning and cannulation, and competency sign-off by ultrasound-trained emergency medicine faculty. Monthly classes were offered during the implementation period. A total of 33 nurses and ED technicians completed training and competency by the end of 2025. Because exact monthly attendance counts were not retained, training volume is reported cumulatively rather than month by month. In the ED at our hospital, a 4:1 nursing ratio is maintained; and by the end of 2025, 20.6% of the department's nursing and technical workforce were competent in the USPIV procedure.

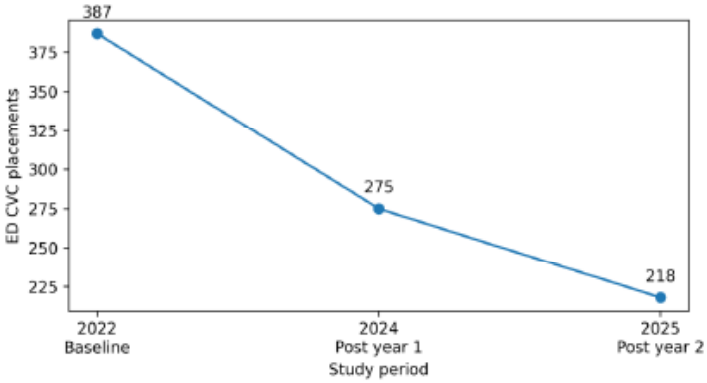


**Figure 1.** Number of central venous catheter placements in the emergency department annually across study periods before and after the rollout of an ultrasound-guided peripheral intravenous placement program.
The 2023 rollout year was excluded from the primary comparison due to November 2023 program launch date.
*CVC,* central venous catheter*; ED,* emergency department.

The program was available within a department that also supports physician and advanced practice practitioner ultrasound education; however, this initiative primarily emphasized bedside nurses and ED technicians because they perform the earliest vascular access attempts in local workflow. Independent competency required successful completion of the curriculum and supervised clinical sign-off. The threshold for independent procedural competency was 10 supervised USPIVs; this threshold was retained as the operational standard during rollout.

The primary endpoint was the annual number of ED CVC placements. Data were extracted from the Epic electronic health record system (Epic Systems Corp). using the SlicerDicer function. Queries were limited to procedure documentation attributable to ED attending and resident physicians to avoid misclassification from lines placed by non-ED services in boarded patients. The 2022 calendar year served as the baseline preintervention period. The 2023 implementation year was excluded from the primary pre/post comparison because only November and December were exposed to the intervention. The first and second full postimplementation years were 2024 and 2025.[3]

This retrospective analysis was structured according to the

guidelines for retrospective chart review outlined by Worster et al.[3] Analyses were descriptive only. Table 1 summarizes the methodological criteria and their corresponding descriptions relevant to this analysis, as adapted from Worster et al.[3] Because available data consisted of aggregated administrative procedure counts without patient-level covariates, indication-level adjudication, or consistently available ED-visit denominators for rate calculation, we did not perform formal inferential testing or interrupted time-series modeling. Absolute and relative differences from the baseline are reported.

## RESULTS

In the baseline year 2022, we identified 387 CVC placements in the ED, After the November 2023 program launch, the first full post-implementation year (2024) included 275 placements, an absolute reduction of 112 procedures and a relative reduction of 28.9% from baseline. In 2025, 218 CVC placements in the ED were identified, an absolute reduction of 169 procedures and a relative reduction of 43.7% from baseline. Month-by-month counts for 2022, 2024, and 2025 are shown in Figure 2 to illustrate the temporal distribution across study years.

By the end of 2025, 33 nurses and ED technicians had completed USPIV training and competency. There appeared to be an increase in USPIV documentation after implementation in ancillary reports reviewed during manuscript development; however, because USPIV procedure capture was incomplete and inconsistent across clinician groups, USPIV counts were not analyzed as a formal secondary endpoint.

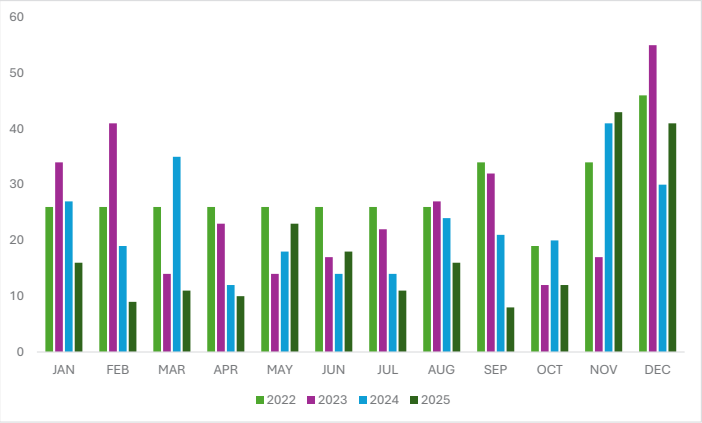


**Figure 2.** Month-by-month emergency department central venous catheter placements in 2022, 2024, and 2025.
*CVC,* central venous catheter.

**Table 1.** Methodological features of a retrospective chart review that evaluated whether a structured ultrasound-guided peripheral intravenous training program for nurses was associated with changes in use of central venous catheter use in the emergency department.

| Methodologic Element | Description |
|---|---|
| Study design | Retrospective descriptive chart review / quality-improvement evaluation |
| Setting | Single academic community ED, Level II trauma center, ~80,000 annual visits |
| Intervention | Structured USPIV training and competency program for ED nurses and technicians launched November 2023 |
| Primary endpoint | Annual number of ED CVC placements |
| Data source | Epic EHR queried with SlicerDicer |
| Inclusion | ED CVC procedure documentation attributed to ED attending and resident physicians |
| Exclusion | Central lines placed by non-ED services in boarded/admitted patients |
| Analytic periods | 2022 baseline; 2024 and 2025 full post-implementation years; 2023 rollout year excluded from primary comparison |

*CVC,* central venous catheter; *ED*, emergency department; *EHR*, electronic health record; *USPIV,* ultrasound-guided peripheral intravenous.

## DISCUSSION

In this single-center retrospective analysis, implementation of a structured USPIV training and competency program for ED nurses and technicians was associated with a sustained decrease in annual ED CVC placement counts over the subsequent two full calendar years. Because the study endpoint was aggregate CVC use rather than patient-level access indication, our findings are best interpreted as a systems-level association rather than proof of causation.

These findings are directionally consistent with prior studies showing that nonphysician USPIV training can reduce reliance on more invasive vascular access devices. Galen et al reported decreased use of peripherally inserted central catheters and midline catheters after nurse USPIV training on an inpatient unit; and Amick et al found reduced midline use after a hospital-wide simulation-based mastery learning curriculum for inpatient nurses.[9,10]

The emergency medicine literature also supports the feasibility of nurse- and technician-performed USPIV. Earlier studies demonstrated successful emergency nurse USPIV adoption and technician training with physician-level success rates, supporting the plausibility that broader frontline USPIV capability can change escalation patterns for difficult vascular access.[5–7] The present study extends that literature by focusing specifically on CVC use in the ED after a nurse- and technician-focused training initiative. In local workflow, difficult access previously escalated to physician involvement when bedside attempts failed. Increasing frontline USPIV capability plausibly reduced the need for escalation to physician-performed invasive access in at least some patients whose primary barrier was

**Table 2.** Annual central venous catheter placements in the emergency department before and after implementation of an ultrasound-guided peripheral intravenous placement program.

| Year | Study Phase | ED CVC Placements | Change vs. 2022 Baseline |
|---|---|---|---|
| 2022 | Preintervention baseline | 387 | Reference |
| 2023 | Rollout year (November-December exposed) | Excluded from primary comparison | Partial implementation year |
| 2024 | First full postimplementation year | 275 | -112 (−28.9%) |
| 2025 | Second full postimplementation year | 218 | -169 (−43.7%) |

*CVC*, central venous catheter; *ED*, emergency department.

vascular access rather than a true central-access indication.

As with the implementation of any clinical QI initiative, this program was associated with modest upfront costs. Importantly, these costs were minimized by leveraging the existing infrastructure of our emergency ultrasound program, which includes dedicated emergency ultrasound faculty, an established ultrasound service line, fellowship leadership, a residency director, and two active fellows. Development of asynchronous educational content was completed as part of routine emergency ultrasound faculty educational responsibilities and supported through existing stipends. Live didactic instruction, simulation-based training, and initial physician-supervised clinical practice were similarly incorporated into established physician educational and clinical compensation models and did not generate additional direct institutional costs.

Nursing staff participating in in-person training were compensated at their standard hourly rate for three hours of training, inclusive of initial supervised clinical practice, at an average rate of $49 per hour (range, $38-$61). Additional supervised clinical practice required to achieve competency occurred during regularly scheduled nursing shifts and did not result in incremental compensation beyond existing staffing costs. Technicians were compensated under the same training time framework at an average hourly rate of $22 (range, $19-$24). Accordingly, the mean direct training cost was $148 per nurse and $65 per ED technician. Based on 33 trained staff by the end of 2025, the total direct training cost was $3,974, which corresponds to approximately $1,325 per year when annualized across the initial three-year implementation period. Using our hospital's estimated direct cost of $811 per ED CVC placement and the observed reduction of 169 CVCs in 2025 compared with the 2022 baseline, a simple program-level estimate suggests $137,132 in gross annual avoided CVC cost. After subtracting the annualized training expense, this corresponds to an approximate net annual savings of $135,807.

**Table 3**: Central venous line complication rates and associated cost.[11–14]

| Complication | Rate per 100 Lines Placed | Cost Estimate |
|---|---|---|
| Infection (CLABSI) | 3 | $16,000-$29,000 |
| Thrombosis | 5 | $10,000 - $25,000 |
| Pneumothorax | 1 | $5,000 - $20,000 |
| Death | 0.5 | $50,000 - $200,000 |

*CLABSI,* central line-associated bloodstream infection.

This estimate assumes that the observed reduction in CVC use was attributable to the training program and that many avoided CVCs were replaced by lower cost peripheral access pathways, most commonly USPIV, rather than reflecting case-mix changes alone. It also does not include potential downstream savings from avoidance of CVC-related complications, which may be substantial and further improve the economic value of the program. Taken together, these findings suggest that this program can be implemented in a cost-conscious, scalable, and financially favorable manner within institutions possessing established ultrasound infrastructure.

Importantly, we did not measure access-related complications, time to treatment, length of stay, patient satisfaction, or direct costs; those outcomes should not be inferred from the present data. Future work should prioritize rate-based analyses using ED visit denominators, patient-level review of CVC indications, and downstream outcome measures such as complications, throughput, and patient experience.

## LIMITATIONS

This study has several limitations. First, it was conducted at a single institution with an established emergency ultrasound infrastructure, which may limit generalizability. Second, the retrospective design and reliance on administrative procedure documentation create risk of missing or misclassified data. Third, the primary analysis used aggregated annual counts without patient-level covariates, limiting adjustment for secular trends or other concurrent practice changes. Fourth, we did not have consistently available ED-visit denominators for rate calculation; therefore, the results are reported as counts rather than rates per 1,000 visits. Fifth, we could not reliably adjudicate which CVCs

were placed exclusively for difficult peripheral access versus other clinical indications. Finally, USPIV procedure documentation was not sufficiently complete across clinician groups to support a robust secondary endpoint analysis.

## CONCLUSION

Implementation of a structured USPIV training and competency program for ED nurses and technicians was associated with a sustained reduction in ED CVC placement counts at our institution. These findings support further study of non-physician USPIV capability as a strategy to reduce potentially avoidable invasive vascular access while preserving appropriate central access for patients who truly need it.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No other author has professional or financial relationships with any companies that are relevant to this study. There are no other conflicts of interest or sources of funding to declare.

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# A Procedural Faculty Development Course for Emergency Physicians Practicing in Community and Academic Settings

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**Introduction:** Maintaining competence in high-acuity, low-occurrence (HALO) procedures poses a challenge for emergency physicians as they progress past residency training or practice in lower-acuity settings. Simulation-based deliberate practice offers a feasible method to sustain procedural competence. We developed and evaluated a blended, faculty development procedural curriculum designed to improve confidence and clinical application of HALO skills across a five-hospital emergency medicine (EM) network.

**Methods:** A faculty needs assessment and departmental quality data informed the creation of a 4-hour procedural curriculum course. The blended curriculum included asynchronous precourse procedural guides and videos followed by a 4-hour, in-person deliberate practice session led by peer EM faculty instructors. Year one procedures included cricothyroidotomy, transvenous pacing, catheter thoracostomy, neonatal resuscitation, and peritonsillar abscess drainage. Year two curriculum included fiberoptic nasotracheal intubation, pediatric airway management, ultrasound-guided pericardiocentesis, intraosseous access, lateral canthotomy, balloon tamponade of gastrointestinal hemorrhage, fascia iliaca nerve block, and orthopedic reduction/splinting. All stations used clinical equipment stocked across the enterprise. Anonymous pre- and post-course surveys measured self-reported procedural confidence and global course satisfaction. Procedure billing data and faculty self-report were used to evaluate clinical application.

**Results:** In year one, 62 of 90 (69%) participants completed surveys which demonstrated significant increases in confidence across all procedures ($P < .01$) with high satisfaction (median 5, IQR 5-5). Year two results were similar: 67 of 87 (77%) completed surveys, again showing significant confidence gains ($P < .01$) and high satisfaction (median 5, IQR 5–5). Seventy percent (47 of 67) of year two respondents were returning participants; among them, 68% reported performing at least one procedure reviewed in year one. All reported increased confidence during clinical performance. Peritonsillar abscess drainage increased from 14 procedures precourse to 133 in year one and 83 in year two, with 35% performed in regional hospitals. We observed no change in procedure-related quality incidents.

**Conclusion:** Our faculty procedural curriculum offers a framework that emergency departments can use to support faculty in increasing confidence in performing HALO and other low-frequency procedures. Future research should evaluate the durability of this educational approach, including how long the intervention preserves procedural confidence without decay. [West J Emerg Med. 2026;27(5)1452–1456.]

## BACKGROUND

Maintaining readiness for high-acuity, low-occurrence (HALO) procedures is challenging for emergency physicians as time since residency increases and clinical exposure remains limited. A growing body of literature demonstrates that procedural skills deteriorate over time without deliberate reinforcement.[1] In emergency medicine (EM) contexts, retention of resuscitative and invasive procedural skills decline shortly after simulation-based training despite strong initial learning.[2-4]

Faculty in academic environments may face greater challenges to maintaining procedural competence.[5] Needs assessments and national surveys reveal that emergency physicians are concerned about procedural skill attrition and cite the presence of learners as a key barrier to hands-on experience.[6] Many academic emergency departments also lack standardized systems to evaluate or maintain attending procedural skills.[7] A recent commentary highlights the need for systems to monitor for skill decay even during residency, underscoring the need for longitudinal continuing education strategies.[8]

Simulation-based education offers a well-supported counter measure. Deliberate practice outperforms traditional clinical exposure for skill acquisition,[9] and mastery-learning programs demonstrate durable performance gains with reductions in procedural complications.[10,11] Guidance on simulation-based procedural training emphasizes structured design principles for rarely performed, high-stakes procedures, supporting its relevance for HALO preparedness.[12]

However, much of the literature focuses on trainees rather than practicing emergency physicians,[13] targets single procedures rather than a comprehensive HALO portfolio,[14-16] or emphasizes initial skill acquisition without addressing longitudinal maintenance across distributed practice environments.[17,18] Few published models describe system-wide faculty development curricula and translational outcomes such as subsequent clinical application or system-level procedure use after faculty-focused curricula.[19]

Our EM faculty practice within a geographically distributed health system that includes a tertiary academic center and multiple affiliated community emergency departments. Procedural equipment, specialist availability, and opportunities for hands-on procedural experience vary across sites, creating challenges in maintaining consistent readiness for HALO procedures and contributing to procedural skill decay. These challenges highlight the need for a faculty development curriculum designed to reinforce procedural competence using the equipment and techniques employed in routine clinical practice across the system.

*Population Health Research Capsule*

What do we already know about this issue?
*Procedural skills decay without reinforcement, yet many emergency medicine faculty lack standardized systems to maintain them.*

What was the research question?
*Can a faculty procedural curriculum improve procedural confidence across ED practice settings?*

What was the major finding of the study?
*Self-reported confidence improved for all procedures among participants ($P < .01$).*

How does this improve population health?
*By improving faculty procedural confidence for rare, high-risk ED procedures, this curriculum may support improved care across academic and community sites.*

## OBJECTIVES

The objective of this project was to design, implement, and evaluate a longitudinal, system-wide EM faculty procedural curriculum to support readiness for HALO and other infrequently performed EM procedures across academic and community practice settings. We aimed to increase self-reported procedural confidence, promote subsequent clinical application of targeted procedures, and align training with clinically available equipment, informed by system-level quality priorities. A secondary objective was to assess faculty engagement and early implementation outcomes including participation and satisfaction.

## CURRICULAR DESIGN

We conducted a targeted needs assessment in fall 2022 to inform curriculum content. An anonymous, voluntary survey using REDCap was completed by 78 of 105 EM faculty. We selected 23 procedures, guided by the American Board of Emergency Medicine model of clinical practice,[20] and asked faculty whether they had personally performed each within the prior three years (supervision excluded; simulation or cadaver practice included). Only 10 of 23 procedures were performed by more than 50% of respondents. These findings, together with procedures prioritized by our quality division based on complication trends, informed the initial curriculum by focusing on high-impact skills with low recent exposure. Although most selected procedures aligned with standard HALO classifications, several less acute or higher-frequency procedures were included because the needs assessment demonstrated low recent performance and they were deemed important by our faculty education and training team and departmental leadership.

Five initial index procedures were selected for a half-day course: cricothyroidotomy; transvenous pacing; percutaneous catheter thoracostomy; neonatal resuscitation; and peritonsillar abscess (PTA) drainage. We developed a blended curriculum strategy using Kern's curriculum design framework.[21] The curriculum combined precourse asynchronous review of our previously published and described procedural guides and publicly available instructional videos (YouTube) with a 4-hour in-person interactive session focused on deliberate practice.[22]

Two peer instructors coached each station. Instructors were selected via an internal application process and ranged from one to more than 20 years post residency (predominantly early- to mid-career). Many had fellowship training and demonstrated a track record of successful medical education teaching. Before course launch, instructors completed a 4-hour development session focused on curriculum design and simulation-based procedural training.[23] Instructors met at least quarterly with the course directors to review postcourse survey feedback and implement any curricular refinements.

Each procedure was covered in a 45-minute session with participants rotating through the five stations. Groups were capped at four participants to prioritize coaching and hands-on practice. All stations incorporated task trainers, including primarily novel trainers as well as commercially available standard airway manikins. Ultrasound-focused stations combined standardized patients and phantom task trainers to enhance realism. Each station was stocked with the same procedure kits used across our hospitals to align training with clinical practice.

Instructor assignments were made by the course directors based on instructor preference and relevant expertise. The course was offered six times per academic year and participants were encouraged to attend one session; the curriculum was standardized across sessions. Participation was voluntary though incentivized through the department's existing bonus structure, with attendees receiving an additional 0.75% of annual base salary. Over 90% of faculty participated.

We obtained institutional review board approval to administer anonymous surveys. Participants completed a voluntary postcourse REDCap survey; completion was not tied to any incentive. The survey was completed immediately after the course and included retrospective pre- and post-procedural confidence items and global course ratings. Confidence was measured on a 5-point Likert scale, and paired Wilcoxon signed-rank tests compared pre- and post-responses for statistical significance. Survey instruments are provided as supplementary materials (Appendix 1).

After year one, the curriculum was revised based on faculty surveys of desired procedures, input from the quality division, and review of the initial needs assessment. Year one instructor feedback and prior-year participant survey data also informed year two content; final selections were made by the course directors. The year two curriculum maintained the same five-station, 45-minute small-group format and included fiberoptic nasotracheal intubation, pediatric airway management, ultrasound-guided pericardiocentesis, intraosseous access, lateral canthotomy, balloon tamponade of gastrointestinal hemorrhage, fascia iliaca nerve block, and orthopedic reduction/splinting. Some procedures were paired within a single station to optimize hands-on time and instruction within the 45-minute session. The quality division prospectively monitored procedure-based complications via the hospital error tracking system to identify emerging trends.

## IMPACT/EFFECTIVENESS

In year one, 62 of 90 participants (69%) completed surveys. Participants demonstrated statistically significant increases in self-reported confidence across all targeted procedures ($P < .01$). Global course satisfaction was high (median 5, IQR 5–5). In year two, 67 of 87 participants (77%) completed surveys again showing confidence gains ($P < .01$) with similarly high satisfaction (median 5, IQR 5–5) (Figure). Participant demographics are shown in Table.

Among year two survey respondents, 70% (47 of 67) were returning participants. Sixty-eight percent reported performing a procedure taught in year one, and all of those respondents (100%) reported increased confidence in performing that procedure. As an example, 45% reported performing a PTA

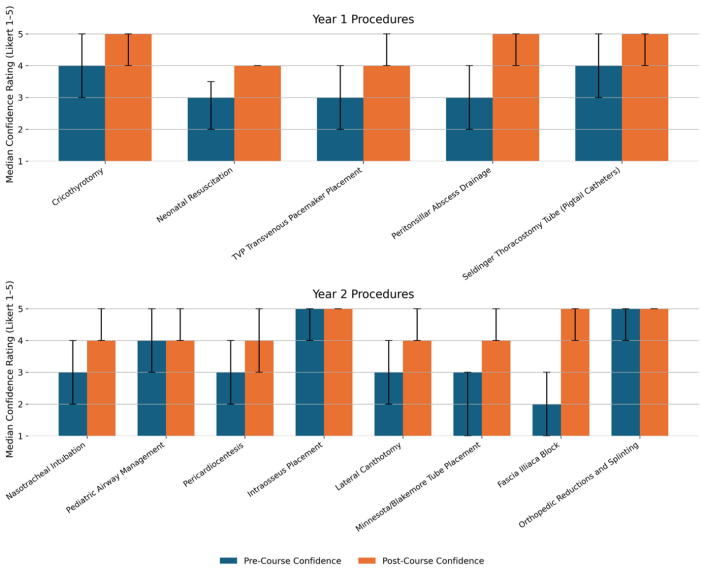


**Figure.** Median pre- and post-course self-reported confidence of faculty participants across procedures during the two-year intervention period. Error bars represent the interquartile range (IQR). Confidence was measured using a 5-point Likert scale (1–5).
Likert scale: 1 = very uncomfortable; would consult and not perform; 2 = uncomfortable; would likely consult but might perform in select situations; 3 = comfortable with need for refresher prior to performance; 4 = comfortable; 5 = very comfortable and confident performing independently.

**Table.** Participant demographics for the 2024 and 2025 Faculty Education and Training (FacET) cohorts. One participant did not report practice environment in 2024; years since residency completion were missing for several respondents (2024: n = 20; 2025: n = 8). Hybrid faculty were defined as those who allocated a portion of their professional effort to both the academic and community practice settings.

| | 2024 | 2025 | Total 2024-25 |
|---|---|---|---|
| Total participants | 62 | 67 | 129 |
| Practice environment | | | |
| Academic | 40 (66%) | 40 (60%) | 80 (63%) |
| Community | 7 (11%) | 18 (27%) | 25 (19%) |
| Hybrid | 14 (23%) | 9 (13%) | 23 (18%) |
| Years from Residency | | | |
| < 5 years | 11 | 18 | |
| 5-10 years | 11 | 12 | |
| > 10 years | 20 | 32 | |

drainage. Our billing data demonstrated that in the year before implementation, emergency physicians drained 14 PTAs across our five hospitals. During year one, PTA drainages increased to 133 followed by 83 in year two. Across both years, 75 of 216 (35%) PTA drainages occurred at our four regional hospitals. These data are limited by reliance on billing records and were not consistently available for other procedures.

Evaluation of this curriculum suggests that a structured, simulation-based approach can enhance faculty confidence for HALO and other lower-frequency procedures. Program success was supported by using supplies that mirrored the clinical environment, departmental support for peer instructors, and financial incentives that encouraged broad participation. Additionally, year two respondents reported clinical application, with 68% performing procedures taught in year one. There was no change in reported quality incidents for these procedures.

Limitations of this study include reliance on self-report rather than patient-level outcomes, the absence of baseline performance or objective competency measures (limiting outcomes to confidence and selected use signals), and a 69% survey response rate with potential nonresponse bias.

## LESSONS LEARNED

Several factors were central to the program's success. Delivering a defined curriculum over one year promoted sustained engagement and reinforced consistent objectives, maximizing cumulative impact. Aligning sessions with faculty schedules and protecting time from clinical demands reduced extraneous cognitive load from competing priorities. Small groups maximized hands-on time, a strength noted by participants. Additionally, while we partnered with outside experts for some procedures, (eg, the neonatal outreach team for our neonatal resuscitation station) the stations were led by EM faculty to maintain peer-to-peer coaching and ensure that scenarios and stations were practical and resembled our real-world clinical experiences. Finally, we encouraged faculty lunch outings after each course to enhance collegiality among faculty participants and reinforce longitudinal interest in the program.

## CONCLUSION

Our faculty procedural curriculum offers a framework that emergency departments can use to support their faculty in increasing confidence in performing HALO and other low-frequency procedures. Future research should evaluate the durability of this educational approach, including how long the intervention preserves procedural confidence without decay.

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# Impact of Street Medicine on Emergency Department Use: A Three-Year Evaluation of People Experiencing Homelessness

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**Introduction:** People experiencing homelessness (PEH) frequently utilize the emergency department (ED) for acute and primary healthcare needs. Loyola Street Medicine is a multidisciplinary team comprised of physicians, students, and other professionals who provide weekly healthcare services to PEH at a train station in Chicago. The objective of the study was to identify the specific patient demographics, chief complaints, and clinical interventions associated with increased odds of these patients reporting that they would have sought care at an ED had Loyola Street Medicine been unavailable.

**Methods:** We conducted a retrospective review of patients seen by Loyola Street Medicine between September 2021 and September 2024, with 2,121 total encounters and a subset of 1,565 with identifying data. The primary outcome measure was whether the patient reported they would have gone to the ED for care, and the secondary outcome measures were patient demographics, chief complaints, and interventions provided. We estimated odds ratios with univariable logistic regression mixed models, with random intercept accounting for multiple patient visits in the subset of patients with identifiers.

**Results**: For 63% of all encounters ($N$ = 1,293), people experiencing homelessness indicated they would have gone to the ED without street medicine, with the most common demographics including Black race (77%), male sex (80%), and a mean age of 46.7 years. Among patients who indicated they would have gone to the ED, the most prevalent chief complaints were wound check (22%), musculoskeletal issues (17%), and podiatry concerns (14%). Black and "other" race patients had decreased odds of indicating they would have gone to the ED compared to White patients (0.69 [95% CI, 0.49-0.97], $P$ = .03 and 0.39 [95% CI, 0.22-0.69], $P$ = .001, respectively). Patients with wound-related complaints and those needing wound care as an intervention had greater odds of indicating they would go to the ED versus any other location such as a clinic or a primary care physician (1.46 [95% CI, 1.07-1.99], $P$ = .02 and 1.5 [95% CI, 1.11-2.03], $P$ = .009, respectively).

**Conclusion:** The findings demonstrate that street medicine can play a vital role in addressing the complex needs of people experiencing homelessness. By providing consistent, low-barrier care, street medicine has the potential to reduce nonemergent ED use and improve continuity of care. [West J Emerg Med. 2026;27(5)1457–1466.]

## INTRODUCTION

At a given point in time, an estimated 771,480 people experience homelessness (PEH) in the United States.[1] Homelessness presents a significant public health challenge that compounds chronic disease management and complicates acute care delivery. People experiencing homelessness have an

estimated average life expectancy of 42 to 52 years.[2] Barriers to healthcare for this population include lack of insurance, high costs, transportation limitations, stigma, and an overall lack of resources, resulting in lower primary care use.[3,4] While primary care is underused among PEH, the emergency department (ED) is frequently overused and serves as the setting that these patients rely on for care.[4]

*Population Health Research Capsule*

What do we already know about this issue?
*Street medicine may reduce emergency department (ED) use among persons experiencing homelessness (PEH).*

What was the research question?
*What factors are linked to greater odds of PEH reporting they would have used the ED without street medicine?*

What was the major finding of the study?
*63% of PEH stated they would have gone to the ED without street medicine. Wound care was the most common reason (22%).*

How does this improve population health?
*Our study demonstrates that street medicine may reduce ED use while improving continuity of care and healthcare access for PEH.*

**Emergency Department Use**

Between 2016 and 2021, there were approximately 1,441,000 ED visits made annually by unhoused individuals in the US.[5] They were seen an average of 5.7 times per year at the same ED compared to 3.2 times for housed patients and had significantly longer lengths of stay (LOS).[6] Further, PEH were over seven times more likely to return to the ED within the first 30 days from the prior visit and approximately 11 times more likely within the next two years compared to housed individuals with Medicaid.[7] Patients who are discharged from the ED to a shelter or the streets are also at an increased risk of readmission, further complicating their care and use of healthcare resources.[8]

Their more frequent use of the ED places a strain on the healthcare system and contributes to significant costs. Admissions for PEH have been estimated to cost $2,559 more than admissions for housed patient after adjusting for demographic factors and intensity of resource use.[9] People experiencing homelessness are admitted with a higher frequency and tend to have longer hospital LOS, according to a national dataset analysis.[6] Among PEH who are Medicaid/Medicare eligible in Southern California, 87% of total costs were attributable to the ED, hospital, and use of skilled nursing facility use.[10]

People experiencing homelessness are also at higher risk of trauma and violence. Emergency department visits from these patients were often related to injury at higher rates than housed patients (47.5% versus 33.8%, respectively) across the US.[6] Their use of the ED is further complicated by the trimorbidity of homelessness, which is defined by the overlap of mental health issues, substance use disorder, and chronic medical conditions. A national study showed increased odds of alcohol and substance use disorder-related diagnoses in PEH presenting to the ED.[6] In Boston, behavioral health disorders accounted for about one third of ED visits and one half of hospitalizations among PEH.[11] Qualitative interviews with ED staff and people experiencing housing insecurity emphasized that a key factor in improving their healthcare and decreasing ED use is better overall communication and connection with community resources.[12]

**Street Medicine**

Street medicine is an innovative approach to delivering healthcare by meeting patients where they are physically located, whether it be in an encampment, a shelter, under bridges, or another unsheltered environment.[13] A typical street medicine team consists of an interdisciplinary group of physicians, nurses, students, and outreach workers who provide medical care and address the social needs of PEH. While there is variation between street medicine teams in terms of care capabilities, most teams manage medications for chronic conditions, provide wound care, address acute complaints, and provide referrals to community resources. There has also been a more recent focus on incorporating psychiatric care. One study found that an outreach team for PEH had an average decrease of approximately 2.3 predicted ED visits per person in the 12-month follow-up period compared to the pre-enrollment period.[14] However, studies are limited on the intersection between street medicine and ED use.

The number of street medicine teams has grown in the US in recent years. Loyola Street Medicine was established in January 2020 in response to the unmet medical needs of Chicago's unsheltered homeless population. On a given day, there are an estimated 7,452 PEH, 1,316 of whom are unsheltered, according to the 2025 Chicago Point-in-Time (PIT) Count.[15] Every Thursday from 8 PM to midnight, volunteers from Loyola Street Medicine have provided medical care at the Chicago Transit Authority Blue Line train station since September of 2021. On a given week, the typical outreach team consists of 6-10 volunteers, which includes a board-certified emergency physician or internal medicine physician who supervises all patient encounters, medical students, and nursing students. Psychiatrists, dentists, and

ophthalmologists also volunteer, as do residents from a variety of specialties.

Most patient encounters take 10 to 20 minutes depending on the number of complaints, the complexity of their medical issues, and the length of time the patient is willing to stay. The typical number of patients seen per weekly outreach is 20-35, a number that continues to grow. The Chicago Transit Authority train station was chosen to maximize convenience for individuals who were already using the train as their primary shelter, based on the 2020 PIT count. In fact, 43.2% of people experiencing unsheltered homelessness in the city reported that they would spend the night on buses and trains.[16]

### Present Study

While street medicine has been demonstrated to decrease ED use among PEH, it is usually discussed within a conceptual framework or from a program rather than patient level.[12,17] Limited research has shown a reduction in the number of ED visits after patients engage in street medicine with outreach services.[14] However, a gap remains in the literature that specifically asks PEH where they would have sought care and whether they would have gone to the ED without street medicine. While the demographics, presenting complaints, and interventions associated with their ED utilization have been studied,[6,18] to our knowledge no prior research has investigated the demographics, presenting complaints, and interventions required among PEH who reported they would have sought care in the ED without street medicine.

## METHODS

This retrospective observational study aimed to describe PEH who reported they would have gone to the ED for care, as well as to identify patient demographics, chief complaints, and interventions associated with patients indicating self-reported intent of ED use without street medicine. For each week of service between September 13, 2021, and September 26, 2024, data were collected for each patient encounter. Recorded variables included patient initials, date of birth, age, sex, race, length of homelessness, insurance, chief complaint, intervention provided, and response to the question, "Where would you go for care if Loyola Street Medicine was not here tonight?" This information was logged by the student, physician, or other health professional who was primarily involved in the encounter with the patient.

A single abstractor performed all chart coding using a standardized data collection tool (REDCap) with predefined variable definitions. Records were then regularly reviewed with the principal investigator to ensure consistency in coding. Worster et al (2005) describe the criteria for the adherence to methodologic standards in medical record review studies; the present study adhered to the following criteria: abstractors training; variable definition; use of a data abstraction form; medical record identified; abstractors' performance monitored; missing-data management plan; and institutional review board (IRB) approval.[19] This study was approved by the IRB at Loyola University of Chicago (LU#218244). Based on our research questions, the primary outcome measure was whether the patient stated that they intended to go to the ED for care, and the secondary outcome measures were patient demographics, chief complaints, and intervention provided.

### Chief Complaint

After each encounter, the patient's chief complaint was recorded. There was no limit on the number of chief complaints, and each chief complaint was uniquely coded. However, if there were two complaints within the same category, this was coded only once (eg, if blood pressure check and glucose check were a patient's chief complaints, this was coded once as a wellness check). After assessing all chief complaints, the following categories were created: Respiratory; Musculoskeletal (MSK); Trauma/Injury; Medication Refill; Wound Check; Dermatology/Bites; Wellness Check; Ear Nose Throat (ENT)/Upper Respiratory Infection (URI)/Allergy; Gastrointestinal (GI); Dental Pain; Vaccines; Psychiatric; Neurology; Podiatry; Ophthalmology; Substance use; Genitourinary (GU); Cardiology/Chest Pain; Frostbite; and other. If a patient had a foot wound or foot pain, it was coded as podiatry rather than wound check or MSK, respectively.

### Intervention

The following categories were created based on the most common interventions provided by the Loyola Street Medicine team: medication administered; vaccine administered; wound care; MSK intervention; referral to ED or 911 call; referral to social work; referral to primary care physician; foot care; and vitals/physical exam. Patients were not limited to one intervention for the purposes of coding, and similarly to the chief complaint category, two interventions in the same category were coded only once. For the medication administered, this was further subcategorized into the following: over-the-counter medications; inhalers; antibiotics or prescription medications; topicals; eye drops; prescription refill; and other. If a vaccine was administered, it was further subcategorized as influenza or COVID-19 vaccine.

### Research Question 1: Where would you go for care if Loyola Street Medicine was not here tonight?

Each patient was asked the above question and given the following options: ED; primary care physician (PCP); clinic; would not have pursued care; does not know where to go; or other. It is important to note that this outcome represented a self-reported hypothetical measure of intended healthcare use. Because patients ultimately engaged with the street medicine team, there was no mechanism to verify whether and when they might have ultimately presented to the ED or other location. If a patient listed a particular physician's name, this

was coded as PCP. If a particular hospital was listed, this was coded as ED. The specific response options for this question were mutually agreed upon with our community partner, the Night Ministry, which was also tracking this question during their street outreach.

**Statistical Methods**

There were 2,121 patient encounters between September 2021 and September 2024. For all encounters, we summarized categorical values with counts and percentages, and we summarized continuous variables with means and standard deviations. For the full anonymized data, no formal hypothesis tests were performed, and descriptive statistics were provided for the first research question. Between September 13, 2021, and September 29, 2022 (classified as "year 1"), the patient's date of birth was not collected, as it was not initially included among the predefined variables on the data collection instrument. Of the 2,121 total encounters, there were 1,613 observations in years 2 and 3 when date of birth was collected. Of those 1,613 encounters, 1,565 had date of birth and "patient initials" data, which represented 706 unique patients (see supplemental materials Figure 1 for a flow diagram). The 1,565 patient encounters for which there were identifiers comprised the subset group analyzed for the second research question. For this subset of the total encounters, we estimated odds ratios (OR) and corresponding 95% confidence limits with univariable logistic regression mixed models, with random intercept accounting for multiple patient visits. This study followed a single group of patients with no controls for which descriptive statistics were calculated; a subset of the total patient encounters with identifiers was used to estimate OR with univariable logistic regression mixed models.

**Research Question 1**

The first research question describes the demographics, chief complaints, and interventions among all 2,121 patient encounters (ie, those patients who indicated they would have otherwise gone to the ED. As all encounters were used for this research question (even those without identifiers), all data are descriptive given that no adjustment for patient correlations could be performed.

Of all encounters, 1,293 patients (63%) indicated that if they had not sought care with Loyola Street Medicine, they would have gone to the ED. The demographics of these patients included Black race (77%), male sex (80%), and a mean age of 46.7 years (Table 1); 48% of those indicating potential ED visits had Medicaid insurance and 23% did not have insurance. Of those who indicated possible ED use, wound check (22%), musculoskeletal (17%), and podiatry (14%) were the most common chief complaints (Table 2).

As shown in Table 1, there was a higher percentage of individuals who were homeless between 1-5 years among PEH who would have sought care in the ED (36%) compared to those who indicated they would have sought other care (29%). Additionally, there was a higher percentage of PEH presenting with wound-related complaints who indicated they would seek care in the ED (22%) versus those who would have gone elsewhere (16%; Table 2). Among PEH who indicated they would have sought care in the ED, there was a lower percentage of wellness check as the chief complaint (7%) compared to those who indicated they would not have gone to the ED (12%). These percentages are for descriptive purposes only, as no statistical comparisons were performed for research question 1. Table 3 includes the interventions provided by Loyola Street Medicine stratified by whether PEH would have otherwise gone to the ED versus another location (including PEH who would not have sought care).

**Research Question 2: How likely is it that you would use the emergency department if it were not for street medicine?**

The second research question aimed to identify demographics, chief complaints, and interventions associated with an increased odds of PEH indicating they would have gone to the ED versus any other location. To answer this question, a subset of the total patient encounters with identifiers with initials and date of birth was used for analysis (N = 1,565). We used univariable logistic regression mixed models with random intercept accounting for multiple visits to calculate OR and corresponding 95% confidence intervals. Two-sided $P$ values < 0.05 were deemed statistically significant. All analyses were performed with SAS 9.4 (Cary, NC).

Black individuals and those with "other" self-identified race had lower odds of reporting they would have gone to the ED compared to White individuals as shown in Table 4 (0.69 [95% CI, 0.49-0.97], $P$ = .03 and 0.39 [95% CI, 0.22-0.69], $P$ = .001, respectively). Patients with "other" homelessness status (eg, intermittent, unknown, or homeless but unsure for how long) also had lower odds of reporting they would have gone to the ED than those experiencing homelessness for <1 year (0.69 [95% CI, 0.49-0.97], $P$ = .03). Those with wound checks as a chief complaint had greater odds of indicating they would go to the ED versus any other location as shown in Table 5 (1.46 [95% CI, 1.07-1.99], $P$ = .02). Similarly, as depicted in Table 6, patients needing wound care as an intervention had greater odds of indicating they would have gone to the ED versus any other location (1.5 [95% CI, 1.11-2.03], $P$ = .009). If 911 was called or an ED referral was made, there were greater odds of the patient expressing they would have gone to the ED versus any other location (3.02, [95% CI, 1.35-6.74], $P$ = .007).

## DISCUSSION

The findings of the study demonstrate that street medicine can be a crucial component of care for PEH. Further, 63% of the patients seen at the CTA Blue Line Station stated that they would have otherwise gone to the ED for care. While the results should not be interpreted as the actual percentage of

**Table 1.** Demographics stratified by whether patients would have otherwise gone to the emergency department. (ED) without Loyola Street Medicine for all patient encounters between September 2021 and September 2024 in a study examining the intersection of street medicine and the ED.

| Demographics | All data, *N* = 2,121 | Not ED, *n* = 828 | ED, *n* = 1,293 |
|---|---|---|---|
| Age, mean (SD) | 46.9 (11.9) | 47.2 (11.7) | 46.7 (12) |
| Male (%) | 1,663 (79) | 634 (77) | 1,029 (80) |
| Race (%) | | | |
| White | 370 (18) | 128 (16) | 242 (20) |
| Black | 1,549 (77) | 598 (77) | 951 (77) |
| Other | 100 (5) | 55 (7) | 45 (3) |
| Hispanic (%) | 122 (6) | 59 (7) | 63 (5) |
| Insurance (%) | | | |
| Yes, but unknown | 105 (5) | 42 (6) | 63 (5) |
| Medicaid | 907 (47) | 335 (46) | 572 (48) |
| Medicare | 59 (3) | 21 (3) | 38 (3) |
| Private | 312 (16) | 110 (15) | 202 (17) |
| None | 463 (24) | 184 (25) | 279 (23) |
| Other | 69 (4) | 31 (4) | 38 (3) |
| VA | 7 (0.5) | 2 (0.3) | 4 (0.4) |
| Unsure / unknown | 14 (0.7) | 10 (1) | 4 (0.3) |
| Duration of homelessness (%) | | | |
| < 1 month (30 days) | 53 (3) | 22 (3) | 31 (3) |
| 1 month-6 months, | 244 (13) | 99 (15) | 145 (13) |
| > 6 months-1 year | 277 (15) | 102 (15) | 175 (15) |
| >1-5 years | 606 (33) | 197 (29) | 409 (36) |
| > 5-10 years | 162 (9) | 61 (9) | 101 (9) |
| > 10 years | 122 (7) | 46 (7) | 76 (7) |
| Not homeless | 206 (11) | 90 (13) | 116 (10) |
| Intermittent | 18 (1) | 5 (1) | 13 (1) |
| Unknown | 39 (2) | 16 (2) | 23 (2) |
| Homeless but unsure how long | 91 (5) | 30 (4) | 61 (5) |

Missingness: age, 34; sex, 7; race, 102; ethnicity, 24; insurance, 185; duration of homelessness, 303.
*ED*, emergency department; *SD*, standard deviation; *VA*, Veterans Affairs.

individuals who would have otherwise gone to the ED, given that this measure was self-reported, the results do suggest that many PEH would consider going to the ED if it were not for street medicine. Further, this study characterizes the potential chief complaints that could have been seen in the ED if it were not for street medicine, with wound care, musculoskeletal, and podiatry complaints being the most frequent among individuals who indicated they would have otherwise gone to the ED. Only 4% of PEH who stated that they would have gone to the ED for care were subsequently referred to the ED after being assessed by Loyola Street Medicine, which demonstrates the ability for street medicine to manage a variety of medical issues and chief complaints that might have otherwise resulted in ED use.

Research has largely focused on conceptually arguing for the need for street medicine or relies on qualitative data.[10,17] This relative lack of quantitative data extends to the connection between street medicine and potential ED deferral. In a survey of 25 California-based street medicine teams, a recurring theme was that street medicine allows for continuity of care compared to the typical pattern of ED use.[20] Editorials have also described its potential to save the healthcare system significant amounts of money through reduced ED use but provide specific program level reports and more hypothetical data for cost savings.[10] While concept papers have highlighted the importance of street medicine as a cost-effective means to decrease ED use, they do not provide original quantitative data.[21] In a scoping review of 15 articles on street medicine

**Table 2.** Chief complaints stratified by whether patients would have otherwise gone to the emergency department (ED) without Loyola Street Medicine for all patient encounters between September 2021 and September 2024 in a study examining the intersection of street medicine and the ED.

| Chief Complaint | All data, *N* = 2,121 | Not ED, *n* = 828 | ED, *n* = 1,293 |
|---|---|---|---|
| Respiratory (%) | 224 (11) | 83 (10) | 141 (10) |
| Musculoskeletal (%) | 354 (17) | 129 (16) | 225 (17) |
| Trauma / Injury (%) | 34 (2) | 16 (2) | 18 (1) |
| Medication refill (%) | 165 (8) | 67 (8) | 98 (8) |
| Wound care (%) | 418 (20) | 129 (16) | 290 (22) |
| Rash / bug bites / dermatology (%) | 196 (9) | 76 (9) | 120 (9) |
| Wellness check (%) | 195 (9) | 99 (12) | 96 (7) |
| ENT, URI, Allergy (%) | 197 (9) | 80 (10) | 117 (9) |
| Abdominal pain / GI (%) | 51 (2) | 21 (3) | 30 (2) |
| Dental pain (%) | 43 (2) | 15 (2) | 28 (2) |
| Vaccines (%) | 47 (2) | 24 (3) | 23 (2) |
| Psychiatric (%) | 18 (1) | 12 (1) | 6 (0.5) |
| Neurology (%) | 105 (5) | 36 (4) | 69 (5) |
| Podiatry (%) | 300 (14) | 116 (14) | 184 (14) |
| Ophthalmology (%) | 31 (1) | 12 (1) | 19 (1) |
| Complaints related to substance use (%) | 31 (1) | 11 (1) | 20 (1) |
| GU (%) | 58 (3) | 21 (3) | 37 (3) |
| Heart / Chest Pain (%) | 23 (1) | 8 (1) | 15 (1) |
| Frostbite (%) | 6 (0.3) | 3 (0.4) | 3 (0.2) |
| Other (%) | 23 (1) | 11 (1) | 12 (1) |
| Number of Complaints (%) | | | |
| 0 | 28 (1) | 14 (2) | 14 (1) |
| 1 | 1713 (81) | 672 (81) | 1041 (81) |
| 2 | 340 (16) | 131 (16) | 209 (16) |
| 3 or 4 | 40 (2) | 11 (1) | 29 (2) |

No missing data. A complaint was either mentioned, or it was considered absent.
*ED*, emergency department; *ENT*, ear, nose, and throat; *URI*, upper respiratory infection; *GI*, gastrointestinal; *GU*, genitourinary.

and mobile clinics, no studies examined where individuals would have gone for care without street medicine; the current evidence of decreased ED use is heterogeneous across outcome definitions.[17] Further, Lynch et al found that "SM [street medicine] studies have lacked methodological rigor…"[10]

While scoping reviews and landscape surveys identify street medicine as a means for ED deferral, the few quantitative studies that have demonstrated that street medicine has the potential to decrease ED visits significantly differ in methodology. For example, a study of 54 PEH found a reduction of 2.3 ED visits in the 12-month follow-up period with a street outreach team compared to the 12-month pre-enrollment period.[14] However, without a control group, it is difficult to know whether the reduction was solely attributed to the outreach team. Based on review of current literature, most studies demonstrating that street medicine reduces ED visits are at the program level, examine a reduction in ED visits for their patients after engagement with street medicine. We use a longitudinal approach at the patient-level; to our knowledge, this is the only study that tracks individuals who did not go to the ED for care and instead engaged with street medicine services. No other studies have specifically asked patients where they would have gone for care (such as the ED) without street medicine.

Among the PEH population, individuals identifying as Black and "other" race had decreased odds of indicating they would have gone to the ED compared to White individuals. Studies that examine ED use among PEH emphasize that Black men are overrepresented in the ED, but this is often compared to the general population or non-PEH visits.[6,18] Few studies have examined the demographics of homeless patients

**Table 3.** Interventions stratified by whether patients would have otherwise gone to the emergency department (ED) without Loyola Street Medicine for all patient encounters between September 2021 and September 2024 in a study examining the intersection of street medicine and the ED.

| Intervention | All data, *N* = 2,121 | Not ED, *n* = 828 | ED, *n* = 1,293 |
|---|---|---|---|
| Medication administered (%) | 1428 (67) | 554 (67) | 874 (68) |
| Type of medication administered (%) | | | |
| Over the counter | 797 (38) | 311 (38) | 486 (38) |
| Inhaler | 320 (15) | 118 (14) | 202 (16) |
| Antibiotics or prescriptions medicagtions | 290 (14) | 108 (13) | 182 (14) |
| Topicals | 349 (16) | 113 (16) | 216 (17) |
| Eye drops | 19 (1) | 9 (1) | 10 (1) |
| Pharmacy / Prescription refill | 23 (1) | 8 (1) | 15 (1) |
| Other | 27 (1) | 10 (1) | 17 (1) |
| Vaccine administered? (%) | 54 (3) | 25 (3) | 29 (2) |
| Type of vaccine (%) | | | |
| Influenza | 16 (1) | 7 (1) | 9 (1) |
| COVID-19 | 46 (2) | 22 (3) | 24 (2) |
| Wound care (%) | 447 (21) | 137 (17) | 310 (24) |
| MSK intervention (%) | 91 (4) | 41 (5) | 50 (4) |
| Referred to ED (or 911 call) (%) | 62 (3) | 11 (1) | 51 (4) |
| Referred to social work (%) | 29 (1) | 17 (2) | 12 (1) |
| Referred to PCP (%) | 71 (3) | 29 (4) | 42 (3) |
| Foot care (%) | 100 (5) | 37 (4) | 63 (5) |
| Vitals/Exam (%) | 99 (5) | 48 (6) | 51 (4) |

No missing data. A complaint was either mentioned or was considered absent.
*ED*, emergency department; *MSK*, musculoskeletal; *PCP*, primary care physician.

presenting to the ED as compared to those of the larger homeless population, and none have examined this in the context of street medicine. One Canadian study found that within a sample of homeless adults, Black participants had a lower rate of ED use but a higher rate of visits to social service professionals.[22]

In the United States, the majority of PEH are White men. However, Black men are overrepresented in the count relative to the number who identify as Black in the United States (32% versus 12%).[1] A longstanding history of mistrust in the healthcare system could contribute to Black PEH having decreased odds of indicating that they would go to the ED if it were not for street medicine services.[23] However, other studies not specific to homeless status have shown that Black patients are more likely than White patients to use the ED and less likely to use primary care.[24,25] Further studies are needed to better understand the reasons for these ED trends, specifically for PEH.

Wound check was the most frequent chief complaint among this patient population. Wound care needs are common among PEH, with trauma wounds, lower leg ulcers, and frostbite wounds the most common.[26] This is not surprising given the living conditions and environmental exposures that increase injury and infection risk within this population. Those with wound check as a chief complaint had significantly greater odds of indicating they would go to the ED, comprising 22% of potential ED visits without the presence of street medicine. In a nationally representative sample of PEH in the United States presenting to the ED, 55% of visits were due to injuries.[27] However, studies examining ED visits by PEH often do not separate the chief complaints of injuries from wounds, making it difficult to assess the number of individuals going to the ED specifically for wound care. The statistically increased odds of indicating potential ED use among those with wound care complaints presenting to Loyola Street Medicine could mean that individuals have a greater concern for their wounds compared to other health problems. We posit that some PEH may not seek care for initially minor wounds until they get to a point that warrants a physician's care. The study results highlight the importance of wound care training for street medicine physicians, students, and other professionals.

**Table 4.** Odds ratios for people experiencing homelessness indicating they would have gone to the emergency department (ED) versus other location by demographics in the subset of Loyola Street Medicine's patients with unique identifiers between October 2022 and September 2024 in a study examining the intersection of street medicine and the ED.

| Demographics | Odds Ratio of ED (95% CI) | *P* Value |
|---|---|---|
| Age, per unit increase | 1.00 (0.98-1.01) | .46 |
| Male vs Female | 1.14 (0.84-1.55) | .39 |
| Race | | |
| White (Reference) | | |
| Black vs White | 0.69 (0.49-0.97) | .03 |
| Other vs White | 0.39 (0.22-0.69) | .001 |
| Hispanic vs non-Hispanic | 0.70 (0.42-1.17) | .17 |
| Insurance | | |
| Medicaid (Reference) | | |
| Private vs Medicaid | 1.06 (0.74-1.52) | .73 |
| None vs Medicare | 0.91 (0.70-1.23) | .52 |
| Other (Yes but unknown, Medicare, VA, Unsure / Unknown) vs Medicaid | 0.88 (0.63-1.21) | .42 |
| Duration of Homelessness | | |
| <1 year (Reference) | | |
| >1-5 years | 1.15 (0.84-1.57) | .40 |
| > 5 years | 1.07 (0.72-1.58) | .75 |
| Not Homeless | 0.82 (0.55-1.24) | .35 |
| Other (Intermittent, unknown, homeless but unsure for. how long) | 0.69 (0.49-0.97) | .03 |

*ED*, emergency department; *VA*, Veterans Affairs.

**Table 5.** Odds ratios for people experiencing homelessness indicating they would have gone to the emergency department (ED) versus other location by chief complaints in the subset of Loyola Street Medicine patients with unique identifiers between October 2022 and September 2024 in a study examining the intersection of street medicine and the ED.

| Chief Complaint | Odds Ratio of ED (95% CI) | *P* value |
|---|---|---|
| Respiratory | 1.00 (0.69-1.46) | .10 |
| Musculoskeletal | 1.02 (0.74-1.39) | .92 |
| Trauma / Injury | 1.02 (0.39-2.64) | .97 |
| Medication refill | 1.10 (0.74-1.64) | .64 |
| Wound care | 1.46 (1.07-1.99) | .02 |
| Rash / Bug bites / Dermatology | 1.00 (0.68-1.49) | .98 |
| Wellness check | 0.68 (0.46-1.00) | .05 |
| ENT, URI, Allergy | 1.00 (0.69-1.47) | .99 |
| Abdominal pain / GI | 1.21 (0.58-2.56) | .61 |
| Dental pain | 1.10 (0.48-2.51) | .83 |
| Vaccines | 0.28 (0.05-1.71) | .17 |
| Psychiatric | 0.28 (0.05-1.62) | .16 |
| Neurology | 1.47 (0.84-2.55) | .18 |
| Podiatry | 0.80 (0.56-1.13) | .20 |
| Ophthalmology | 1.69 (0.65-4.41) | .28 |
| Complaints related to substance use | 1.03 (0.30-3.55) | .96 |
| GU | 1.45 (0.71-2.95) | .31 |
| Heart / Chest pain | 1.10 (0.41-2.95) | .85 |
| Frostbite | 0.35 (0.05-2.44) | .29 |
| Other | 0.82 (0.27-2.49) | .72 |
| Number of Complaints | | |
| 0 | Reference | |
| 1 | 1.16 (0.49-2.76) | .75 |
| 2 | 1.21 (0.49-2.98) | .68 |
| 3 or 4 | 2.25 (0.64-7.99) | .21 |

*ED*, emergency department; *ENT*, ear, nose, and throat; *GI*, gastrointestinal; *GU*, genitourinary; *URI*, upper respiratory infection.

The findings from our specific study demonstrate that many PEH indicate that they would have gone to the ED for care if it were not for street medicine. Given that the average cost of an ED visit would be more expensive and use more resources than street medicine services, street medicine can be considered a more cost-effective solution. Startup funds for street medicine programs range between $5,000-$10,000, depending on departmental or university funding. The average cost of annual maintenance is $10,000-$15,000, but this can also vary widely depending on the breadth of services provided by the street medicine team. The cost of maintenance of Loyola Street Medicine is about $15,000 annually, with funding from the university, grants, and donations. Since there is no method to confirm where individuals would have sought care without street medicine, any specific estimate of the potential cost savings to our EDs and healthcare system would not be feasible. However, given that just 4% of the PEH who indicated they would have gone to the ED were actually referred to the ED after being assessed by Loyola Street Medicine, we conclude that street medicine can address many medical needs outside the acute setting of the ED.

Future studies could directly compare the chief complaints of PEH who present to the ED versus those who use street medicine services. Understanding whether there is a significant difference between these groups would better clarify the clinical needs that are met by both. Since PEH are transient and difficult to track, a multicenter study involving all street medicine teams in the city would better characterize ED use. As a follow-up study, it would also be interesting to

**Table 6.** Odds ratios for people experiencing homelessness indicating they would have gone to the emergency department (ED) versus other location by interventions in the subset of Loyola Street Medicine's patients with unique identifiers between October 2022 and September 2024 in a study examining the intersection of street medicine and the ED.

| Intervention | Odds Ratio of ED (95% CI) | *P* value |
|---|---|---|
| Medication Administered | 1.06 (0.83-1.36) | .63 |
| Type of medication administered | | |
| Over the counter | 0.962 (0.76-1.22) | .75 |
| Inhaler | 1.02 (0.73-1.43) | .90 |
| Antibiotics or prescriptions medication | 1.03 (0.85-1.66) | .30 |
| Topicals | 1.12 (0.82-1.53) | .46 |
| Eye drops | 1.46 (0.41-5.20) | .55 |
| Pharmacy / prescription refill | 1.16 (0.43-3.11) | .77 |
| Other | 1.43 (0.47-4.32) | .53 |
| Vaccine Administered? | 0.21 (0.02-1.38) | .21 |
| Type of Vaccine | | |
| Influenza | NE | |
| COVID-19 | NE | |
| Wound care | 1.50 (1.11-2.03) | .009 |
| MSK intervention | 0.75 (0.44-1.30) | .31 |
| Referred to ED (or 911 call) | 3.02 (1.35-6.74) | .007 |
| Referred to social work | 0.55 (0.21-1.49) | .24 |
| Referred to PCP | 0.90 (0.51-1.61) | .73 |
| Foot Care | 0.91 (0.55-1.51) | .72 |
| Vitals/Exam | 0.76 (0.45-1.27) | .30 |

*ED*, emergency department; *MSK*, musculoskeletal; *NE*, not estimable; *PCP*, primary care physician.

assess how soon the individuals would have gone to the ED if it were not for street medicine. Further, while wound care was the most frequent complaint among those who stated they would have gone to the ED, it would be interesting to stratify the findings based on the type of wound (eg, gunshot wound, abscess). Future studies should examine the demographics and chief complaints of PEH who would have otherwise sought care at a primary care clinic or who would not have gotten any care.

The present study is one of the largest street medicine studies in the United States, including 2,121 patient encounters. While existing studies have examined healthcare use and access to services in the context of street medicine, this is the first to document where patients indicated they would have gone in the absence of street medicine and to categorize the chief complaints and interventions that could have potentially taken place in the local ED. Another strength of the study is that it includes longitudinal data over the span of three years, whereas other studies were primarily cross-sectional. Finally, the 20 categories of chief complaints, allowing for a more nuanced understanding of the conditions that PEH presented with who indicated they would have otherwise gone to the ED.

## LIMITATIONS

The study is not without its limitations. The study coincided with the COVID-19 pandemic, which could have impacted the prevalence of various chief complaints (eg, respiratory issues) or interventions (eg, vaccine administration) compared to typical years. Another limitation is the lack of standardization between individuals recording the chief complaint and interventions. Although all encounters were supervised by a physician or other healthcare professional, chief complaints were often documented by medical trainees, which likely introduced variability in both the number and type of complaints recorded across encounters. Another limitation concerns the question, "Where would you go for care if Loyola Street Medicine was not here tonight?" Some PEH named a local hospital, which was assumed to be the ED and was coded as such. A further limitation with this question is that it is self-reported, and therefore there is no feasible method to confirm definitive data on ED use, and the results should not be interpreted as such. In other words, while 63% of patients indicated they would have gone to the ED without street medicine, there is no way to confirm the exact amount of ED reduction or the exact number of each chief complaint through concrete data such as ED records. Finally, the results reflect the intersection between Loyola Street Medicine and the ED, which may not be representative of all street medicine groups.

## CONCLUSION

Our study demonstrates that street medicine and the emergency department are intertwined, with street medicine serving as a critical point of intervention and providing greater continuity of care for PEH. The findings are based on patient self-report, with many PEH stating that they would have gone to the ED without street medicine. The high prevalence of wound care-related complaints underscores the importance of proper wound care training to mitigate life-threatening wound care complications. Further research is needed to understand ED use patterns based on specific demographic factors such as age, race, and sex to better inform targeted interventions for this population.

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# Syphilis Screening in Pregnancy During Emergency Department Gonorrhea and Chlamydia Testing

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**Introduction**: Congenital syphilis is rising in the United States, especially among infants born to women with limited prenatal care. Emergency departments (ED) offer opportunities for early detection, particularly among patients evaluated for urogenital sexually transmitted infection (STI) concerns. In October 2019, our health system implemented an ED STI order set that promoted HIV co-testing and included a preselected option for syphilis testing. In this study, we evaluated change in syphilis testing during the post-implementation period among ED encounters with both pregnancy and gonorrhea/chlamydia (GC/CT) testing.

**Methods**: We conducted a retrospective, quasi-experimental study across 20 EDs, using health record data from 2018 to 2023 for patients aged 15–44 years who received both pregnancy and GC/CT testing. We measured annual syphilis and HIV testing and positivity, stratified by pregnancy status. The primary study outcome was syphilis testing during the encounter; HIV testing and detection outcomes were secondary.

**Results**: Among 59,171 ED encounters with pregnancy and GC/CT testing, 5,178 (8.8%) involved pregnant patients, and 9,538 (16.1%) received syphilis testing. Syphilis testing among pregnant patients increased from .9% in 2018 to 46.1% in 2023 (+45.1 percentage points [95% CI, 40.4–49.6]). Testing among nonpregnant patients rose from 1.2% to 35.9% (+34.6 percentage points [95% CI, 33.3–35.9]). Overall, only 1,068 of 5,178 pregnant encounters received a syphilis test (20.6%). Among 1,068 syphilis-tested pregnant encounters, 15 (1.4%) were treponemal-positive and 9 (.8%; 843 per 100,000 tested) met the Centers for Disease Control and Prevention surveillance definition for active syphilis (approximately 1 per 119 tests). Using all pregnant encounters with GC/CT testing as the denominator, the encounter-based active syphilis rate was 173.8 per 100,000 (.17%). HIV testing increased similarly (pregnant: .4% in 2018 to 44.5% in 2023), while HIV positivity remained rare (2 pregnant; 13 overall).

**Conclusion**: Syphilis testing and case detection increased during the postimplementation period following introduction of a preselected STI order set in the electronic health record. Many encounters in the analytic cohort still did not include syphilis testing. These findings support the ED as an important setting for identifying syphilis in pregnancy while underscoring the need for further work to understand remaining testing gaps. [West J Emerg Med. 2026;27(5)1467–1477.]

## INTRODUCTION

Congenital syphilis, which can cause stillbirth, infant death, and severe morbidity, has risen more than tenfold in the US between 2012 and 2023.[1,2] In Ohio, case numbers rose from 22 in 2018 to 93 in 2022.[3] Early detection and treatment are critical to prevention. Centers for Disease Control and Prevention (CDC) guidelines recommend screening at the first prenatal visit for all pregnant individuals, with repeat testing in the early third trimester and at delivery for those at elevated risk or without prior testing.[4]

Congenital syphilis disproportionately affects infants born to socially vulnerable women with limited prenatal care.[1] In surveillance data, 41% of cases occurred after no timely maternal test, and most of these mothers had no prenatal care.[5] In Clark County, Nevada, between 2017 and 2022 more than half of mothers delivering a child with congenital syphilis had an emergency department (ED) visit > 30 days before delivery, yet only two-thirds were tested then.[6] Together, these findings highlight missed opportunities—and suggest the ED visit, including pregnancy confirmation, as a practical point for standardized, electronic health record (EHR)-driven syphilis screening. A positive pregnancy test in the ED is an opportunity to screen and treat early, preventing fetal loss and congenital infection.[7-10]

In prior work, an EHR-based order set increased HIV co-testing for ED patients undergoing gonorrhea and chlamydia (GC/CT) testing and included a preselected option for syphilis screening.[11] Testing for GC/CT provided the cohort most relevant to this intervention. In the ED, patients undergoing GC/CT testing represent a higher-risk population in whom broader sexually transmitted infection (STI) evaluation, including syphilis and HIV testing, is often clinically appropriate and guideline supported. We therefore focused on encounters with both pregnancy and GC/CT testing because pregnancy defines a subgroup in which syphilis screening is especially important, while GC/CT testing identifies visits in which STI evaluation is already in progress and syphilis testing could be added during the same encounter.

Using that cohort, we evaluated this order set in a retrospective, quasi-experimental study across 20 EDs. Our main objective was to determine whether syphilis testing increased among ED encounters with both pregnancy and GC/CT testing, overall and by ED site. Secondary objectives were to assess changes in HIV testing and to describe syphilis and HIV detection, including active syphilis among pregnant patients, using both test-based and ED encounter–based denominators.

*Population Health Research Capsule*

What do we already know about this issue?
*Congenital syphilis is rising, and pregnancy-related emergency department (ED) visits for sexually transmitted infection testing may miss syphilis screening.*

What was the research question?
*Did a preselected order set increase syphilis testing in pregnant gonorrhea/chlamydia-tested encounters?*

What was the major finding of the study?
*In pregnant gonorrhea/chlamydia-tested encounters, syphilis testing rose from 0.9% to 46.1%, an increase of 45.1 percentage points (95% CI, 40.4–49.6).*

How does this improve population health?
*Electronic order sets may expand syphilis screening during pregnancy-related ED gonorrhea/chlamydia testing and identify untreated infection.*

## METHODS

### Setting and Study Population

We conducted a retrospective quasi-experimental study using EHR data from all patients aged 15–44 years who received both pregnancy and GC/CT testing in one of 20 EDs within the Cleveland Clinic's Northeast Ohio health system between January 1, 2018, and December 31, 2023. Syphilis and HIV co-testing were evaluated, stratified by pregnancy status. Pregnancy testing in the ED is typically ordered at clinician discretion (eg, for abdominal pain, vaginal bleeding, or prior to imaging or medication use).

The Cleveland Clinic Institutional Review Board reviewed this project and determined that it constitutes internal quality improvement within standard health care operations and therefore does not represent human subjects research requiring formal approval.

### Implementation Strategy

The implementation strategy consisted of an EHR-based STI order set and audit-and-feedback. Beginning in October 2019, when clinicians ordered GC/CT testing, syphilis and HIV serology were preselected by default in a standardized order set, which could be deselected only with an active choice. Implementation was supported by staff and director meetings and periodic feedback reports summarizing site- and clinician-level co-testing rates. Co-testing rates and the shift from stand-alone to bundled syphilis-plus-HIV orders served as quantitative indicators of adoption and implementation fidelity. Core elements—the preselected syphilis and HIV tests

within a single order set and the audit-and-feedback reports—were specified a priori and remained unchanged across sites, while ED leaders had flexibility in how they promoted and reinforced the order set locally.[11]

We compared changes in syphilis testing over time among patients who received both pregnancy and GC/CT testing before and after implementation. Unless otherwise specified, all analyses used a consistent denominator of ED encounters in which both pregnancy and GC/CT tests were performed.

### Data Sources, Laboratory Methods, and Chart Review

Demographic, pregnancy, and STI data were retrieved from Epic Clarity (Epic Systems Corporation, Verona, WI) and stored within a secure, password-protected institutional Teradata DataLab environment. Primary measures were extracted electronically from structured EHR fields. For treponemal-positive results, one author (CBF), an infectious diseases physician, performed targeted chart review to adjudicate whether cases met the CDC 2018 surveillance case definition for active syphilis. This review was not blinded to study aims, and no formal interrater reliability assessment was performed.[12]

To screen for syphilis, we used a reverse-sequence testing algorithm: treponemal antibody screen followed by rapid plasma reagin (RPR) test where the former was reactive. If the RPR was nonreactive, a second treponemal antibody assay was added to adjudicate discordant results. The initial treponemal antibody screen was performed using Bio-Plex 2200 Syphilis IgG test (Bio-Rad Laboratories Inc, Hercules, CA) through September 2019, followed by the Bio-Plex 2200 Syphilis total IgM/IgG test from October 2019 to February 2022, and thereafter the Syphilis TP test (Abbott Laboratories, Abbott, IL). The latter test detects both IgM and IgG antibodies. A reactive or equivocal treponemal antibody result was followed by the Macro-Vue RPR Card test kit (Becton, Dickinson and Company, Franklin Lakes, NJ). If the RPR was nonreactive, confirmation was performed with Trep-Sure enzyme-linked immunoassay (Trinity Biotech plc, Bray, County Wicklow, Ireland). All the treponemal antibody assays used highly purified recombinant antigens of *Treponema pallidum*.

Operational definitions followed CDC guidance.[13,14] Results were categorized as follows: a) treponemal antibody false-positive result—a reactive initial treponemal antibody screening assay followed by a nonreactive confirmatory treponemal antibody assay; and b) confirmed treponemal-positive syphilis—a reactive screening and confirmatory treponemal antibody assay, regardless of nontreponemal test result. This category includes active infection, previously treated infection, and very recent infections prior to nontreponemal (RPR) seroconversion.

- Cases with a reactive nontreponemal test (eg, RPR) and compatible clinical or epidemiologic findings were considered active syphilis.
- Cases with both a reactive treponemal antibody test and reactive RPR, along with compatible signs and symptoms, were classified as active syphilis per CDC guidance. This distinction separated active cases from serofast individuals and those with treated syphilis but biologically false-positive RPR results (eg, due to HIV infection).
- Cases with nonreactive or low-titer (serofast) RPR results, absence of symptoms, and documentation of prior adequate therapy—with no epidemiologic or laboratory evidence of reinfection (≥ 4-fold rise in RPR titer) or treatment failure—were classified as previously treated syphilis.

(c) Active syphilis (CDC surveillance case definition): cases meeting the CDC 2018 Surveillance Case Definition—typically treponemal antibody–positive with a reactive RPR and compatible clinical or epidemiologic criteria. Patients with documented prior adequate treatment and no evidence of treatment failure or reinfection were excluded from this category.

For tests performed after December 31, 2019, EHR result labels ("Active Treponemal Infection," "Treated Past Treponemal Infection") were mapped to these categories (including treponemal antibody false-positive results when applicable); earlier results and active-case status were adjudicated by the infectious diseases physician's chart abstraction described above.

## OTHER SEXUALLY TRANSMITTED INFECTIONS

In addition to syphilis, test results for HIV, *Chlamydia trachomatis*, and *Neisseria gonorrhoeae* were retrieved from the EHR.

### Study Outcomes

The primary study outcome was syphilis testing during ED encounters with both pregnancy and GC/CT testing, overall and by ED site. Secondary outcomes included HIV testing, combined syphilis plus HIV co-testing, confirmed treponemal-positive syphilis, active syphilis per CDC case definition among pregnant patients, and HIV positivity, reported both as proportions among those tested and as rates per 100,000 ED encounters in the analytic cohort.

### Statistical Analysis

We summarized demographics descriptively. Testing rates and positivity were reported as proportions with percentages and 95% CIs, stratified by year and pregnancy status. We used Wilson score intervals for proportions; exact (Clopper–Pearson) intervals were applied for small or extreme values. Absolute differences were expressed as percentage-point changes with Newcombe 95% CIs. When shown, rate ratios were calculated using the Katz method with continuity correction. Rates per 100,000 were based on either the number tested or the broader cohort screened for both pregnancy and GC/CT, with CIs scaled accordingly. Age was summarized as median [IQR]. As analyses were descriptive and not

hypothesis-driven, P values were not reported.

A site-level analysis compared each ED's change in syphilis testing between 2018 and 2023 (y-axis) with its 2023 share of network testing volume (x-axis), with bubble size proportional to the absolute increase in tests performed. Median values of change in testing and volume share defined four quadrants—high-volume/high-gain; high-volume/low-gain; low-volume/high-gain; and low-volume/low-gain—to identify sites contributing most to network-wide improvement.

All eligible ED encounters during 2018–2023 were included. We did not perform a priori sample size calculation because analyses were descriptive and based on the full available cohort. Data management was performed using Statistical Analysis System 9.4 (SAS Institute, Cary, NC). Analyses were conducted using SAS and Python 3.12 (pandas, NumPy, SciPy [scipy.stats], Matplotlib). This study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline.[15]

## RESULTS

### Population Characteristics

Among 59,171 encounters in the analytic cohort, 5,178 (8.8%) were among pregnant patients. Median age was similar between pregnant and nonpregnant patients (24 versus 25 years). Pregnant patients were more likely to have Medicaid insurance, be unemployed, and have slightly greater interpreter need. Additional demographic details appear in Table 1.

### STI Testing Overall

Syphilis testing was the primary outcome and the study's clearest finding. Positivity for GC/CT was more common than syphilis or HIV positivity in both pregnancy groups (Table 2). Overall STI and GC/CT positivity were lower among pregnant encounters.

### Syphilis Testing Over Time

Syphilis testing increased markedly in both pregnant and nonpregnant patients during the study period (Figure 1). Among pregnant patients, testing rose from 0.9% in 2018 to 46.1% in 2023, an absolute increase of 45.1 percentage points (95% CI, 40.4–49.6); among nonpregnant encounters, it rose from 1.2% to 35.9%, an increase of 34.6 percentage points (95% CI, 33.3–35.9). Over time, syphilis testing in pregnant encounters shifted from occasional stand-alone ordering toward testing more often paired with HIV testing, narrowing the difference between syphilis testing and combined syphilis/HIV co-testing.

Among the 15 patients with confirmed treponemal-positive serology, nine met CDC surveillance criteria for active syphilis (Table 2) and required treatment, including one with evidence of reinfection; the remaining six had serologic evidence of previously treated infection without reinfection or treatment failure. The active syphilis rate was 843 per 100,000 among those tested and 173.8 per 100,000 among all pregnant encounters with GC/CT testing. Treponemal false-positive results were rare in both pregnancy groups. Pregnancy-specific yearly trends in confirmed treponemal-positive and active syphilis are shown in Figure 2 and Table 3.

### Characteristics of Syphilis-Tested and Positive Patients

Syphilis-tested encounters differed from those not tested on several demographic measures, and treponemal-positive patients were more often older and socially vulnerable on measures such as Medicaid insurance and unemployment. Details appear in Supplemental Tables 1–4, which compare tested versus untested encounters overall and in the pregnant subgroup, and treponemal-positive versus negative encounters overall and in the pregnant subgroup.

### HIV Testing

Testing for HIV also increased during the study period, but HIV positivity remained rare (Tables 2–4). Among pregnant encounters, HIV testing rose from 0.4% in 2018 to 44.5% in 2023; among nonpregnant encounters it rose from 0.9% to 32.8% (Tables 3–4). Overall, 13 patients tested HIV positive, including 2 pregnant patients. No patients were co-infected with both HIV and syphilis.

### Site-Level Variation in Syphilis Testing

Improvement in syphilis testing was not uniform across EDs (Figure 3). Across all 20 EDs, the mean syphilis testing rate increased by 36 percentage points from 2018 to 2023, but a subset of high-volume sites accounted for most of that gain. Seven high-volume/high-gain EDs represented 72% of 2023 encounters and 85% of the absolute increase in testing, whereas three additional high-volume sites accounted for 11% of encounters but only 7% of added tests. Similar heterogeneity was present in the pregnant subgroup (Supplemental Figure 1): the mean testing rate increased by 45 percentage points, and 8 high-volume/high-gain EDs, representing 78% of 2023 volume, accounted for 88% of added tests.

## DISCUSSION

The central finding of this study was a substantial increase in syphilis testing following introduction of a preselected EHR STI order set. The pattern of improvement, including marked variation across EDs, suggests that the order set contributed to broader testing. That broader testing identified additional infections, including among pregnant patients, and revealed a syphilis burden among ED patients evaluated for urogenital STIs that exceeded rates reported for the general population of women aged 15–44 years. Among syphilis-tested pregnant encounters, we identified approximately one active case per 119 tests, underscoring both the feasibility and the clinical

**Table 1.** Demographic characteristics of encounters among patients tested for pregnancy and gonorrhea/chlamydia in a study to evaluate whether a standardized order set would increase syphilis testing.

| Factor | Not pregnant | Pregnant |
|---|---|---|
| Denominator (group totals) | *n* = 53,993 | *n* = 5,178 |
| Age at encounter | 25.0 [21.0, 31.0] | 24.0 [21.0, 29.0] |
| Homeless | | |
| Yes | 174 (0.3% [0.3–0.4]) | 13 (0.3% [0.1–0.4]) |
| Interpreter Needed | | |
| Yes | 791 (1.5% [1.4–1.6]) | 119 (2.3% [1.9–2.7]) |
| Race/Ethnicity | | |
| Hispanic | 5,058 (9.4% [9.1–9.6]) | 575 (11.1% [10.3–12.0]) |
| Non-Hispanic White | 12,818 (23.7% [23.4–24.1]) | 932 (18.0% [17.0–19.1]) |
| Non-Hispanic Black | 33,545 (62.1% [61.7–62.5]) | 3,405 (65.8% [64.5–67.0]) |
| Non-Hispanic Asian | 260 (0.5% [0.4–0.5]) | 24 (0.5% [0.3–0.7]) |
| Other/Declined | 2,312 (4.3% [4.1–4.5]) | 242 (4.7% [4.1–5.3]) |
| Employment | | |
| Full-time/Retired | 19,280 (35.7% [35.3–36.1]) | 1,698 (32.8% [31.5–34.1]) |
| Part-time | 4,433 (8.2% [8.0–8.4]) | 406 (7.8% [7.1–8.6]) |
| Unemployed | 29,061 (53.8% [53.4–54.2]) | 2,974 (57.4% [56.1–58.8]) |
| Student | 665 (1.2% [1.1–1.3]) | 36 (0.7% [0.5–1.0]) |
| Unknown | 554 (1.0% [0.9–1.1]) | 64 (1.2% [1.0–1.6]) |
| Language | | |
| English | 52,546 (97.3% [97.2–97.5]) | 4,973 (96.0% [95.5–96.5]) |
| Spanish | 1,035 (1.9% [1.8–2.0]) | 139 (2.7% [2.3–3.2]) |
| Other | 412 (0.8% [0.7–0.8]) | 66 (1.3% [1.0–1.6]) |
| Marital Status | | |
| Single | 46,560 (86.2% [85.9–86.5]) | 4,467 (86.3% [85.3–87.2]) |
| Married/Partner | 5,537 (10.3% [10.0–10.5]) | 601 (11.6% [10.8–12.5]) |
| Divorced/Separated | 1487 (2.8% [2.6–2.9]) | 90 (1.7% [1.4–2.1]) |
| Other | 112 (0.2% [0.2–0.2]) | 6 (0.1% [0.1–0.3]) |
| Unknown | 297 (0.6% [0.5–0.6]) | 14 (0.3% [0.2–0.5]) |
| Primary Payor | | |
| Selfpay | 5,295 (9.8% [9.6–10.1]) | 492 (9.5% [8.7–10.3]) |
| Private | 10,303 (19.1% [18.8–19.4]) | 804 (15.5% [14.6–16.5]) |
| Medicare | 1,088 (2.0% [1.9–2.1]) | 70 (1.4% [1.1–1.7]) |
| Medicaid | 37,062 (68.6% [68.2–69.0]) | 3,797 (73.3% [72.1–74.5]) |
| TRICARE/Military | 169 (0.3% [0.3–0.4]) | 9 (0.2% [0.1–0.3]) |
| International | 11 (0.0% [0.0–0.0]) | 0 (0.0% [0.0–0.1]) |
| Uninsured | 65 (0.1% [0.1–0.2]) | 6 (0.1% [0.1–0.3]) |

Continuous variables are reported as median [P25, P75].
*ED*, emergency department; *EHR*, electronic health record.

importance of ED-based detection during pregnancy.

The ED often serves as a safety-net setting for individuals with limited access to routine prenatal or primary care. In many EDs, however, STI evaluation is more likely to include gonorrhea and chlamydia testing than serologic screening for infections such as syphilis or HIV. In that context, a bundled order set may help normalize more complete STI evaluation within an existing clinical workflow.

Our findings extend prior work on ED STI order sets in two ways: by focusing on syphilis testing during the

**Table 2.** Sexually transmitted infection co-testing and results among ED patients aged 15–44 years tested for both pregnancy and gonorrhea/chlamydia.

| Factor | Not pregnant | Pregnant | Difference (Pregnant - Not pregnant) |
|---|---|---|---|
| STI Testing Among GC/CT-Screened Encounters | | | |
| Syphilis test | 8,470/53,993 (15.7% [15.4–16.0]) | 1,068/5178 (20.6% [19.5–21.7]) | 4.9 pp [3.5–6.4] |
| HIV test | 7,440/53,993 (13.8% [13.5–14.1]) | 826/5178 (16.0% [15.0–17.0]) | 2.2 pp [0.9–3.5] |
| HIV and Syphilis co-testing | 7,090/53,993 (13.1% [12.8–13.4]) | 799/5178 (15.4% [14.5–16.4]) | 2.3 pp [1.1–3.6] |
| STI Positivity Among Those Tested | | | |
| ≥1 positive result | 6,653/53,993 (12.3% [12.0–12.6]) | 511/5,178 (9.9% [9.1–10.7]) | –2.5 pp [–3.5–-1.3] |
| GC/CT positive | 6,491/53,993 (12.0% [11.8–12.3]) | 494/5,178 (9.5% [8.8–10.4]) | –2.5 pp [–3.5–-1.4] |
| Confirmed treponemal-positive syphilis | 184/8,470 (2.2% [1.9–2.5]) | 15/1068 (1.4% [0.9–2.3]) | –0.8 pp [-1.7–0.4] |
| Active syphilis (CDC surveillance case definition) | — | 9/1068 (0.8% [0.4–1.6]) | — |
| Syphilis – false-positive | 32/8,470 (0.4% [0.3–0.5]) | 5/1068 (0.5% [0.2–1.1]) | 0.1 pp [–0.3–0.8] |
| HIV positive | 11/7,440 (0.1% [0.1–0.3]) | 2/826 (0.2% [0.1–0.9]) | 0.1 pp [–0.2–0.8] |
| HIV and Syphilis both positive | 0/7090 (0.0% [0.0–0.1]) | 0/799 (0.0% [0.0–0.5]) | 0.0 pp [–0.1–0.5] |
| Positivity per 100,000 Among GC/CT-Screened Encounters | | | |
| Confirmed treponemal-positive syphilis | 184 (340.8 per 100,000 [295.0–393.6]) | 15 (289.7 per 100,000 [175.6–477.4]) | — |
| Active syphilis (CDC surveillance case definition) | — | 9 (173.8 per 100,000 [91.5–330.0]) | — |
| HIV Positive | 11 (20.4 per 100,000 [11.4–36.5]) | 2 (38.6 per 100,000 [10.6–140.7]) | — |

Testing rows use the GC/CT-screened cohort as the denominator and are reported as n/N (% [95% CI]). Positivity rows are reported among those tested for the specified assay. Per-100,000 rows use the GC/CT-screened cohort as the denominator. Active syphilis reflects the subset of confirmed treponemal-positive pregnant encounters meeting CDC surveillance criteria.
C*DC*, Centers for Disease Control and Prevention; *ED*, emergency department; *GC/CT*, gonorrhea/chlamydia; *pp*, percentage points.

postimplementation period across 20 EDs; and by describing clinically meaningful detection outcomes, particularly active syphilis among pregnant patients. Similar interventions have increased syphilis screening in other ED settings, including among pregnant patients, and our findings are consistent with that literature.[8,16] In an adult Level I trauma ED in Chicago, an opt-out workflow built on existing HIV screening infrastructure increased syphilis screening substantially, with the largest gains among pregnant patients and a marked rise in diagnoses.[17] Data from Clark County, NV, further underscore the importance of the ED setting: Many mothers of infants with congenital syphilis had an ED visit before delivery but were not tested for syphilis at that visit.[6] In our cohort, testing before implementation was rare among encounters with both pregnancy and GC/CT testing. During the postimplementation period, testing rose substantially, and active syphilis requiring treatment was identified among pregnant patients.

The active syphilis rate among pregnant patients in our ED cohort was 843 per 100,000 among those tested for syphilis and 173.8 per 100,000 among all pregnant encounters with GC/CT testing. These rates are notable in the context of Cuyahoga County, where our health system is based and where the reported syphilis rate among women aged 15–44 years is 22.7 per 100,000—already well above the CDC threshold of 4.6 per 100,000 used to define areas for intensified screening.[18,19] According to CDC guidelines, all pregnant persons should be screened for syphilis at the

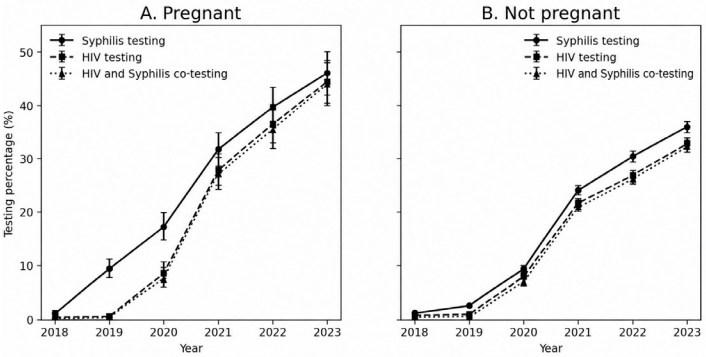


**Figure 1.** Syphilis and HIV testing over time among emergency department patients tested for both pregnancy and gonorrhea/chlamydia, 2018–2023. Panel A: Annual testing rates (%) among pregnant patients tested for both pregnancy and gonorrhea/chlamydia. Panel B: Corresponding rates (%) among nonpregnant patients tested for both pregnancy and gonorrhea/chlamydia. Each panel displays annual rates of syphilis testing, HIV testing, and combined HIV + syphilis co-testing. Error bars represent 95% confidence intervals. The EHR-based order set promoting HIV and syphilis co-testing was implemented in October 2019. In a retrospective, quasi-experimental EHR study across 20 EDs (2018–2023) of encounters among patients aged 15–44 years who received both pregnancy and GC/CT testing.
*HIV*, human immunodeficiency virus; *ED*, emergency department; *EHR*, electronic health record; *GC/CT*, gonorrhea/chlamydia.

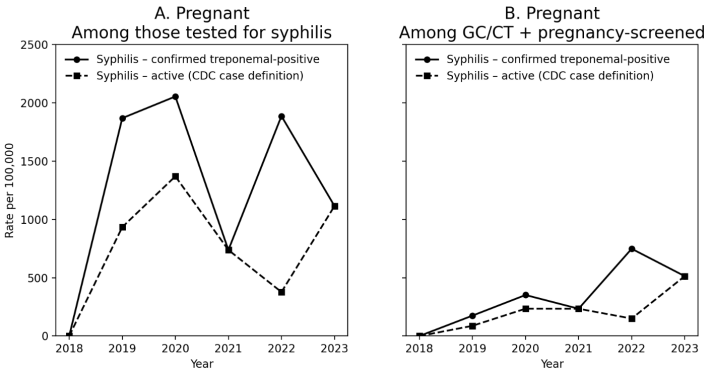


**Figure 2.** Syphilis detection among pregnant patients tested in the emergency department for both pregnancy and gonorrhea/chlamydia, 2018–2023. Panel A: Annual rates (per 100,000) among pregnant patients tested for syphilis. Panel B: Corresponding rates (per 100,000) among all pregnant patients tested for both pregnancy and gonorrhea/chlamydia (GC/CT), regardless of whether syphilis testing was performed. Each panel displays confirmed treponemal-positive encounters and the subset meeting the CDC surveillance criterion for active syphilis. Confidence intervals are omitted for visual clarity; exact values appear in Table 3.
*CDC*, Centers for Disease Control and Prevention.

first prenatal visit, with repeat testing in the early third trimester and at delivery for those at increased risk or in areas of high prevalence. The American College of Obstetricians and Gynecologists recommends universal screening at all three time points.[20] Despite these recommendations, populations at highest risk for syphilis often have inadequate or no prenatal care, making the ED their only opportunity for early detection.[6]

Although syphilis testing increased substantially during the post-implementation period, many encounters in the analytic cohort still did not include syphilis testing. Implementation was not uniform across EDs. Low ED syphilis co-testing has also been reported nationally among patients undergoing GC/chlamydia testing, suggesting that low baseline co-testing is common in this clinical context. In a national ED sample, syphilis testing was performed in only 2.9% of GC/chlamydia encounters, and combined HIV-syphilis cotesting in 1.5%.[21] In our system, testing increased substantially over time, but that increase was concentrated in a subset of EDs, which likely contributed to the lower overall testing proportion across the full cohort. Among pregnant encounters, syphilis testing also became increasingly paired with HIV testing over time, suggesting that the bundled workflow was becoming more consistently incorporated into routine practice. Because we did not directly measure clinician-, workflow-, or patient-level reasons for nontesting, we cannot determine why testing remained incomplete at specific encounters. These findings therefore identify a persistent implementation gap.

Interpretation of these findings requires caution. This was a retrospective before-after study conducted during a period of broader change in ED utilization and STI testing practice, including the COVID-19 pandemic. Accordingly, the observed increase in testing during the postimplementation period should be interpreted as a temporal association rather than as proof that the order set alone caused the increase. The uneven pattern of improvement across EDs nevertheless suggests that local implementation and reinforcement contributed to the observed differences in performance, rather than the increase reflecting only a uniform secular trend across the health system.

The intervention was also simple to deploy. We did not perform a formal economic evaluation, but implementation required approximately 6 hours of EHR analyst time for build, testing, and deployment (≈$450 total), with about 2 hours of annual maintenance. Result follow-up used an existing ED pharmacy callback workflow.

## LIMITATIONS

This study has several limitations. First, we did not perform adjusted analyses to isolate the independent association of the order set with testing outcomes. Accordingly, the observed increase in testing may reflect a

**Table 3.** Sexually transmitted infection testing trends and results for pregnant patients in the emergency department tested for both pregnancy and gonorrhea/chlamydia.

| Factor | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Change 2018→2023 | Ratio 2023/2018 |
|---|---|---|---|---|---|---|---|---|
| Yearly Trends in STI Testing Among *GC/CT* Screened Encounters | | | | | | | | |
| Denominator per year | *N* = 1,074 | *N* = 1,144 | *N* = 853 | *N* = 855 | *N* = 668 | *N* = 584 | | |
| Syphilis test | 10 (0.9% [0.5–1.7]) | 107 (9.4% [7.8–11.2]) | 146 (17.1% [14.7–19.8]) | 271 (31.7% [28.7–34.9]) | 265 (39.7% [36.0–43.4]) | 269 (46.1% [42.1–50.1]) | 45.1 pp [40.4–49.6] | 49.47 [24.66–98.94] |
| HIV test | 4 (0.4% [0.1–1.0]) | 7 (0.6% [0.3–1.3]) | 73 (8.6% [6.9–10.6]) | 238 (27.8% [24.9–30.9]) | 244 (36.5% [33.0–40.2]) | 260 (44.5% [40.5–48.6]) | 44.1 pp [39.6–48.4] | 119.54 [42.51–335.16] |
| HIV and Syphilis co-testing | 2 (0.2% [0.1–0.7]) | 6 (0.5% [0.2–1.1]) | 65 (7.6% [6.0–9.6]) | 232 (27.1% [24.3–30.2]) | 237 (35.5% [31.9–39.2]) | 257 (44.0% [40.0–48.1]) | 43.8 pp [39.4–48.0] | 236.32 [59.18–940.80] |
| Yearly STI Positivity Rate Among Those Tested | | | | | | | | |
| ≥1 positive result | 90/1074 (8.4% [6.9–10.2]) | 101/1144 (8.8% [7.3–10.6]) | 79/853 (9.3% [7.5–11.4]) | 106/855 (12.4% [10.4–14.8]) | 72/668 (10.8% [8.6–13.4]) | 63/584 (10.8% [8.5–13.6]) | 2.4 pp [-1.7–6.7] | 1.29 [0.84–1.98] |
| GC/CT positive | 90/1074 (8.4% [6.9–10.2]) | 99/1144 (8.7% [7.2–10.4]) | 76/853 (8.9% [7.2–11.0]) | 103/855 (12.0% [10.0–14.4]) | 66/668 (9.9% [7.8–12.4]) | 60/584 (10.3% [8.1–13.0]) | 1.9 pp [-2.1–6.1] | 1.23 [0.79–1.89] |
| Confirmed treponemal-positive syphilis | 0/10 (0.0% [0.0–30.8]) | 2/107 (1.9% [0.5–6.6]) | 3/146 (2.1% [0.7–5.9]) | 2/271 (0.7% [0.2–2.7]) | 5/265 (1.9% [0.8–4.3]) | 3/269 (1.1% [0.4–3.2]) | 1.1 pp [-27.4–3.2] | — |
| Active syphilis (CDC surveillance case definition) | 0/10 (0.0% [0.0–30.8]) | 1/107 (0.9% [0.2–5.1]) | 2/146 (1.4% [0.4–4.9]) | 2/271 (0.7% [0.2–2.7]) | 1/265 (0.4% [0.1–2.1]) | 3/269 (1.1% [0.4–3.2]) | 1.1 pp [–27.4–3.2] | — |
| Syphilis – false-positive | 1/10 (10.0% [1.8–40.4]) | 0/107 (0.0% [0.0–3.4]) | 1/146 (0.7% [0.1–3.8]) | 2/271 (0.7% [0.2–2.7]) | 1/265 (0.4% [0.1–2.1]) | 0/269 (0.0% [0.0–1.4]) | –10.0 pp [–40.4—0.4] | 0.00 [0.00–0.79] |
| HIV positive | 0/4 (0.0% [0.0–60.2]) | 0/7 (0.0% [0.0–41.0]) | 0/73 (0.0% [0.0–4.9]) | 1/238 (0.4% [0.1–2.3]) | 1/244 (0.4% [0.1–2.3]) | 0/260 (0.0% [0.0–1.4]) | 0.0 pp [–49.0–1.5] | — |
| HIV positive and confirmed treponemal-positive syphilis | 0/2 (0.0% [0.0–84.2]) | 0/6 (0.0% [0.0–45.9]) | 0/65 (0.0% [0.0–5.5]) | 0/232 (0.0% [0.0–1.6]) | 0/237 (0.0% [0.0–1.5]) | 0/257 (0.0% [0.0–1.4]) | 0.0 pp [–65.8–1.5] | — |
| Yearly Syphilis and HIV Rates per 100,000 Among *GC/CT* Screened Encounters | | | | | | | | |
| Denominator per year | N=1074 | N=1144 | N=853 | N=855 | N=668 | N=584 | | |
| Confirmed treponemal-positive syphilis | 0 (0.0 per 100,000 [0.0–342.9]) | 2 (174.8 per 100,000 [48.0–635.2]) | 3 (351.7 per 100,000 [119.7–1028.9]) | 2 (233.9 per 100,000 [64.2–848.9]) | 5 (748.5 per 100,000 [320.1–1740.1]) | 3 (513.7 per 100,000 [174.9–1499.3]) | | |
| Active syphilis (CDC surveillance case definition) | 0 (0.0 per 100,000 [0.0–342.9]) | 1 (87.4 per 100,000 [15.4–493.5]) | 2 (234.5 per 100,000 [64.3–850.8]) | 2 (233.9 per 100,000 [64.2–848.9]) | 1 (149.7 per 100,000 [26.4–843.0]) | 3 (513.7 per 100,000 [174.9–1499.3]) | | |
| HIV positive | 0 (0.0 per 100,000 [0.0–342.9]) | 0 (0.0 per 100,000 [0.0–321.9]) | 0 (0.0 per 100,000 [0.0–431.5]) | 1 (117.0 per 100,000 [20.6–659.5]) | 1 (149.7 per 100,000 [26.4–843.0]) | 0 (0.0 per 100,000 [0.0–629.7]) | | |

Note: Testing rows use the GC/CT-screened cohort as the denominator (per-year denominators shown). Positivity rows are reported as n/N (% [95% CI]) among those tested.
*CDC*, Centers for Disease Control and Prevention; *GC/CT*, gonorrhea/chlamydia; *pp*, percentage points; *STI*, sexually transmitted infection.

**Table 4.** Sexually transmitted infection testing trends and results for nonpregnant ED patients aged 15–44 years tested for both pregnancy and gonorrhea/chlamydia in the emergency department.

| Factor | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | Change 2018→2023 | Ratio 2023/2018 |
|---|---|---|---|---|---|---|---|---|
| Yearly Trends in STI Testing Among *GC/CT*-Screened Encounters | | | | | | | | |
| Denominator per year | *N* = 10,062 | *N* = 10,815 | *N* = 8,695 | *N* = 8,890 | *N* = 8,015 | *N* = 7,516 | | |
| Syphilis test | 124 (1.2% [1.0–1.5]) | 279 (2.6% [2.3–2.9]) | 813 (9.4% [8.8–10.0]) | 2,130 (24.0% [23.1–24.9]) | 2,429 (30.3% [29.3–31.3]) | 2,695 (35.9% [34.8–36.9]) | 34.6 pp [33.3–35.9] | 29.10 [23.70–35.71] |
| HIV test | 87 (0.9% [0.7–1.1]) | 114 (1.1% [0.9–1.3]) | 695 (8.0% [7.4–8.6]) | 1,930 (21.7% [20.9–22.6]) | 2,148 (26.8% [25.8–27.8]) | 2,466 (32.8% [31.8–33.9]) | 31.9 pp [30.7–33.2] | 37.95 [29.81–48.29] |
| HIV and Syphilis co-testing | 52 (0.5% [0.4–0.7]) | 63 (0.6% [0.5–0.7]) | 600 (6.9% [6.4–7.5]) | 1,864 (21.0% [20.1–21.8]) | 2,088 (26.1% [25.1–27.0]) | 2,423 (32.2% [31.2–33.3]) | 31.7 pp [30.5–32.9] | 62.38 [46.07–84.45] |
| Yearly STI Positivity Rate Among Those Tested | | | | | | | | |
| ≥1 positive result | 957/10,062 (9.5% [9.0–10.1]) | 1,134/10,815 (10.5% [9.9–11.1]) | 1,265/8,695 (14.5% [13.8–15.3]) | 1,326/8,890 (14.9% [14.2–15.7]) | 1,049/8,015 (13.1% [12.4–13.8]) | 922/7,516 (12.3% [11.5–13.0]) | 2.8 pp [1.4–4.1] | 1.29 [1.14–1.46] |
| GC/CT positive | 953/10,062 (9.5% [8.9–10.1]) | 1,130/10,815 (10.4% [9.9–11.0]) | 1,257/8,695 (14.5% [13.7–15.2]) | 1,294/8,890 (14.6% [13.8–15.3]) | 1,006/8,015 (12.6% [11.8–13.3]) | 851/7,516 (11.3% [10.6–12.1]) | 1.9 pp [0.6–3.1] | 1.20 [1.06–1.35] |
| Confirmed treponemal-positive syphilis | 3/124 (2.4% [0.8–6.9]) | 4/279 (1.4% [0.6–3.6]) | 11/813 (1.4% [0.8–2.4]) | 37/2,130 (1.7% [1.3–2.4]) | 55/2,429 (2.3% [1.7–2.9]) | 74/2,695 (2.7% [2.2–3.4]) | 0.3 pp [–4.7–2.6] | 1.13 [0.32–4.16] |
| Syphilis – false-positive | 2/124 (1.6% [0.4–5.7]) | 0/279 (0.0% [0.0–1.3]) | 8/813 (1.0% [0.5–1.9]) | 9/2,130 (0.4% [0.2–0.8]) | 6/2,429 (0.2% [0.1–0.5]) | 7/2,695 (0.3% [0.1–0.5]) | –1.4 pp [–5.6–0.1] | 0.16 [0.02–1.21] |
| HIV positive | 2/87 (2.3% [0.6–8.0]) | 1/114 (0.9% [0.2–4.8]) | 0/695 (0.0% [0.0–0.5]) | 1/1,930 (0.1% [0.0–0.3]) | 1/2,148 (0.0% [0.0–0.3]) | 6/2,466 (0.2% [0.1–0.5]) | –2.1 pp [–7.9—0.1] | 0.11 [0.01–0.84] |
| HIV positive and confirmed treponemal-positive syphilis | 0/52 (0.0% [0.0–6.8]) | 0/63 (0.0% [0.0–5.7]) | 0/600 (0.0% [0.0–0.6]) | 0/1,864 (0.0% [0.0–0.2]) | 0/2,088 (0.0% [0.0–0.2]) | 0/2,423 (0.0% [0.0–0.2]) | 0.0 pp [–6.9–0.2] | — |
| Yearly Syphilis and HIV Rates per 100,000 Among *GC/CT*-Screened Encounters | | | | | | | | |
| Denominator per year | *N* = 10,062 | *N* = 10,815 | *N* = 8,695 | *N* = 8,890 | *N* = 8,015 | *N* = 7,516 | | |
| Confirmed treponemal-positive syphilis | 3 (29.8 per 100,000 [10.1–87.6]) | 4 (37.0 per 100,000 [14.4–95.1]) | 11 (126.5 per 100,000 [70.7–226.4]) | 37 (416.2 per 100,000 [302.1–573.1]) | 55 (686.2 per 100,000 [527.6–892.1]) | 74 (984.6 per 100,000 [785.0–1234.2]) | | |
| HIV positive | 2 (19.9 per 100,000 [5.5–72.5]) | 1 (9.2 per 100,000 [1.6–52.4]) | 0 (0.0 per 100,000 [0.0–42.4]) | 1 (11.2 per 100,000 [2.0–63.7]) | 1 (12.5 per 100,000 [2.2–70.6]) | 6 (79.8 per 100,000 [36.6–174.1]) | | |

Testing rows use the gonorrhea/chlamydia-screened cohort as the denominator (per-year denominators shown). Positivity rows are reported as n/N (% [95% CI]) among those tested. Per-100,000 rows use the gonorrhea/chlamydia-screened cohort as the denominator.
*GC/CT*, gonorrhea/chlamydia; *pp*, percentage points.

combination of implementation strategy, changes in patient mix across years, site-level practice variations, and broader secular trends. This limitation is particularly important because the order set was introduced in October 2019, only a few months before the COVID-19 pandemic disrupted ED utilization, staffing, workflow, and STI testing practices. The observed increases should therefore be interpreted as temporal associations during the postimplementation period rather than as evidence that the order set alone caused the increase.

Second, we did not perform chart reviews in nonpregnant patients to determine whether confirmed treponemal-positive serologic results met the CDC case definition for syphilis or reflected previously treated infection.[13] Consequently, the confirmed treponemal-

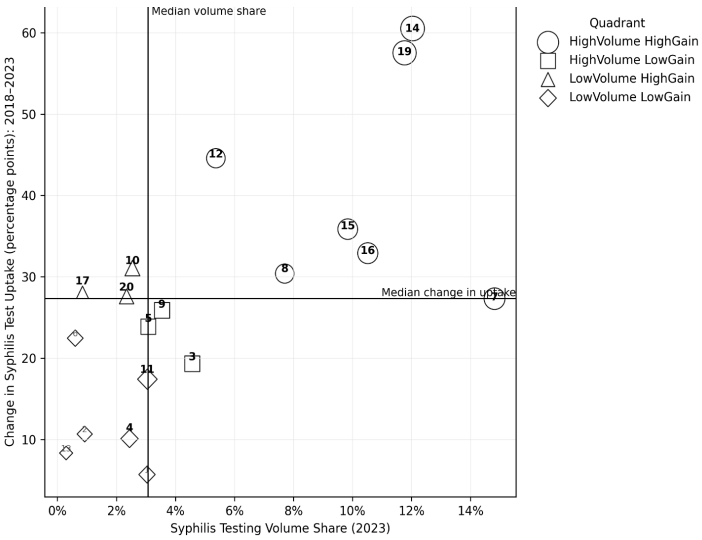


**Figure 3.** Site-level variation in syphilis testing among emergency department patients tested for both pregnancy and gonorrhea/chlamydia, 2018–2023.
This plot compares each ED's change in syphilis testing from 2018 to 2023 (y-axis) with its 2023 share of total network testing volume (x-axis). Each point represents one ED; bubble size is proportional to the absolute increase in tests performed. Median volume share and median testing change define four quadrants (high-volume/high-gain; high-volume/low-gain; low-volume/high-gain; low-volume/low-gain), illustrating that most network-wide improvement was concentrated among a few large, high-performing EDs.

positive rate should not be interpreted as the incidence of active syphilis, as it includes both current and previously treated cases. Third, treatment completion and clinical outcomes were not assessed. Although positive results were routed through an existing ED pharmacist callback workflow and reported to the Department of Health, treatment completion was not measured. Fourth, the study period included changes in treponemal assays, with the replacement of a syphilis IgG assay by syphilis total IgG/IgM assays with a narrower window period. However, all assays were used within an accepted reverse-sequence testing framework, and we do not believe these changes materially altered the study's main descriptive findings. Fifth, we did not measure whether the intervention reduced congenital syphilis incidence. Finally, as with any screening program, false-positive results and follow-up burden remain important considerations, although treponemal false-positive results were uncommon in our cohort.[22-26]

## CONCLUSION

Syphilis testing increased substantially during the postimplementation period following introduction of a preselected EHR order set. Although detection in pregnancy was clinically meaningful, testing remained incomplete across the analytic cohort. These findings support the ED as an important setting for screening while highlighting persistent variation in implementation across sites.

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# Point-of-Care Ultrasound After Medical Screening Exam Reduces Time to Ruptured Ectopic Pregnancy Diagnosis and Surgery

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**Introduction:** Ectopic pregnancy remains the leading cause of first-trimester maternal mortality. Delays in diagnosis and operative management increase morbidity and may be exacerbated by emergency department (ED) crowding. We evaluated whether integration of point-of-care ultrasound (POCUS) into the medical screening exam of pregnant patients—the obstetric medical screening exam—was associated with improved timeliness of care for patients with surgically managed ectopic pregnancy.

**Methods:** We conducted a single-center retrospective cohort study of adult patients undergoing operative management for ruptured ectopic pregnancy between January 1, 2019, and December 31, 2023, at a county safety-net hospital. The obstetric screening exam was implemented July 12, 2021, and incorporated focused transabdominal pelvic and right upper quadrant ultrasound into the initial ED evaluation, often prior to bed assignment. The primary outcome was time from ED arrival to operating room (OR). Secondary outcomes included time to obstetric consultation, time to hospital admission, ED length of stay (LOS), and POCUS use. Nonparametric testing was used for skewed time data. Logistic regression evaluated the odds of reaching the OR within four hours. Patient-level interrupted time series analysis assessed temporal trends.

**Results**: A total of 150 patients were included (87 pre- and 63 post-implementation). Median arrival-to-OR time decreased from 516 minutes (interquartile range [IQR] 324–709.5) to 391 minutes (IQR 220–619), a 125-minute reduction ($P = .020$; bootstrap 95% CI, 8–233). The proportion of patients reaching the OR within four hours increased from 16.1% to 31.8% (odds ratio 2.42; 95% CI, 1.11–5.29; $P = .02$). Time to obstetric consultation (210 vs 146 minutes; $P = .003$), time to hospital admission (345 vs 250 minutes; $P = .005$), and ED LOS (451 vs 367 minutes; $P = .03$) were all reduced. Point-of-care ultrasound use increased from 41.4% to 66.7% ($P < .001$), while the remainder underwent radiology ultrasound. Interrupted time series analysis demonstrated no significant immediate change after implementation ($P = .790$), but a significant postintervention trend toward reduced arrival-to-OR time (−0.45 minutes/day, $P = .01$).

**Conclusion**: Embedding POCUS into the medical screening examination in triage was associated with sustained improvement in operative timeliness for ruptured ectopic pregnancy. Early diagnostic integration within ED workflow may mitigate system-level delays in time-sensitive obstetric emergencies. [West J Emerg Med. 2026;27(5)1478–1484.]

## INTRODUCTION

Ectopic pregnancy accounts for approximately 1–2% of all pregnancies and remains the leading cause of maternal mortality in the first trimester, contributing to an estimated 75% of first-trimester deaths and 9-13% of all pregnancy-related deaths.[1] Despite advances in diagnostic testing and management, mortality rates have remained relatively unchanged in the setting of delays in definitive care.[1] Tubal rupture, the primary driver of ectopic pregnancy-related mortality, is associated with severe hemorrhage, transfusion, longer hospital length of stay (LOS), and increased morbidity.[2] Timely diagnosis and management are crucial to reducing morbidity and mortality. However, diagnosis can be challenging, particularly in emergency department (ED) settings where symptoms often overlap with other acute conditions and with prolonged wait times, and where resource constraints may delay critical care.[3] Further, rupture cannot be reliably predicted by traditional clinical risk factors, gestational age, or serum β–human chorionic gonadotropin (β-hCG) levels. Falcone et al demonstrated that tubal rupture occurred across all β-hCG ranges and was not associated with known ectopic risk factors.[2] Similarly, discriminatory zone-based strategies and historical predictors have limited ability to identify which pregnancies will progress to rupture or are ruptured.[2]

Young patients with hemorrhage may remain deceptively well appearing during the compensatory phase of shock, with preservation of blood pressure and only subtle abnormalities in routine vital signs. Trauma literature describes this state as occult hypoperfusion—defined as inadequate tissue oxygenation despite normal vital signs—and associates it with worse outcomes. In normotensive trauma patients, the shock index has been shown to identify compensated shock more effectively than blood pressure alone; however, a normal shock index should not be interpreted as reassuring, as compensated shock may persist despite normal heart rate and blood pressure. These physiologic principles are directly relevant to ruptured ectopic pregnancy, in which traditional vital signs correlate poorly with the degree of hemoperitoneum and may fail to identify patients with significant intraabdominal bleeding until compensatory reserve is exhausted and sudden decompensation occurs. Collectively, these findings suggest that reliance on a single set of normal vital signs at triage may contribute to delayed recognition of hemorrhage in this population.[5-9]

Timeliness of diagnosis and operative intervention is therefore central to reduce ectopic pregnancy-related morbidity. Delays in care are associated with increased rates of rupture and hemorrhage.[1] In parallel, a substantial body of literature demonstrates that ED crowding and boarding are associated with delayed treatment, longer hospital LOS, and increased inpatient mortality.[10,11] Even high-acuity patients are not immune to the adverse effects of crowding.[11] As ED volumes rise and inpatient capacity remains constrained, system-level delays may disproportionately impact time-sensitive conditions such as ruptured ectopic pregnancy.

*Population Health Research Capsule*

What do we already know about this issue?
*Ectopic pregnancy is the leading cause of first-trimester maternal mortality. Emergency department (ED) crowding delays diagnosis, worsening morbidity.*

What was the research question?
*Does embedding ultrasound into the ED medical screening exam reduce time to surgery for ruptured ectopic pregnancy?*

What was the major finding of the study?
*Median arrival-to-OR time decreased 125 min (516 vs 391 min; P = .02; 95% CI, 8–233 min) after implementation of obstetric medical screening exam.*

How does this improve population health?
*Embedding ultrasound at triage can reduce delays for a high-mortality emergency, offering a scalable model in crowded safety-net EDs.*

Within this context, the Emergency Medical Treatment and Labor Act mandates a medical screening examination (MSE) for all patients presenting to the ED. While the MSE serves as a regulatory screening requirement, existing evidence indicates that triage-based evaluations and early physician assessment improve operational flow but do not reliably reduce delays in definitive surgical management in time-sensitive conditions.[1,12] For patients with suspected early pregnancy complications, traditional workflow in crowded ED environments often involves an MSE followed by triage to the waiting room with screening laboratory testing and consultative imaging while the patient waits for a care space in the monitored environment of the ED care area. This sequential approach may introduce diagnostic latency, particularly when imaging availability is constrained by technician staffing or after-hours coverage.[1]

To address these issues, our institution introduced a quality improvement (QI) initiative incorporating point-of-care ultrasound (POCUS) into an obstetric medical screening exam. Prior studies have demonstrated that emergency physicians can accurately diagnose ectopic pregnancy using both transabdominal and transvaginal approaches with POCUS.[3,4] Previous studies also suggest that ED patients with a ruptured ectopic pregnancy who undergo POCUS had shorter times to diagnosis, obstetric consultation, and

operating room (OR) arrival compared with those who received radiology-performed ultrasound.[6-7] By embedding POCUS into the triage process, this QI initiative was designed to streamline the diagnosis and treatment of patients with suspected ruptured ectopic pregnancy by reducing time to diagnosis and surgical intervention.

This study evaluates the impact of the obstetric screening exam protocol on the care of patients with ruptured ectopic pregnancy requiring surgical intervention. Specifically, we compared POCUS use rates, time to diagnosis, time to OR arrival, and ED LOS before and after the implementation of the OB MSE.

## METHODS

### Study Design and Setting

This was a single-center retrospective cohort study of all ED patients found to have a ruptured ectopic pregnancy between January 1, 2019–December 31, 2023, at a county safety-net hospital in Houston (average 81,000 visits/year). This facility offers 24/7 consultative pelvic ultrasound via radiology and an in-house obstetrics service with its own triage area staffed by obstetric/gynecologic (OB/GYN) physicians for patients 20 weeks or greater in gestation. Point-of-care ultrasound examinations were performed by a range of clinicians, including physician assistants, residents, ultrasound fellows, and attending physicians with and without ultrasound fellowship training. An obstetric MSE was performed on all patients with known pregnancy or confirmed pregnancy test in the ED.

During the screening exam, clinicians obtained transabdominal transverse and sagittal views of the pelvis to evaluate for presence or absence of intrauterine pregnancy (IUP), and pelvic free fluid. Subsequent to the transabdominal pelvic window, a coronal view of the right upper quadrant was then obtained to evaluate for extrapelvic free peritoneal fluid (Figure 1). Ultrasound images were obtained using 1-5 megahertz (Mhz) curvilinear or 1-5 Mhz phased-array transducers on Sonosite LX, PX, and Xporte systems (Fujifilm, Bothell, WA). All ultrasound images were then reviewed in real time with the emergency attending physician staffing the triage care area at the time.

### Patient Selection

We identified patients at least 18 years of age diagnosed with ectopic pregnancy in the ED based on discharge diagnoses, using *International Classification of Diseases, 10th Revision,* (*ICD-10*) codes. We included all patients who underwent diagnostic laparoscopy for suspected ruptured ectopic pregnancy, regardless of whether POCUS was documented or performed. We excluded patients with nonruptured ectopic pregnancies, intrauterine pregnancies, or pregnancies of unknown location managed without operative intervention, after physician reviewer confirmation of the final diagnosis. There were no cases of heterotopic pregnancy in our sample.

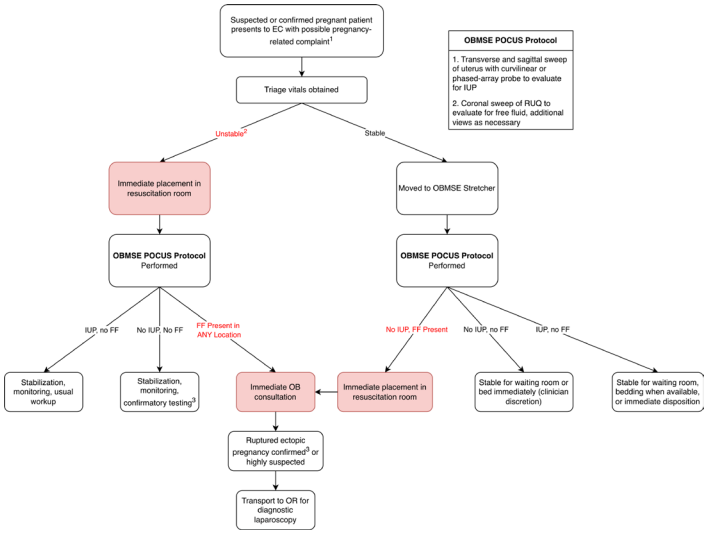


**Figure 1.** Protocol for obstetric medical screening examination in the emergency department.
[1]Pregnancy-related complaints include confirmed or suspected pregnancy plus one of the following: abdominal pain/cramping, vaginal bleeding, or vaginal discharge.
[2]Unstable vitals include one or more of the following: systolic blood pressure < 90 mm Hg or mean arterial pressure < 65 mm Hg; heart rate > 120 beats per minute; or oxygen saturation < 90% or unreadable.
[3]Confirmatory testing could include one, or a combination of, laboratory serum human chorionic gonadotropic testing; radiology-performed transabdominal and/or transvaginal pelvic ultrasound; computed tomography abdomen/pelvis; or repeat/real-time review of the emergency clinician-performed bedside ultrasound with both the emergency and obstetric attendings present.
*EC,* emergency center*; FF*, free fluid*; IUP,* intrauterine pregnancy; *POCUS,* point-of-care ultrasound; *OB*, obstetrics*; OBMSE,* obstetric medical screening exam; *OR,* operating room*; RUQ*, right upper quadrant.

### Data Collection

For retrospective chart review, we followed key methodological recommendations from Worster and Bledsoe to ensure rigor: 1) We defined clear inclusion and exclusion criteria; 2) used a standardized data abstraction form; and 3) defined all key variables a priori. Emergency physicians with specialized fellowship training in POCUS reviewed and extracted all chart values and imaging.[8] The primary outcomes were as follows; time to diagnosis of ruptured ectopic pregnancy (defined as the interval from ED arrival time to the time a gynecology consult order was placed in the electronic health record (EHR), which occurs simultaneously with verbal communication with the consultant at our institution); time to operative management (the interval from ED arrival to the earlier of either "anesthesia start" time or "arrived in OR" times in the EHR); and ED LOS (defined as the interval from ED arrival to departure from the ED). Time of clinician evaluation was defined as the MSE completion. Time of

admission was defined as the time the admit order was placed by the OB/GYN physician. Emergency department LOS, ED admission time, and OR time were all analyzed and recorded separately due to a number of delays affecting the ED. Stable patients would occasionally be admitted to the observation unit or antepartum service prior to going to the OR. Documenting admission times compared to ED LOS allowed us to capture any effect of ED boarding.

We recorded POCUS findings from documented procedure notes detailing the presence or absence of IUP and/or free intraperitoneal fluid. We defined POCUS time as the sooner of the acquisition time or procedure note timestamp, because procedure notes are written in real-time according to the obstetric MSE process. Radiology-performed ultrasound times were defined as the time of acquisition listed on the radiology report. All data were abstracted from the EHR by a team of trained emergency physician reviewers. Because the obstetric MSE occurs on initial evaluation, we recorded triage vitals and calculated mean arterial pressures. We also performed a subanalysis of the primary outcomes OR time and ED LOS for patients with ruptured ectopic pregnancy managed by emergency physicians with and without ultrasound fellowship training.

### Outcome Measures and Analysis

Patients were categorized based on presentation before or after implementation of the obstetric MSE protocol (July 12, 2021). We recorded all time-based outcomes in minutes, including time from ED arrival to ultrasound, obstetrics consultation, hospital admission, OR arrival, and ED LOS. The primary outcome was time from ED arrival to OR. Secondary outcomes included time to obstetrics consultation, time to hospital admission, ED LOS, and the proportion of patients reaching the OR within 240 minutes. All continuous variables are summarized as medians with interquartile ranges (IQR) (Q1-Q3). For continuous outcome variables, the normality assumption was assessed using the Shapiro–Wilk test and quantile-quantile (QQ) plots.

Given non-normal distributions, we performed comparisons between groups using the Wilcoxon rank-sum test. The Welch two-sample *t*-test was conducted as a sensitivity analysis to assess the robustness of the results. We used bootstrap resampling (1,000 iterations) to construct 95% confidence intervals for median differences. We compared categorical outcome variables using the chi-square test. Logistic regression was used to estimate odds ratios (OR) with 95% confidence intervals. The Fisher exact test was performed as a sensitivity analysis. A patient-level interrupted time series (P-ITS) analysis using segmented linear regression was conducted to evaluate temporal trends. The model included elapsed time (days), an indicator for obstetric MSE implementation, and time since implementation. A two-sided $P$ value < .05 was considered statistically significant.

## RESULTS

### General

Table 1 displays the observed characteristics of patients presenting before and after implementation of the obstetric MSE. Baseline characteristics were similar between groups, with no statistically significant differences in age, heart rate, gravidity, or estimated blood loss. Mean arterial pressure was higher in the post-implementation group.

Among the 150 patients who required operative intervention for ruptured ectopic pregnancy, 87 presented before and 63 after implementation of the obstetric MSE. Use of POCUS increased from 41.4% before implementation to 66.7% after implementation.

### Primary Outcomes

Median time from ED arrival to OR decreased from 516 minutes (IQR 324–709.5) before the obstetric MSE to 391 minutes (IQR 220–619) after implementation (median difference 125 minutes; $P$ = .02). The bootstrap 95% confidence interval for the median difference was 8 to 233 minutes. Results were consistent using the Welch *t*-test ($P$ = .02). The proportion of patients reaching the OR within 240

**Table 1.** Characteristics of patients before and after implementation of ultrasound in the emergency department pregnancy screening examination.

| | Pre-OBMSE Group (*n* = 87) | | Post-OBMSE Group (*n* = 63) | | Comparison |
|---|---|---|---|---|---|
| | Median | IQR (Q1-Q3) | Median | IQR (Q1-Q3) | *P* value* |
| Age (years) | 30 | 26-34 | 33 | 26-36 | .28 |
| Triage HR (bpm) | 94 | 83-102 | 89 | 81-98 | .15 |
| Triage MAP (mm Hg) | 90 | 83-97 | 94 | 88-102 | .05 |
| Gravid | 3 | 2-4 | 3 | 2-5 | .30 |
| EBL (cc) | 70 | 20-250 | 28 | 5-300 | .78 |

*P value based on Student *t*-test.
*EBL*, estimated blood loss; *HR*, heart rate; *IQR*, interquartile range; *MAP*, mean arterial blood pressure; *OBMSE*, obstetric medical screening examination; *Q1*, quartile 1; *Q3*, quartile 3.

minutes increased from 16.1% before implementation of the obstetric MSE to 31.8% after implementation ($P = .024$). The odds of reaching the OR within 240 minutes were higher after implementation (OR 2.42; 95% CI, 1.11–5.29). The Fisher exact test yielded similar results ($P = .03$).

Table 2 displays each of the primary outcome measures. There was no significant immediate change in time to OR following implementation of the obstetric MSE ($\beta = -27.3$ minutes, $P = .79$). However, there was a significant change in slope after implementation (−0.45 minutes/day, $P = .01$), indicating a progressive reduction in time to OR over the study period. Figure 2 displays the distribution of time to OR pre- and post-implementation as a density curve.

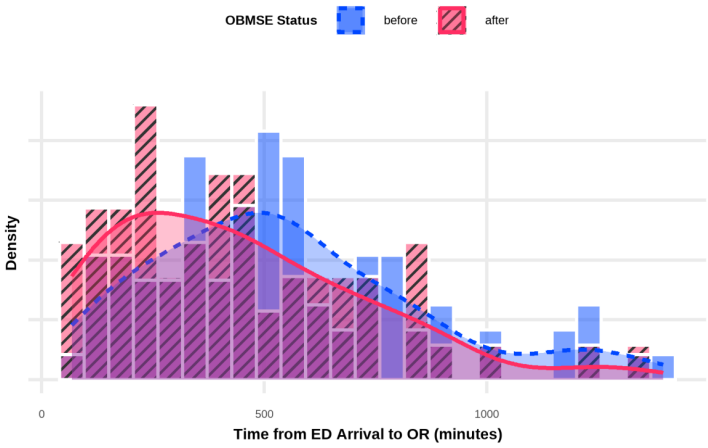


**Figure 2.** Distributions of time in minutes from emergency department (ED) arrival to before and after implementation of ultrasound in the ED pregnancy screening examination. Curve shows the distribution of the data by smoothing the frequency of observations. It highlights where values are concentrated and allows for easy comparison between groups, even when sample sizes differ.
*OBMSE*, obstetric medical screening examination.

### Secondary Outcomes

Time to obstetrics consultation decreased from a median of 210 minutes to 146 minutes ($P = .003$; median difference 64 minutes; 95% CI, 24–125). Time to hospital admission decreased from 345 minutes to 250 minutes ($P = .005$; median difference 95 minutes), although the bootstrap 95% CI (−3 to 173 minutes) included zero. Emergency department LOS decreased from 451 minutes to 367 minutes ($P = .03$; median difference 84 minutes; 95% CI, 6–203). Interrupted time series analysis demonstrated a significant decrease in trend following implementation (−0.35 minutes/day, $P = .01$), shown in Figure 3.

### Point-of-Care Ultrasound Subgroup Analysis

Among patients who underwent POCUS, median time to OR was 324 minutes compared to 533 minutes in those who did not (median difference 209 minutes; $P < .001$; 95% CI, 121.5–307.5). Figure 4 displays the distribution of time as a density curve stratified by POCUS use. Patients who received POCUS were more likely to reach the OR within 240 minutes (37.2% vs 6.5%; OR 7.93; 95% CI, 2.87–21.95; $P < .001$).

## DISCUSSION

In this single-center retrospective cohort study, implementation of an obstetric-focused medical screening examination incorporating POCUS was associated with shorter time to operative management for patients with ruptured ectopic pregnancy. Median time from ED arrival to the OR decreased by 125 minutes, and the proportion of patients reaching the OR within four hours nearly doubled. Time to obstetric consultation, time to hospital admission, and ED LOS were also shorter following implementation, with a concurrent increase in POCUS use.

These findings suggest that integration of ultrasound into the earliest phase of ED evaluation may facilitate earlier recognition of intraperitoneal hemorrhage and accelerate activation of operative care pathways. Importantly, patient-level interrupted time series analysis demonstrated that this improvement was not immediate but occurred progressively

**Table 2.** Comparison of primary and secondary outcomes before and after implementation of ultrasound in the pregnancy screening examination performed in the emergency department.

| | Pre-OBMSE Group ($n$ = 87) | | Post-OBMSE Group ($n$ = 63) | | Comparison | | |
|---|---|---|---|---|---|---|---|
| | Median | IQR (Q1-Q3) | Median | IQR (Q1-Q3) | Median Difference | Confidence Interval | *P* value* |
| Time to Consult (min) | 210 | 141-333.5 | 146 | 60.5-245 | 64 | 24-125 | .003 |
| Time to OR (min) | 516 | 324–709.5 | 391 | 220–619 | 125 | 8 - 233 | .02 |
| ED LOS (min) | 451 | 281-604 | 367 | 203-495.5 | 84 | 6-203 | .03 |
| Time to Admit (min) | 345 | 221.5-132.5 | 146 | 132.5-371 | 95 | -3 - 173 | .005 |

*P value based on Mann-Whitney *U* test (or Wilcoxon rank-sum test).
*Dx*, diagnosis; *ED*, emergency department; *IQR*, interquartile range; *LOS*, length of stay; *OBMSE*, obstetric medical screening examination; *OR*, operating room; *Q1*, quartile 1; *Q3*, quartile 3; *time to US,* time to first ultrasound either point of care or radiology.

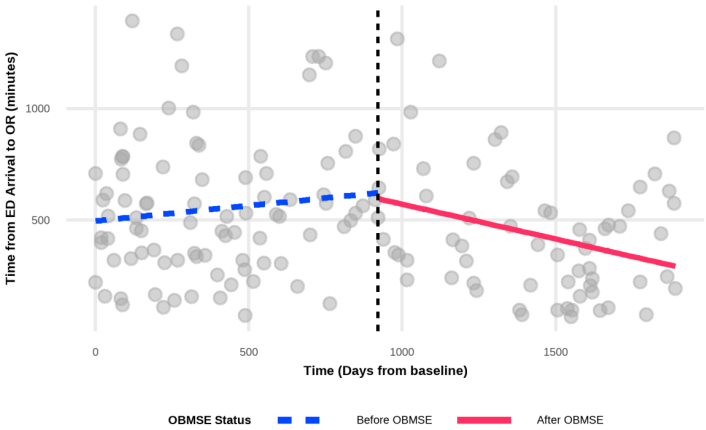


**Figure 3.** Patient-level interrupted time series analysis demonstrates a significant decrease in trend following implementation of. obstetric medical screening exam.
*ED,* emergency department*; OBMSE*, obstetric medical screening exam; *OR*, operating room.

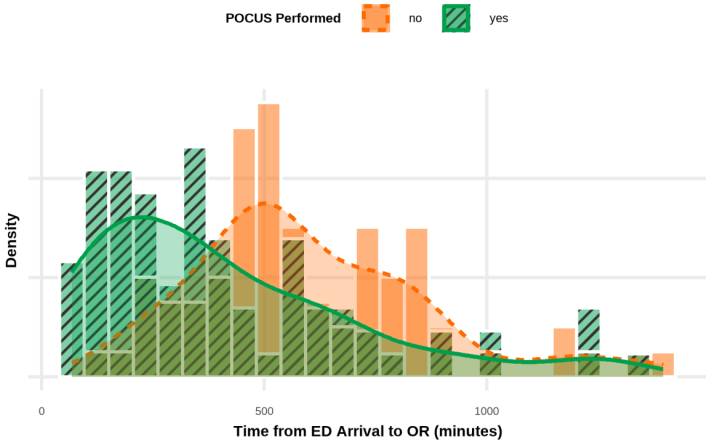


**Figure 4.** Distributions of time in minutes from emergency department arrival to operating room stratified by point-of-care ultrasound use.
*POCUS*, point-of-care ultrasound.

over time following implementation, with a significant postintervention slope change of −0.45 minutes per day. This corresponds to an estimated improvement of approximately 41 minutes per quarter and more than two hours per year, suggesting sustained gains in operational efficiency as clinicians adapted to the workflow of the obstetric screening exam.

Prior studies have demonstrated that POCUS can expedite diagnosis in patients with early pregnancy complications and intraabdominal bleeding. However, most prior work has evaluated ultrasound after placement in a treatment bed rather than as part of the initial medical screening examination. Our findings extend this literature by evaluating POCUS as a workflow intervention embedded at the point of triage evaluation. This distinction is clinically meaningful because delays related to bed placement, radiology availability, and patient transport represent known barriers to timely care in crowded EDs. The use of POCUS during the screening exam is not to exclude ectopic pregnancy but rather to evaluate for rupture, positive free fluid to expedite care.

The association between POCUS performance and shorter time to operative intervention further supports the plausibility of this workflow. Patients who underwent POCUS had a median reduction of 209 minutes in time to OR and were significantly more likely to undergo early operative intervention. While this finding does not establish causation, it provides internal consistency suggesting that earlier imaging may contribute to more rapid clinical decision-making. At the same time, the obstetric screening exam represents a combined systems intervention that includes both earlier imaging and workflow restructuring, and the independent contribution of each component cannot be fully isolated.

This study has several strengths. It includes a relatively large cohort of surgically confirmed ruptured ectopic pregnancies and evaluates clinically meaningful, time-based outcomes. The use of nonparametric testing, bootstrap confidence intervals, logistic regression, and patient-level interrupted time series analysis provides a robust and comprehensive analytic framework. In particular, the use of P-ITS strengthens inference by accounting for underlying temporal trends and demonstrating a sustained postintervention improvement rather than a transient effect.

These findings have important clinical implications. Ruptured ectopic pregnancy is a time-sensitive emergency in which delays in diagnosis and operative management may increase hemorrhagic morbidity. In busy EDs, particularly those affected by crowding and boarding, workflows that rely on sequential evaluation and consultative imaging may introduce delays. Integrating focused ultrasound into the medical screening examination may allow earlier identification of patients with suspected hemoperitoneum and facilitate more timely consultation and operative intervention.

Future research should evaluate this approach in multicenter and prospective settings and examine whether improvements in timeliness translate into better patient-centered outcomes, including transfusion requirements, complications, and mortality. Additional work is also needed to determine how similar workflow redesign strategies may be applied to other time-sensitive emergency conditions.

## LIMITATIONS

This study has several limitations. First, its retrospective design introduces the potential for unmeasured confounding and limits the ability to establish causal relationships. Second, the study was conducted at a single high-volume safety-net hospital with an established ultrasound training program,

which may limit generalizability to other clinical settings. Third, the protocol for the obstetric screening exam represents a combined intervention involving both earlier use of POCUS and broader workflow changes. As a result, the relative contribution of ultrasound itself versus other system-level factors cannot be independently determined.

Fourth, although patient-level interrupted time series analysis was used to account for underlying temporal trends, residual confounding from concurrent system-level changes cannot be excluded. Implementation of the protocol followed a period of heightened institutional awareness regarding delays in care; other unmeasured changes in clinical practice, staffing, or interdepartmental coordination may have contributed to the observed improvements independent of the intervention. Fifth, identification of POCUS use relied on documentation within the EHR. It is possible that some ultrasound examinations were performed but not documented or archived, commonly referred to as "ghost scans," which may have resulted in misclassification bias.

Finally, the study period overlapped with the COVID-19 pandemic, which may have influenced ED operations, patient presentation patterns, and hospital throughput in ways that are difficult to fully account for.

## CONCLUSION

Integration of point-of-care ultrasound into the medical screening examination was associated with shorter time to operative management for patients with ruptured ectopic pregnancy, with improvements occurring progressively over time following implementation. These findings suggest that embedding diagnostic ultrasound into ED triage workflow may represent an effective systems-level strategy to reduce delays in time-sensitive obstetric emergencies.

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*Conflicts of Interest*: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No other author has professional or financial relationships with any companies that are relevant to this study. There are no other conflicts of interest or sources of funding to declare.

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# Retrospective Comparison of the Pericapsular Nerve Group Block Versus the Fascia Iliaca Block for Hip Fractures in the Emergency Department

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**Introduction:** Hip fractures are a common injury among the elderly and a substantial cause of morbidity and mortality worldwide. Pain management is an essential component of care for patients with hip fractures, particularly for improving patient outcomes. Ultrasound-guided nerve blocks such as the fascia iliaca block (FIB) are evidence-based means of providing perioperative analgesia and reducing opioid use. Newer nerve blocks, such as the pericapsular nerve group (PENG) block, may serve as alternatives to the FIB. The objective of this study was to retrospectively compare pain reduction following the PENG block and FIB in patients with hip fractures treated in our emergency department. Secondary objectives included block-related complications such as local anesthetic systemic toxicity (LAST), greater hospital length of stay, and increase in mortality.

**Methods:** The primary outcome measure was to investigate whether the PENG block is an effective alternative to FIB in achieving analgesia. Secondary objectives include data on rates of LAST, block complications, hospital length of stay, and mortality. We conducted a retrospective chart review on adult patients (≥18 years) with hip fractures who received either a FIB or PENG block between June 2021 and June 2023. Among the participants, pain scores (0–10 scale) were recorded before and after the block. Opioid use 24 hours postblock was also documented. We used generalized estimating equation modeling to compare pre-to-post block pain reduction between the FIB and PENG block groups.

**Results:** A total of 88 participants met inclusion criteria (73 FIB, 15 PENG). The mean (SD) preblock pain scores were 6.5 (2.1) for FIB and 7.9 (1.6) for PENG, improving to 4.4 (2.0) and 4.3 (2.1) postblock, respectively. Generalized estimating equation analysis revealed a statistically significant greater reduction in pain for the PENG group compared to FIB (mean difference = 1.42; 95% CI, 0.21–2.63; $P$ = .02). In this study, there were no cases of local anesthetic systemic toxicity or other block-related complications observed (0%; 95% CI, 0%–3.4%).

**Conclusion:** Patients who received the PENG block achieved a greater reduction in pain scores compared to the FIB in this small retrospective cohort study. These findings suggest that the PENG block may be an effective alternative to FIB for analgesia in this setting. However, larger, prospective studies are needed to confirm these results. Given the study design and baseline differences in pain scores, these findings should be interpreted with caution. [West J Emerg Med. 2026;27(5)1485–1489.]

## INTRODUCTION

Hip fractures continue to be a significant public health issue leading to considerable morbidity and mortality. The global incidence of hip fractures was estimated to be 14.2 million in 2019. The number of hip fractures is projected to increase 1.9-fold by 2050 compared to 2018.[1]

Pain management strategies in patients with hip fractures include ultrasound-guided regional nerve blocks. Two studies have shown that ultrasound-guided regional anesthesia (femoral nerve block and fascia iliaca block [FIB]) is more effective than parenteral or intramuscular morphine in a preoperative setting.[2,3] A meta-analysis by Zaki et al demonstrated that the femoral nerve block and FIB provided more effective analgesic outcomes compared to parenteral opioids, with reduced need for rescue analgesia and fewer opioid-related adverse effects.[4] Although FIB is considered the gold standard of care for analgesia in hip fracture patients, a newer regional nerve block—the pericapsular nerve group (PENG) block—provides promising results. The PENG block is injected directly into the pericapsular space between the psoas tendon and the pubic ramus (medial to the anterior inferior iliac spine), targeting the articular branches of the femoral, obturator, and accessory obturator nerves.[5] The FIB is injected beneath the fascia iliaca, targeting the femoral, lateral femoral cutaneous, obturator, and genitofemoral nerves.[6]

Multiple studies have demonstrated that patients who received postoperative PENG blocks had lower pain scores (measured by the visual analog scale), reduced total opioid consumption, and received higher postoperative analgesia satisfaction scores compared to those who received the FIB.[7,8] Sahoo et al compared analgesic effectiveness and adverse effects between PENG blocks and intravenous opioids in the emergency department (ED), demonstrating further evidence of improved analgesia, based on numerical rating scale pain scores, and fewer adverse effects with PENG blocks.[9] The PENG block is becoming a popular alternative to the FIB for pain control; however, further studies are needed to compare the PENG block with other analgesic methods in the ED setting.

The primary objective was to evaluate retrospectively whether PENG blocks were an effective alternative to the FIB for analgesia in patients who presented to the ED with hip fractures. Secondary objectives included data on rates of local anesthetic systemic toxicity (LAST), block complications, hospital length of stay (LOS), and mortality.

*Population Health Research Capsule*

What do we already know about this issue?
*Ultrasound-guided fascia iliac blocks (FIB) reduce pain in hip fracture patients. The newer pericapsular nerve group (PENG) block has limited studies on efficacy.*

What was the research question?
*Do PENG blocks provide greater analgesia than fascia iliaca blocks for emergency department (ED) hip fracture patients?*

What was the major finding of the study?
*The PENG block reduced pain 1.42 points more than FIB (95% CI, 0.21–2.63; P = .02).*

How does this improve population health?
*The PENG block may improve pain control for hip fracture patients in the ED and can be another option to FIB.*

## METHODS

### Study Design

This study is a retrospective chart review on participants who received a PENG block or FIB during their ED hospitalization for hip fracture. Data were extracted using the SlicerDicer feature in the electronic health records (EHR) software (Epic Systems Corporation), with a date range from June 2021–June 2023. Institutional review board approval was obtained on September 27, 2023. We collected data on pain level and opioid usage before and after the procedure. All data were collected from patient visits to the ED of Eisenhower Medical Center, a community hospital with an annual volume of approximately 100,000. Evaluation of these patients demonstrated a distribution of six postgraduate year (PGY) 1, five PGY-2, six PGY-3 emergency medicine (EM) residents, and four EM attending clinicians. The chart review was conducted by an ultrasound fellowship-trained emergency physician.

Inclusion criteria were patients 18 years of age or older who presented with a hip fracture and received a FIB/PENG block in the ED. Exclusion criteria were patients who were intubated or unable to verbalize pain score because of underlying pathology, those with no documented block type, and those whose nerve blocks were performed outside the ED or by a non-EM physician. Patients were also excluded if they lacked recorded preblock or postblock pain scores, block times, or local anesthetic dosages.

We collected data on patient demographics, type of injury, type of nerve block (PENG or FIB), pain scores, local anesthetic dosages, and 24-hour opioid use during hospitalization.

### Data Collection

The methodological recommendations described by Worster et al were considered during this retrospective chart

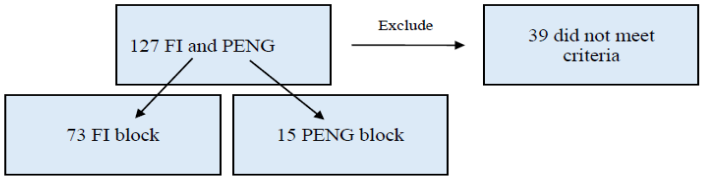


**Figure 1.** Flow diagram of participant inclusion and exclusion in the pericapsular nerve group versus fascia iliaca block study. *FI,* fascia iliaca; *PENG,* pericapsular nerve group.

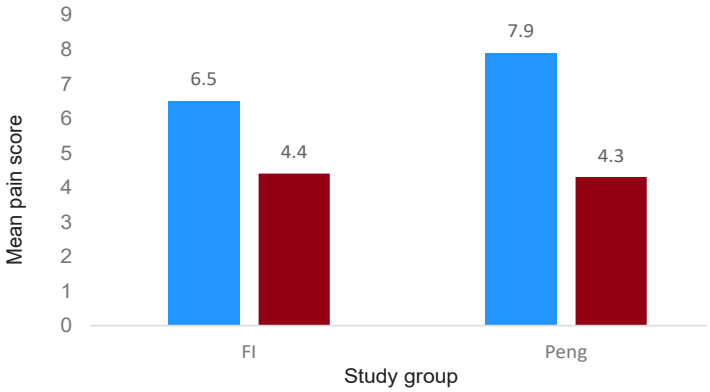


**Figure 2.** Average pain score before and after nerve block, by study group in the pericapsular nerve group versus fascia iliaca block study.
The graph shows pain scores as observed, without any adjustment. Adjusted pain scores are reported in Table 2.

review.[10] We used an Excel spreadsheet to record data. The abstractor was trained on data collection and chart review through the EHR system. Inclusion and exclusion criteria were defined. Charts were de-identified using the last four digits of the medical record number. We recorded the block type, anesthetic dosage, age, sex, medical history, diagnosis, morphine milligram equivalents (MME) in 24 hours, LOS, and complications. However, given that this retrospective review was completed by a single abstractor, interrater reliability testing was not performed. The abstractor was not blinded to the study objectives.

### Statistical Analysis

Pain was recorded on a 0–10 numeric rating scale repeatedly preblock and postblock. Because measurement frequency and timing varied across participants, we calculated an average pain score for each patient before and after the nerve block. We compared changes in pain intensity following the block (calculated as the average pain score postblock minus the average pain preblock) between the FIB and PENG groups; a generalized estimating equation was used to account for the potential correlation between preblock and postblock pain scores. The study group (FIB vs PENG), time period (preblock vs postblock), and their interaction were included as fixed factors in the model. Model-based marginal means by group and period, as well as within-group changes, were derived from the fitted model. We specified a Gaussian family with an identity link and an exchangeable correlation structure to account for the clustering of preblock and postblock observations within each patient. No imputation was performed. Analysis was performed with SPSS Statistics for Windows, version 31.0 (IBM Corp). All reported *P* values are two-sided.

## RESULTS

### Study Sample

We selected 127 patients for review, identifying 110 FIB and 17 PENG blocks. Of the 110 FIB patients, 37 were excluded for the following reasons: one hip dislocation; one with no ropivacaine administration time recorded; one done by anesthesia; one with no pain score; 9 with no nursing documentation of the block; and 24 with no pain scores recorded preblock or postblock. Two PENG block candidates were excluded due to lack of recorded pain scores preblock or postblock. Included in the final analysis were 73 patients in the FIB group and 15 in the PENG group. The mean pain score before the nerve block was 6.5 in the FIB group and 7.9 in the PENG group, which decreased to 4.4 and 4.3, respectively (Figure 2).

### Generalized Estimating Equation Analysis

A total of 88 patients were included for the generalized estimating equation analysis. The interaction between the study group and preblock/postblock was statistically significant (Wald $\chi^2 = 5.28$; df = 1; $P = .02$), indicating a greater pre-to-post reduction in pain in the PENG group than in the FIB group (Table 1).

### Safety Outcomes

There were no cases of local anesthetic systemic toxicity

**Table 1.** Generalized estimating equation analysis.

| Source | Type III | | |
|---|---|---|---|
| | Wald $\chi^2$ | df | *P* value |
| (Intercept) | 623.140 | 1 | < .001 |
| Study group | 3.278 | 1 | .070 |
| Pre/post Injection | 81.114 | 1 | < .001 |
| Study group * Pre/post Injection | 5.280 | 1 | .02 |

*P* value for the interaction between study group and preblock/postblock indicates a difference in pain score change after the block between the study groups.
We used the Wald $\chi^2$ statistic to compute *P* value.

**Table 2.** Estimated marginal means before and after nerve block, by study group.

| Study Group | Pre/ Postblock | Mean | SE | 95% Wald CI (Lower) | 95% Wald CI (Upper) |
|---|---|---|---|---|---|
| PENG | Post | 4.40 | 0.47 | 3.48 | 5.32 |
| PENG | Pre | 7.89 | 0.46 | 6.98 | 8.80 |
| FIB | Post | 4.28 | 0.24 | 3.80 | 4.76 |
| FIB | Pre | 6.35 | 0.34 | 5.68 | 7.01 |

*FIB,* fascia iliaca block; *PENG,* pericapsular nerve group; *SE,* standard error.

or other block-related complications in this study of 88 patients. The observed complication rate was 0% (95% CI, 0% - 3.4%).

As shown in Table 2, pain in the PENG group improved by 1.42 points more than the FIB group (95% CI, 0.21–2.63; $P = .02$).

## DISCUSSION

This retrospective comparative study between the PENG block and FIB in patients who sustained hip fractures demonstrated improved pain scores in the PENG group compared to the FIB group. Mean pain scores before the nerve block were 6.5 in the FIB group and 7.9 in the PENG group with improvement to 4.4 and 4.3, respectively, with statistical significance. This suggests that the PENG block was more effective than the FIB in pain control. Although the PENG group in our study was relatively small ($n = 15$), supporting evidence from previous prospective studies showed equivalence in anesthesia between PENG and FIB. One study involving 40 patients in each group demonstrated similar analgesic efficacy between FIB and PENG.[11] Of the 88 patients, none experienced block-related complications, which include LAST, prolonged hospital LOS, or increased mortality.

Our data suggest an association between the PENG block and improved analgesia in preoperative patients in a community ED. Prior studies have also found that the PENG block provides greater postoperative pain relief with less quadriceps muscle weakness in patients with intertrochanteric femoral fractures.[7,12] These motor-sparing properties can lead to improved postoperative recovery times and earlier mobilization. However, the clinical significance of these findings is unclear because other studies have found no significant differences in overall recovery between the FIB and the PENG block, despite the preserved quadriceps function.[13]

## LIMITATIONS

One key limitation of our study is the nature of a retrospective chart review. Pain score assessment times were inconsistent; therefore, the precision or quality of data is not as robust compared to a prospective study. Several recommendations for retrospective chart review methodology described by Worster et al were followed. However, not all quality measures were possible. For instance, interrater reliability was not assessed because chart review was performed by one reviewer. Additionally, the abstractor was not blinded to the hypothesis, and no independent validation of data abstraction was performed. These points are important to consider because of measurement bias. Another key limitation is our small sample size, with 73 patients in the FIB group compared to 15 in the PENG group. The fascia iliaca block is more commonly performed by emergency clinicians. Additionally, preblock pain scores were higher in the PENG block group (7.9 vs 6.5), which raises the possibility of regression to the mean effects.

We analyzed the results with generalized estimating equation modeling. However, no additional adjustments for fracture type, time to block, anesthetic dose variability, clinician experience, or opioid use prior to block were made for baseline differences between the groups. Furthermore, baseline imbalance in preblock pain scores could have introduced the possibility of selection bias. With regard to missing data, we excluded outliers where no pain scores were recorded preblock or postblock.

Four data points demonstrated high MME postblock in patients with a history of chronic myeloid leukemia, rheumatoid arthritis, breast cancer, alcohol or opioid use disorder, and chronic pain. Three patients had more MME prior to the nerve block; however, these individuals had a delay in nerve block administration of at least three hours after presenting to the ED. Seven patients had a baseline score of zero preblock but reported mean pain score postblock.

A total of 21 data points demonstrated worsening pain scores postblock. It is possible that the training level of the administering physician could have affected the administration of both nerve blocks. The operators included six PGY-1, five PGY-2, six PGY-3 EM residents, and four EM attending clinicians. We were unable to control for the prior ultrasound-guided procedural experience of the physicians performing the nerve blocks.

Finally, although we did not observe block-related complications, our study was not sufficiently powered to assess safety of the procedure.

## CONCLUSION

Patients who received the PENG block achieved a greater reduction in pain scores compared to the FIB. The PENG block was associated with greater reduction in mean pain scores. Future studies should take into consideration the training level of emergency clinicians, assess for variables including multiple comorbidities and chronic pain, and gather data with complete chart documentation. A future randomized controlled trial could provide a blinded comparison of the two

nerve blocks alongside the evaluation of total time required for nerve block setup and completion. Larger sample sizes are needed to determine whether the PENG block provides greater pain contol, functional recovery, and long-term outcomes.

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# Standardized Exam of the Abdomen Protocol Through Telemedicine in the Emergency Department

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**Introduction:** Abdominal pain is a common emergency department (ED) presentation, and virtual assessment of such complaints remains a challenge due to the limitations of remote physical examination. The standardized exam of the abdomen protocol (SEAP) was developed to guide patients in performing a self-abdominal examination during telemedicine consultations. We aimed to evaluate agreement between patient-performed abdominal self-examinations using the SEAP and physician-performed abdominal examinations.

**Methods:** We conducted a prospective, single-center study at the American University of Beirut Medical Center ED in Lebanon from August 2023–August 2024. Adult patients who presented with abdominal pain and met the inclusion criteria were enrolled. Each patient performed a video-guided abdominal self-examination by following a brief instructional video (SEAP). The SEAP was developed by an emergency medicine faculty at our institution using pre-established abdominal examination principles and clinical practice frameworks. The protocol was translated into a structured, two-minute instructional video. Blinded abdominal examinations were then performed by an emergency medicine resident and an attending physician. The primary outcome was agreement in abdominal tenderness across seven predefined regions, assessed using the Cohen kappa coefficient. Patient experience and feasibility measures were also collected.

**Results:** We included a total of 103 patients. Agreement between patient-performed and physician-performed examinations was slight to fair across six of the seven abdominal regions ($\kappa$ range, .13–.41). The highest agreement was observed in the right lower quadrant, with fair agreement between patients and residents ($\kappa$ = .47; 95% CI, 0.30-0.64) and patients and attending physicians ($\kappa$ = .36; 95% CI, 0.18-0.53). Agreement in the remaining regions, including the upper quadrants and flanks, remained low; right upper quadrant ($\kappa$ = .13), left upper quadrant ($\kappa$ = .28), and flanks ($\kappa$ range, -0.04 to .41). Most patients (97.9%; n = 94/96) rated the instructional video as clear and easy to follow.

**Conclusion:** Patient-performed abdominal self-examination using the SEAP demonstrated limited agreement with physician examinations across most abdominal regions. Agreement in the right lower quadrant was also fair. These findings indicate that patient-performed abdominal self-examination does not reliably reproduce physician assessment. However, they provide a foundation for further studies aimed at refining and better defining the role of patient-guided abdominal examinations in telemedicine settings. [West J Emerg Med. 2026;27(5)1490–1498.]

## INTRODUCTION

Telemedicine refers to the use of communication technologies to deliver healthcare services when distance is a limiting factor.[1] Its use expanded significantly during the COVID-19 pandemic, improving access to care and continuity for a wide range of clinical conditions.[2,3] Despite its advantages, telemedicine remains limited in its ability to replicate components of the physical examination that rely on direct clinician-patient contact.

Prior telemedicine research has explored clinician-guided patient self-examination, in which clinicians instruct patients to perform elements of the physical examination on themselves during video encounters.[4] Such approaches have been described across multiple body systems, including neurologic and musculoskeletal examinations, and have demonstrated variable feasibility and diagnostic utility.[5,6] However, existing studies are heterogeneous, frequently limited to small samples, and have largely focused on feasibility or clinical decision-making rather than on reproducibility or agreement between patient-performed and clinician-performed examination findings.[4,5] Moreover, while previous studies focused on triage or small-sample feasibility,[4] our study is unique in systematically measuring the reproducibility of patient-led exam findings compared to blinded physician assessments in a high-volume emergency department (ED). Furthermore, although artificial intelligence (AI) models are currently being developed for abdominal pain diagnosis, they typically do not incorporate findings from the patient's own physical exam.[4,5] This study provides a foundation for incorporating such data.

The evaluation of abdominal pain presents a particular challenge in telemedicine, as abdominal assessment traditionally relies heavily on palpation to localize tenderness and guide diagnostic reasoning.[7] Although abdominal pain accounts for approximately 7–10% of ED visits worldwide, telemedicine studies involving abdominal complaints have primarily focused on follow-up care, triage decisions, or isolated case reports rather than systematic evaluation of patient-performed abdominal examinations.[8-10] As a result, there is no standardized, reproducible protocol for guiding abdominal self-examination during telemedicine encounters, and evidence is limited regarding how closely patient-performed abdominal findings align with physician examinations.

To address this gap, we developed the standardized exam of the abdomen protocol (SEAP), a structured, video-guided approach designed to support patient-performed abdominal self-examination during telemedicine consultations. We aimed to evaluate agreement between patient-performed abdominal self-examination using SEAP and physician-performed abdominal examination in an ED setting, and to assess the feasibility of implementing such a protocol.

*Population Health Research Capsule*

What do we already know about this issue?
*Telemedicine struggles to replicate the abdominal exam, and no validated protocol exists for patient-performed abdominal self-examination.*

What was the research question?
*Does video-guided patient self-exam of the abdomen agree with blinded physician abdominal exam in the emergency department (ED)?*

What was the major finding of the study?
*Patient–resident agreement was fair only in the right left quadrant (κ = .47; 95% CI, 0.30–0.64; P < .001), and poor in other areas.*

How does this improve population health?
*This paper establishes baseline performance and limits of patient-led abdominal self-exam to guide safer telemedicine triage in overburdened EDs.*

## METHODS

### Study Design

This is a single-center, prospective, cross-sectional study conducted at the ED of the American University of Beirut Medical Center (AUBMC). The AUBMC is a tertiary-care academic hospital and major referral center in Lebanon, receiving an average of 55,000 ED visits annually with around 5,000 presenting with abdominal pain. The ED is staffed by a mix of emergency physicians and practitioners with extensive emergency medicine (EM) experience. This study included adult patients presenting to the ED with abdominal pain between August 2023–August 2024. This study was reviewed and approved by the international review board at the American University of Beirut under protocol number SBS-2021-0202.

The study was carried out over a one-year period and involved three participant groups: patients presenting with abdominal pain; EM residents; and attending physicians.

### Selection of Participants

Patients were identified prospectively at ED triage based on "abdominal pain" listed as one of the chief complaints. Trained research team members approached eligible patients prior to evaluation by a resident or attending physician. After confirming eligibility and obtaining informed consent, patients completed the self-examination protocol before any physician-performed abdominal examination took place. Eligible patients were identified at triage by trained ED nurses who had received a prior orientation about the study. A visual reminder of inclusion criteria was placed in the triage area to support

screening. In parallel, in-basket notifications in the electronic health record (EHR) (Epic Systems Corporation, Verona, WI) were configured to alert the research team in real time when a patient presented with an abdominal complaint. The research team then confirmed eligibility and approached the patient to explain the study. Participation was voluntary. Written informed consent was obtained using a LimeSurvey form (LimeSurvey GmbH, Hamburg, Germany) sent directly to the patient's phone. A survey was specifically developed for the purpose of this study (Supplementary). All participating residents and attendings were consented prior to the start of patient enrollment.

### *Inclusion Criteria*

Patients were eligible if they were ≥ 18 years of age, presented with a triage complaint related to abdominal pain, and possessed a smartphone capable of running audiovisual communication applications (such as WhatsApp, Zoom, or Viber).

### *Rationale for Inclusion of Clinically Stable Patients*

Only clinically stable patients were included for two reasons. First, participation required the ability to provide informed consent, watch a two-minute instructional video, and perform a guided self-examination without delaying urgent care. Second, the study was designed to evaluate a protocol intended for real-world telemedicine and remote triage settings, where patient stability is a prerequisite for self-directed examination.

### *Exclusion Criteria*

Patients were excluded if they met any of the following: disorientation or agitation; known or suspected pregnancy; severe abdominal pain with a numerical rating scale (NRS) ≥ 8; body mass index (BMI) > 35; activation of the ED sepsis protocol; hemodynamic instability (heart rate >180 beats per minute, systolic blood pressure < 60 mm Hg, mean arterial pressure < 50 mm Hg, Emergency Severity Index (ESI) level 1, or deemed unstable by a physician); prior enrollment in the study; primary psychiatric complaint; cognitive or communication impairment; altered mental status; drug or alcohol intoxication; initial physical exam performed by a medical student; active or suspected COVID-19 infection; or current employment as a healthcare worker (including nurses, physicians, or students in medical or nursing programs).

Sample size was estimated using the Cochran's formula for finite populations. Based on a retrospective review of ED visits at the AUBMC, approximately 8% of adult ED presentations involve abdominal pain. Using a 95% confidence level and a 5% margin of error, the calculated sample size was 113 patients. We initially enrolled 113 patients. Ten patients were excluded from the final analysis due to incomplete or improperly completed abdominal examination data, resulting in a final analytic sample of 103 patients. Only participants with complete paired examination data across all three examiners were included in the agreement analyses.

Each patient underwent three sequential abdominal examinations in the following order:

### Patient-performed Standardized Exam of the Abdomen Protocol

The patient received a two-minute instructional video (Supplementary) that demonstrated how to perform a guided self-examination of the abdomen. A study team member remained present to observe and record the findings but did not assist or clarify the technique to ensure that patients relied solely on the video. Patients were asked to report whether they experienced tenderness, discomfort, or no symptoms in each of seven abdominal regions: right upper quadrant; right lower quadrant; left upper quadrant; left lower quadrant; flanks; epigastric; and suprapubic areas. The findings were recorded immediately to minimize recall bias.

The two-minute video provides patients with a step-by-step guide on performing the physical exam of the abdomen. The video starts with a text slide as follows:

> This video is part of a research study about self-administered standardized abdominal exam. It is not intended to be used for medical diagnosis. You will be instructed on how to perform the exam and will be asked questions about your findings. You can repeat the video as much as you need and can pause it whenever you want. This video and the following questions ask about TENDERNESS ONLY, that is pain when PRESSING on the abdomen.

The video then transitions into a picture of a woman lying on her back with her knees bent, and the narrator states, "To perform the exam, we lie on our back and bend our knees as depicted in this picture," The video then transitions into a live demonstration of the exam, with a video of an actor lying on his back with lines drawn on his abdomen to divide it into the four main quadrants. The narrator states here "We will first start with the upper abdomen between the ribs and the belly button." The actor in the video places his hands on both upper quadrants and then moves his hands toward the ribs and the umbilicus accordingly. The narrator then says, "We place our hands as depicted in the video," while the actor's hands are placed on both upper quadrants (right hand on upper right quadrant and left hand on upper left quadrant, respectively). The narrator then says, "We press hard on the right upper side noting any pain, then we move to the left upper side pressing hard, noting any pain," while the actor in the video presses firmly with his hands on the right upper quadrant followed by the left.

The narrator then says, "We then move to the lower half of the abdomen, under the belly button," as the actor slides his

right and left hands toward the lower right and left quadrants, respectively. The narrator then says, "We press hard on the right lower side, noting any pain. We then move to the left lower side, pressing hard, noting any pain." Concurrently, the actor presses firmly with his hands on the right lower quadrant followed by the left. The narrator then says, "We then move to the bladder area, above the bone," as the actor points with both index fingers to the bladder area, and the narrator continues, "where we press hard, noting any pain," as the actor presses firmly on the bladder area with both hands.

The narrator then says the following:

> Finally we move to the sides, the flanks, we grab the right side and press hard with the hand and thumb, noting any pain. We then move to the left side, pressing hard with the hand and thumb noting any pain, and we would have concluded our self-administered abdominal exam.

The actor concurrently grabs both flank areas (right and left) with his right and left hands, with his four fingers on the front of his abdomen and his thumbs on the flank area of the lower back. He then presses firmly on the right flank with his hand and thumb followed by the left side. Finally, he moves his hands away from his abdomen and to the sides of his body when the exam is over.

### Resident-performed Abdominal Exam

Following the SEAP, the assigned EM resident performed a standard abdominal examination on the patient. Residents were blinded to the patient's SEAP findings and did not have access to the self-examination results at the time of their assessment.

### Attending-performed Abdominal Exam

Finally, the attending physician conducted a routine abdominal examination as part of the standard of care. Attending physicians were blinded to both the patient-performed SEAP findings and the resident examination findings; they were not involved in the SEAP process.

While the ED at the AUBMC is staffed by experienced practitioners, the participating resident and attending followed standard clinical abdominal examination techniques to ensure the "real-world" applicability of the comparsion. Therefore, no specific study-related training was given to clinicians to maintain blinding. All examination findings were documented independently using separate standardized forms to prevent biased results.

### Method of Measurements

We collected data through chart review, structured forms, and post-encounter surveys. Patient demographics, initial vital signs, associated clinical symptoms, treatments received, final diagnosis, and ED disposition were extracted from the EHR. Abdominal tenderness assessments were recorded for each of the seven predefined abdominal regions using standardized documentation forms completed by the patient, resident, and attending. Additionally, patients completed a structured survey evaluating the clarity, usability, and acceptability of the instructional video, their comfort with performing the self-examination, and overall satisfaction with the process. We excluded from agreement analyses participants with missing or incomplete abdominal examination data in any of the seven predefined regions for any examiner. No imputation was performed. Analyses were restricted to complete cases to ensure valid region-level agreement comparisons.

### Statistical Analysis

This was primarily a comparative study. We used descriptive statistics to summarize the data, with categorical variables presented as frequencies and percentages, and continuous variables as means with standard deviations. In the bivariate analysis, the association between final discharge diagnoses and other categorical variables was analyzed using the Pearson chi-square test, while the association with continuous variables was analyzed using the Student *t*-test. We assessed agreement between the patient-performed SEAP and attending physicians' standard physical examination using the Cohen kappa coefficient for matched-pair analysis with 95% confidence intervals calculated to quantify the precision of the concordance across the seven abdominal regions. All statistical analyses were performed using R (RStudio, PBC, Boston, MA) with appropriate libraries and IBM SPSS Statistics (Internationnal Business Machines Corp, Armonk, NY). A two-tailed $P < .05$ was considered statistically significant.

## RESULTS

Table 1 presents the baseline demographics of patients presenting to the ED with abdominal pain during the study period. The majority were female (71.8%), resided in the capital Beirut (80%), and were insured (87.4%). The mean age was 36.24 years, with nearly half identified as current smokers (46.5%). A history of gastrointestinal surgery was reported in 19.4% of patients, and 21.4% had a prior medical history related to gastroenterology. Only 6.3% had previously used telemedicine services.

Table 2 presents the characteristics of abdominal pain and associated symptoms of patients presenting to the ED during the study period. Radiating pain was reported by 27.7% of patients, and 41.8% had a history of similar episodes. Patients were categorized based on final diagnosis into medical or surgical causes. Surgical patients were more likely to report constipation (21.7% versus 6.3%, $P = .03$), while medical patients were more likely to present with diarrhea (54.4% versus 17.4%, $P < .001$) and nausea/vomiting/loss of appetite (86.1% versus 52.2%, $P < .001$). Left lower quadrant pain was more commonly observed among surgical patients (65.2% versus 46.3%, $P = .07$).

Table 3 presents the comparison of abdominal tenderness

**Table 1.** Demographic characteristics of patients presenting to the emergency department with abdominal pain in a study evaluating agreement between patient-performed and physician-performed abdominal examination.

| | | Total N = 103 |
|---|---|---|
| Sex | Female | 74 (71.8%) |
| Age, years | Mean (SD) | 36.24 (16.79) |
| Weight in kg | Mean (SD) | 70.60 (16.32) |
| Smoking | Yes | 47 (46.5%) |
| Alcohol | Yes | 25 (25.5%) |
| Marital status | Single | 52 (52.5%) |
| | Married | 47 (47.5%) |
| Education | Elementary/high school/ technical | 8 (7.8%) |
| | Higher education | 79 (76.7%) |
| Place of residence | Beirut | 72 (80.0%) |
| Guarantor | Insured | 90 (87.4%) |
| Previous use of telemedicine | Yes | 6 (6.3%) |
| Past surgical history | Gastroenterology | 20 (19.4%) |
| | Gynecologic | 10 (9.7%) |
| | Urology | 5 (4.9%) |
| | Other* | 21 (20.4%) |
| Past Medical history | Gastroenterology | 22 (21.4%) |
| | Cardiovascular | 14 (13.6%) |
| | Diabetes | 7 (6.8%) |
| | Stroke | 1 (1.0%) |
| | Kidney stones | 9 (8.7%) |
| | Gynecological disease | 6 (5.8%) |
| | Other** | 12 (11.7%) |

*Other: tonsillectomy; septoplasty; submucous resection; rhinoplasty; nasal.

assessments across seven pain areas between patients, residents, and attending physicians. The highest agreement was observed in the right lower quadrant, with fair kappa values between patient and resident ($\kappa = .47$; 95% CI, 0.30-0.64), patient and attending ($\kappa = 0.36$; 95% CI, 0.18-0.53), and resident and attending ($\kappa = .55$; 95% CI, 0.38-0.72), all statistically significant ($P < .001$). Fair agreement was also noted in the suprapubic area between resident and attending ($\kappa = .41$; 95% CI, 0.21-0.61; $P < .001$), and in the left flank, again between patient and attending ($\kappa = .41$; 95% CI, 0.13-0.69; $P < .001$).

Table 4 presents descriptive feedback on the instructional video used for the self-examination. Among the 103 participants, most watched the video in English (66.7%), while the rest viewed it in Arabic (33.3%). The majority watched the video only once (97.9%), and only 7.3% reported needing to pause it. Regarding usability, 71.9% strongly agreed and 26.0% agreed that the video was clear and user-friendly. Similarly, 76.0% strongly agreed and 24.0% agreed that the video length was appropriate. When asked about confidence in performing the self-exam after watching the video, 58.3% strongly agreed and 33.3% agreed that they felt confident performing the exam, while only 8.3% remained neutral.

## DISCUSSION

### Interpretation

The variability in agreement across different abdominal regions suggests that anatomical location inherently influences the reliability of clinical assessments. The fair-to-moderate agreement in the right lower quadrant is encouraging for telehealth triage in the setting of appendicitis; however, the poor agreement in other areas underscores a critical gap in patient-led diagnostics. Accordingly, exploring methods to improve patient accuracy in their assessments would help avoid missing surgical diagnoses while using telehealth in the future. These findings may be driven by the fact that patients lack the clinical training to distinguish between subjective pain and objective medical signs such as guarding or rebound tenderness. Moreover, the dual role of the patient as both the examiner and subject creates a psychological and physical barrier to effective deep palpation. When compounded by factors such as body habitus or the analgesic effects of pain medication, these findings suggest that while self-examination has potential for specific triage scenarios, its utility is currently limited by the inherent difficulty of objective self-palpation, an area requiring further investigation.

### Summary of Main Findings

This study evaluated a structured self-examination protocol for abdominal pain in a real-world ED setting. Most participants were young, insured women living in Beirut. The nature of abdominal pain differed between medical and surgical cases, with constipation more commonly reported in surgical diagnoses, while nausea, vomiting, and diarrhea were more frequent among medical diagnoses. Although patients were able to complete the self-performed abdominal exam independently, agreement between patient-performed and physician-performed examinations varied significantly by anatomical region. Our study demonstrated that there was fair -to-moderate agreement between patients, residents, and physicians in the right lower quadrant, where there would be concerns of appendicitis, as well as low-to-moderate agreement in the left flank and suprapubic areas. Conversely, regions such as the upper quadrants and right flank exhibited either fair or poor agreement. Feedback indicated that patients felt comfortable performing the exam and found the video easy to follow.

### Comparison to Previous Studies

While most telehealth studies to date have focused on postdischarge follow-up or imaging-related decisions,[6] our

**Table 2.** Description of abdominal pain nature and associated symptoms in patients presenting to the emergency department stratified by surgical and medical diagnosis.

| | | Total N = 103 | Surgical n = 23 | Medical n = 80 | *P* value |
|---|---|---|---|---|---|
| Duration (hours) | Mean (SD) | 24.57 (26.17) | 18.65 (23.47) | 26.28 (26.80) | .23 |
| Abdominal pain radiation | Yes | 28 (27.7%) | 9 (39.1%) | 19 (24.4%) | .16 |
| Previous similar pain | Yes | 41 (41.8%) | 13 (56.5%) | 28 (37.3%) | .10 |
| Medication taken at home | Yes | 53 (51.5%) | 14 (60.9%) | 39 (48.8%) | .30 |
| Associated symptoms | Fever | 21 (20.8%) | 3 (13.6%) | 18 (22.8%) | .35 |
| | Constipation | 10 (9.8%) | 5 (21.7%) | 5 (6.3%) | .03 |
| | Diarrhea | 47 (46.1%) | 4 (17.4%) | 43 (54.4%) | < .001 |
| | Blood in stool | 1 (1.0%) | 0 (0.0%) | 1 (1.3%) | .59 |
| | Dysuria | 6 (5.9%) | 1 (4.3%) | 5 (6.3%) | .72 |
| | Back/flank pain | 19 (18.6%) | 6 (26.1%) | 13 (16.5%) | .30 |
| | Nausea/vomiting/loss of appetite | 80 (78.4%) | 12 (52.2%) | 68 (86.1%) | < .001 |
| | Bloating | 31 (30.4%) | 9 (39.1%) | 22 (27.8%) | .30 |
| | Other* | 36 (35.3%) | 9 (39.1%) | 27 (34.2%) | .66 |
| Pain area | Right upper quadrant | 35 (14.6) | 8 (34.8) | 27 (33.8) | .93 |
| | Left upper quadrant | 33 (32.0) | 5 (21.7) | 28 (35.0) | .23 |
| | Left lower quadrant | 50 (48.5) | 15 (65.2) | 35 (43.8) | .07 |
| | Right lower quadrant | 48 (46.6) | 11 (47.8) | 37 (46.3) | .89 |
| | Suprapubic | 32 (31) | 10 (43.5) | 22 (27.5) | .14 |
| | Right flank | 17 (16.5) | 5 (21.7) | 12 (15.0) | .44 |
| | Left flank | 15 (14.6) | 3 (13.0) | 12 (15.2) | .80 |

*Other: chest pain; cough; dizziness; headache; rhinorrhea; shortness of breath; sore throat.
*SD,* standard deviation.

study stands out in its evaluation of a structured, patient-performed abdominal exam. It uniquely centers the patient as an active participant in the diagnostic process by validating agreement between their self-exam and the assessments performed by physicians in the ED. While most telemedicine tools focus on postdischarge follow-up, and some aim to support triage accuracy through systems such as the ESI[10] or imaging decision aids, very few consider the patient's role before the initial ED visit.[6] Our study highlights the potential of involving patients in early symptom assessment through structured self-exams.

With the global increase in ED crowding, patients are experiencing longer lengths of stay and delayed care. Furthermore, during the COVID-19 pandemic, many patients avoided seeking emergency care altogether, despite experiencing pain symptoms at home.[3] In parallel, AI models are increasingly being developed to support diagnostic decision-making regarding abdominal pain. However, these tools are primarily designed for use by physicians and do not assess or incorporate the patient's own physical exam findings.

Our study findings are consistent with previous reports indicating that females presented with abdominal pain and related complaints more frequently than males.[11] Moreover, our findings reflect a clear divergence between presentations of surgical and medical cases; surgical cases were more frequently associated with presentations of constipation, while medical cases more frequently involved presentations of nausea, vomiting, and diarrhea. These findings are also consistent with those in the literature.[12]

**Strengths**

A primary strength of this study is its pioneering approach as the first to evaluate a structured, video-guided abdominal self-examination protocol within a high-volume ED setting. The methodological rigor, characterized by prospective, blinded assessments by both residents and physicians, ensures a robust comparison between patient-led and professional evaluations. Furthermore, the feasibility and positive patient feedback demonstrate that the protocol is user-friendly and practical.

**Clinical Implications**

These findings have important implications for health policy, particularly in low-resource and overburdened emergency care settings. For policymakers working to

**Table 3.** Comparison of pain areas between patient versus resident/ patient versus attending / resident versus attending exams.

| | | Patient vs Resident N = 103 | | Patient vs Attending N = 103 | | Resident vs Attending N = 103 | |
|---|---|---|---|---|---|---|---|
| | | No Tenderness | Tenderness | No Tenderness | Tenderness | No Tenderness | Tenderness |
| Pain Area # 1 RU | No Tenderness | 53 (52.0%) | 14 (13.7%) | 52 (52.5%) | 13 (13.1%) | 60 (61.2%) | 12 (12.2%) |
| | Tenderness | 22 (21.6%) | 13 (12.7%) | 23 (23.2%) | 11 (11.1%) | 14 (14.3%) | 12 (12.2%) |
| | *P value* | .08 | | .17 | | < .001 | |
| | *Kappa (95% CI)* | 0.17 (-0.03 to 0.37) | | 0.13 (-0.06 to 0.33) | | 0.30 (0.09 to 0.51) | |
| Pain Area # 2 LU | No Tenderness | 58 (56.3%) | 12 (11.7%) | 61 (61.6%) | 7 (7.1%) | 65 (65.7%) | 9 (9.1%) |
| | Tenderness | 19 (18.4%) | 14 (13.6%) | 20 (20.2%) | 11 (11.1%) | 16 (16.2%) | 9 (9.1%) |
| | *P value* | < .001 | | < .001 | | < .001 | |
| | *Kappa (95% CI)* | 0.27 (0.07-0.47) | | 0.28 (0.08-0.48) | | 0.26 (0.05-0.48) | |
| Pain Area # 3 RL | No Tenderness | 43 (42.2%) | 9 (8.8%) | 40 (40.4%) | 9 (9.1%) | 49 (50.0%) | 8 (8.2%) |
| | Tenderness | 18 (17.6%) | 32 (31.4%) | 23 (23.2%) | 27 (27.3%) | 13 (13.3%) | 28 (28.6%) |
| | *P value* | < .001 | | < .001 | | < .001 | |
| | *Kappa (95% CI)* | 0.47 (0.30- 0.64) | | 0.36 (0.18- 0.53) | | 0.55 (0.38-0.72) | |
| Pain Area # 4 LL | No Tenderness | 40 (39.2%) | 14 (13.7%) | 43 (43.4%) | 10 (10.1%) | 47 (48.0%) | 11 (11.2%) |
| | Tenderness | 20 (19.6%) | 28 (27.5%) | 21 (21.2%) | 25 (25.3%) | 16 (16.3%) | 24 (24.5%) |
| | *P value* | < .001 | | < .001 | | < .001 | |
| | *Kappa (95% CI)* | 0.33 (0.14-0.51) | | 0.36 (0.18-0.54) | | 0.42 (0.23-0.60) | |
| Pain Area # 5 Suprapubic | No Tenderness | 54 (52.9%) | 16 (15.7%) | 57 (57.6%) | 11 (11.1%) | 60 (61.2%) | 8 (8.2%) |
| | Tenderness | 17 (16.7%) | 15 (14.7%) | 19 (19.2%) | 12 (12.1%) | 15 (15.3%) | 15 (15.3%) |
| | *P value* | .01 | | .01 | | < .001 | |
| | *Kappa (95% CI)* | 0.24 (0.04-0.44) | | 0.24 (0.04-0.45) | | 0.41 (0.21-0.61) | |
| Pain Area # 6 RF | No Tenderness | 84 (82.4%) | 1 (1.0%) | 80 (80.8%) | 2 (2.0%) | 93 (94.9%) | 2 (2.0%) |
| | Tenderness | 15 (14.7%) | 3 (2.0%) | 17 (17.2%) | 0 (0.0%) | 3 (3.1%) | 0 (0.0%) |
| | *P value* | .02 | | .51 | | .80 | |
| | *Kappa (95% CI)* | 0.16 (-0.01 to 0.45) | | -0.04 (-0.08 to 0.01) | | -0.02 (-0.05 to -0.001) | |
| Pain Area # 7 LF | No Tenderness | 82 (82.0%) | 3 (3.0%) | 83 (85.6%) | 0 (0.0%) | 89 (92.7%) | 3 (3.1%) |
| | Tenderness | 13 (13.0%) | 2 (2.0%) | 10 (10.3%) | 4 (4.1%) | 3 (3.1%) | 1 (1.0%) |
| | *P value* | .11 | | < .001 | | .03 | |
| | *Kappa (95% CI)* | 0.14 (-0.10 to 0.37) | | 0.41 (0.13 to 0.69) | | 0.22 (-0.19 tto 0.62) | |

*For agreement analyses, patient-reported "discomfort" was grouped with "tenderness" and analyzed as a binary outcome (tenderness present versus absent) to align with physician documentation.
*LF,* left flank; *LL,* left lower; *LU,* left upper; *RF,* right flank; *RL,* right lower; *RU,* right upper.

expand digital health infrastructure, especially in systems strained by limited capacity or crisis conditions, patient-led assessment protocols such as SEAP offer a promising and practical approach to improve access, engagement, and emergency care delivery.

### Research Implications

Although our study did not reveal strong agreement between patient- versus physician-performed abdominal exam, the potential for this approach remains high as it offers a necessary foundation for further studies aimed at refining and better defining the role of patient-guided abdominal examinations in telemedicine settings. Future research should use larger cohorts and a more balanced use distribution to validate these findings.

## LIMITATIONS

This study has several limitations. First, although it was conducted in the largest tertiary ED in the region with a diverse patient population, it was a single-center study, which may affect generalizability. In addition, we included only stable patients, as the exam requires a minimum level of

**Table 4.** Patients' descriptive feedback of the standardized exam of the abdomen protocol video in a study evaluating agreement between patient-performed and physician-performed abdominal examination.

| | | Total N = 103 |
|---|---|---|
| In what language did you watch the video? | English | 64 (66.7%) |
| | Arabic | 32 (33.3%) |
| How many times did you repeat the video? | Once | 94 (97.9%) |
| | Twice | 2 (2.1%) |
| Did you need to pause the video? | Yes | 7 (7.3%) |
| The video is clear and user friendly | Neutral | 2 (2.1%) |
| | Agree | 25 (26.0%) |
| | Strongly agree | 69 (71.9%) |
| The length of the video is appropriate | Agree | 23 (24.0%) |
| | Strongly agree | 73 (76.0%) |
| I feel comfortable self-examining after watching the video | Neutral | 8 (8.3%) |
| | Agree | 32 (33.3%) |
| | Strongly agree | 56 (58.3%) |

participation. This may have led to selection bias. Access to a smartphone was needed to view the video, but this reflects current norms. Moreover, since the study sample consisted mainly of young female patients, further research should be conducted on more diverse populations including comparable proportions of males and females across a wider age range.

Because the primary objective of our study was to establish baseline agreement for SEAP against the current gold standard (physical exam), no negative or positive controls were used in this study. Future studies should include a control group (eg, patients performing a self-exam without the video guide) to isolate the specific impact of the SEAP instructional tool. Additionally, the validation and generalizibilty of the findings may be limited as the physical exam was performed by only one attending and one resident. Moreover, the exclusion of patients with a BMI > 35, while necessary for initial protocol safety and clarity, limits the generalizability of our findings to patients with higher BMI. Finally, we did not compare pain location to final diagnosis since the aim was to assess whether patients could identify tenderness in agreement with physicians. This helps determine whether they need to present to the ED and supports the development of safe and effective telehealth triage.

## CONCLUSION

This prospective study is the first to evaluate a structured, video-guided self-examination protocol for abdominal pain across all quadrants in the ED. While patients were able to complete the exam independently, only fair-to-moderate agreement with physician findings was observed, and only in the right lower quadrant, an area critical for identifying potential surgical conditions like appendicitis. The video was easy to use, could be paused or replayed, and was well-received by patients, supporting its feasibility in real-world settings. This finding highlights the need for effective tools to triage abdominal pain remotely, especially in overwhelmed healthcare systems. By advancing a structured and practical approach to remote abdominal assessment, our findings contribute to expanding telemedicine capabilities and improving ED efficiency, especially during public health crises and patient surges. Nevertheless, these findings are preliminary and require further validation with a larger sample size.

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# Efficiency and Humanism: The Impact of the Humanistic Charting Tool on Patient Experience in the Emergency Department

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**Introduction:** Emphasis on documentation challenges clinicians to strike a balance between efficiency and individualized care, often leading to the depersonalization of patient interactions. The Humanistic Charting Tool (HCT) addresses this by integrating the patient's voice into the electronic medical record (EHR). The objective of this study was to examine whether use of the HCT during emergency department (ED) visits is feasible and improves key patient experience metrics.

**Methods:** The study took place in an urban, academic hospital. Patients in the ED completed the HCT while waiting to see a clinician. The patient's responses were condensed into a two-page summary and uploaded into their EHR. Clinicians were asked whether they used the HCT for each patient at the end of the encounter, and patients completed precare and postcare surveys assessing key experience metrics. Our primary outcome measure was changes in patient experience metrics, including key Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) metrics. Our secondary outcome measure was subgroup analyses among patients facing barriers to care.

**Results:** Approximately 2.8% of the total ED patients were enrolled during the study period. Overall, 129 patients filled out the HCT, and 97 (74%) patients had complete survey data. A total of 65 clinicians participated in the study including 32 attending physicians, 23 resident physicians, and 10 advanced practice practitioners (APP). Clinicians used the HCT for 51 (53%) of these patients. Patients demonstrated significant improvements in feeling that clinicians listened carefully (79% to 92%; $P < .001$), took their preferences into account (61% to 74%; $P = .01$), treated them with courtesy and respect (85% to 94%; $P < .001$), and knew important information about them (43% to 52%; $P = .01$). Patients who did not have a regular clinician (n = 25 [26%]) had a significantly greater increase in feeling involved in their treatment discussion (36% to 60% vs 59% to 66%; $P = .05$). Patients who endorsed at least one social need (n = 15 [16%]) had a significantly greater increase in being listened to carefully (53% to 73% vs 84% to 95%; $P = .01$). No statistical significance was found between patients whose clinicians used the HCT versus not.

**Conclusion:** The Humanisticc Charting Tool demonstrated feasibility and was associated with improvements in patient experience within the ED. This tool has the potential for patients to share their narratives and enrich their own healthcare experience, which is invaluable in a high-stakes, time-sensitive environment. The results also highlight a novel finding that the HCT may help mitigate disparities in communication, trust, and engagement that disproportionately affect vulnerable populations. This study supports the further development of humanism-centered tools within healthcare systems. [West J Emerg Med. 2026;27(5)1499–1505.]

## INTRODUCTION

### Background

The standardization of patient care through electronic health records (EHR) has enhanced productivity and quality of care in various settings.[1–4] However, its emphasis on documentation also challenges clinicians to strike a balance between efficiency and individualized care, often leading to the depersonalization of patient interactions. Documentation time has increased four to five fold with EHR use, significantly reducing the time physicians are able to spend with patients.[5] Clinical standardization within EHRs promotes a more bureaucratic and less individualized approach to patient management.[6] Such depersonalization can hinder the development of patient-clinician rapport, patient satisfaction, and patient-centered care plans that are crucial for improving care.

### Importance

Patient experience is increasingly recognized as a critical component of healthcare quality, influencing everything from clinical outcomes to adherence to treatment plans to reimbursement.[7,8] In the emergency department (ED), where encounters are often brief and high pressure, the challenge of maintaining humanistic, patient-centered care is particularly pronounced, which can ultimately undermine the patient's experience of the visit. Understanding the impact of tools that facilitate individualized communication and support the integration of patients' values and narratives into care planning have the potential to advance healthcare delivery and improve patient experience.

### Goals of this Investigation

The Humanistic Charting Tool (HCT) is a patient-driven questionnaire designed to refocus and individualize the acute care experience based on the needs of each unique patient. The HCT asks open-ended and closed-ended questions about a patient's life, values, and preferences, and maps the responses onto a standardized, condensed document. The feasibility of the HCT was demonstrated within a lower acuity zone of an ED in a pilot study completed between February and April 2023.[9] In this subsequent study, we aimed to investigate the feasibility and early adoption of implementing the HCT across the entire ED and to explore its association with patient experience outcomes.

*Population Health Research Capsule*

What do we already know about this issue?
*Standardization improves efficiency but has also been shown to depersonalize care. Clinicians struggle to strike a balance between the two.*

What was the research question?
*We investigated whether using the Humanistic Charting Tool (HCT) is feasible and improves patient experience in the emergency department.*

What was the major finding of the study?
*Using the HCT led to improvement in feeling listened to (79% to 92%; P < .001) and respected (85% to 94%; P < .001).*

How does this improve population health?
*Humanism-centered tools have the potential to meaningfully improve patient experience in acute-care settings, especially for those who face barriers to care.*

## METHODS

### Study Design and Setting

The pilot was conducted at a large urban academic ED and featured a mixed-method analysis of patient and clinician experiences with the HCT. Ethics approval was granted by the institutional review board (IRB #22-37455).

### Selection of Participants

The study included both clinicians and patients. Attending physicians, resident physicians, and advanced practice practitioners (APP) working in the ED between November to December 2024 opted in to participate. Patients eligible for this study were those over the age of 18 who presented to the UCSF ED and were triaged as an Emergency Severity Index 3, 4, or 5. Psychiatric patients and patients who required immediate medical care were excluded. Written informed consent was obtained from all participants.

### Implementation of the HCT

Between November and December 2024, patients waiting for a clinician in the ED were invited to complete the HCT (Figure 1) on REDCap (version 15.5.26, Vanderbilt University) with the help of medical student researchers. The patient's responses were condensed into a two-page, visually structured summary (Appendix 1) and uploaded into their EHR. Clinicians assigned to the patient were encouraged to review their responses, and clinician use of this information was recorded at the end of the patient encounter. The intervention was deemed complete if the patient completed the required components of the HCT questionnaire, and if the clinician's use of the responses was recorded.

### Measurements

Prior to completing the HCT, patients were administered a precare survey that inquired about their recent healthcare

experiences. Following their ED encounter, patients completed a postcare survey either via phone or in-person. Each patient was assigned unique precare and postcare survey link in REDCap to anonymize and match their precare and postcare survey responses. A copy of the surveys can be viewed in Appendix 2 and 3.

### Outcomes

The primary outcome studied was patient experience metrics after using the HCT, including key Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) metrics for physicians, such as courtesy, taking time to listen, and inclusion in treatment decisions.[10] Secondary outcomes included subgroup analysis of experience metrics by clinician use and barriers to care, as well as user experience of the tool.

### Analysis

A priori sample size calculation was conducted for analysis of variance (ANOVA) comparing the two groups relating to the primary outcome (patient experience metric scores before and after HCT administration). Assuming a large effect size (Cohen $f = 0.40$), an alpha of 0.05, and 80% power, a total sample size of 52 participants (26 per group) was required. We compared average scores for each question across different groups using ANOVA. For the primary analysis, ANOVA was used to compare precare and postcare survey results, as well as the difference based on whether the HCT was used by the clinician. In the secondary analysis, scores were compared across patient subgroups who were identified as having barriers to care.

## RESULTS

### Characteristics of Study Subjects

Approximately 2.8% of the total patients who visited the ED during the study period were enrolled. In total, 129 patients filled out the HCT and 96 patients (74%) had complete presurvey and postsurvey data. Clinicians used the HCT for 51 (53%) of these patients. Of the total participants, 25 (26%) did not see a regular clinician, 17 (18%) reported previously having difficulty following a treatment plan, and 15 (16%) indicated having at least one social need of the following: support; housing; transportation; finances; and resources of daily living. A total of 65 clinicians participated in the study including 32 attending physicians, 23 resident physicians, and 10 APPs.

**Part 1: Your Story**

**In this section, we want to learn a bit about you and your life.**

1-1 How would you like us to call you? _____ (For example, Christopher prefers to be called Chris.)

1-2 What pronouns would you like us to use when you are seen here?
- ☐ She/her/hers
- ☐ He/him/his
- ☐ They/them/theirs
- ☐ Other

Other Pronoun _____

1-3 What do you value most in your life? _____ (For example: my family, my health, the people around me, that I am not treated differently due to my condition, etc.)

1-4 What are some things that you really enjoy? _____ (There is no right answer to this question and whatever you choose is perfect! Examples: spending time with my dog, watching movies with my kids, cooking with my family.)

1-5 What do you feel is important that other people know about you? _____

1-6 3 Words: What are three words that you think describe you best? _____ (Example: soccer, puzzles, and parent - or mother, dancer, and advocate.)

**Part 2: Your Health**

**Here are a few questions our patients wanted their healthcare teams to know about.**

2-1 What would you like to make sure your healthcare team knows about your health? _____

2-2 Why is staying healthy important to you? _____

2-3 Do you see a doctor regularly?
- ○ Yes
- ○ None

If so, please tell us who in the space provided (can be a specialty like primary care, pulmonologist, cardiologist etc or a specific name). _____

**Part 3: Care Preferences**

**This section was designed to inform your healthcare team how they can best work with you. Every person has a preferred way of communicating, learning, and interacting. The main goal of every healthcare team is to keep you healthy. If there is any way to improve the care being provided, it is important to make that effort!**

3-1 What do you believe to be the best doctor/patient relationship when making decisions about your health care?
- ○ I feel comfortable with whatever decision the doctor/provider makes
- ○ I have no preference
- ○ I prefer for the doctor to ask me for my opinion and include me in the decision-making process.

3-2 Which language would you prefer to use with your doctor?
- ○ English
- ○ Spanish
- ○ Other

(Please note if you prefer to read in a language other than the one you speak with your doctor.)

What other language? _____

3-3 When speaking with your healthcare provider, how would you like them to discuss your treatment options, medical conditions, etc.?
- ○ I am more of a big-picture thinker
- ○ I am more detail-oriented
- ○ It depends on the situation
- ○ it would be great if you were to ask me what I prefer

3-4 When you are trying something new how do you learn best?
- ○ Reading about it
- ○ Hearing someone tell you about doing it
- ○ Trying it out yourself

Reading about it

- (Visual learners will typically retain more information when they can see something that graphically depicts what they are trying to learn. The best way to learn are through visual aids whenever possible.) Hearing someone tell you about doing it

- (Auditory learners will retain more information when they hear something. The best way to learn something is to hear it over and over.) Trying it out yourself

- (Physical learners will retain information when they use the hands-on approach - like labs and demonstration or using the tools.)

3-5 Are there any types of treatments/care that you prefer or like to use?
- ○ Yes
- ○ None

((Pills, medications, physical therapy, natural remedies, traditional medicine, herbs/nutrition, etc.))

If so, what kind? _____

| | | |
|---|---|---|
| 3-6 | Are there any treatments/care that you do not feel comfortable with due to your culture, religion, preference, etc.?<br>If so, please write them below in the space provided | ○ Yes<br>○ None |
| | If so, what kind? | _____ |
| 3-7 | What are some things that have bothered you in previous experiences with doctors/health care providers? | _____ |
| 3-8 | What are some great things you remember your favorite doctors/healthcare providers doing? Example: being on time, asking me how I am doing and having some conversation, speaking with me, and not always looking at the computer. | _____ |
| | **Part 4: Variation**<br><br>**Important things to know about your life outside of the hospital!** | |
| 4-1 | Is there anything in your life that is affecting your health (physical, emotional, spiritual, mental, etc.) that you would like to tell us about? | _____<br>(Example: recent death in the family, loss or change of job, retirement, divorce, a child on the way, etc. - anything you think might be important.) |
| 4-2 | Is there anything in your past that you think is important for us to know about? Anything that could impact your health or the care decisions we make together? | _____<br>(Example: I used to use IV drugs. I have been sober for more than 20 years. Due to some experiences in the past, some things can trigger anger or sadness. Long answer) |
| 4-3 | Is there anything in your community (the area you live in), that might be impacting your health? | _____<br>(Example: No grocery stores, unsafe neighborhood, poor transportation, rent, etc.) ) |
| 4-4 | How easy is it for you to go see a doctor? | ○ Very Hard<br>○ Hard<br>○ Neutral<br>○ Easy<br>○ Very Easy |
| 4-5 | What are some things making it more difficult for you to see your doctor? | _____<br>(Example: getting an appointment, I work during the day and the only appointments are from 9 to 5. The doctor's office is too far away. My insurance is not covered. Etc.) |
| 4-6 | Have the treatment plans your health care team put together for you previously been hard to follow? | ○ I have had difficulty<br>○ I have not had difficulty |
| 4-6b | What are some things that have made treatment plans difficult to follow? | _____<br>((e.g. labels are small, words are technical, difficulty reading)) |

| | | |
|---|---|---|
| | **Part 5: Family and Home** | |
| 5-1 | Do you have a support system or people who are important to you? | ○ Yes<br>○ None |
| | Who is your support system or people who are important to you? | _____ |
| 5-3 | How many individuals, including yourself, do you currently live with? | _____ |
| 5-4 | Can you tell us about your living situation? | ○ I have housing<br>○ I have housing but I am worried about losing it<br>○ I do not have housing (staying with others in a hotel, in a shelter, living outside on the street, in a car, or a park)<br>○ I choose not to answer this question |
| | **Part 6: Resources** | |
| 6-1 | What is your current work situation? | ○ Unemployed<br>○ Part-time or temp<br>○ Full-time<br>○ Otherwise unemployed but not seeking work (student, disabled, retired, unpaid primary caregiver)<br>○ I choose not to answer this question |
| | Please Specify | _____ |
| 6-2 | In the past year have you or any family members you live with been unable to get any of the following when it was needed? Check all that apply. | ☐ Food<br>☐ Clothing<br>☐ Utilities<br>☐ Child Care<br>☐ Medicine or any Health Care (Medical, Dental, Mental Health, Vision)<br>☐ Phone<br>☐ Other |
| | Please specify any additional needs | _____ |
| 6-3 | Which method of contact is most reliable for you? | ☐ Phone<br>☐ Email<br>☐ Other |
| | Please specify the best contact method | _____ |
| | What is your phone number? | _____ |
| | What is your email? | _____ |
| 6-4 | Has lack of transportation kept you from medical appointments, meetings, work, or from getting things you need? Check all that apply. | ☐ Yes (it has kept me from medical appointments)<br>☐ Yes (it has kept me from non-medical meetings, work, or from getting things I need)<br>☐ No<br>☐ I choose not to answer this question |
| 6-5 | Has the cost of medical care kept you from seeking medical attention? | ○ Yes<br>○ No<br>○ I choose not to answer this question |

**Figure 1.** Template of the Humanistic Charting Tool used in a study to examine whether its use during emergency department visits is feasible and improves key patient experience metrics.

## Main Results

Patient feedback indicated that 57 (59%) felt their clinician did not already know most of the information collected in the HCT. In addition, 74 (77%) agreed with the importance of their healthcare team having access to the information provided on the HCT; 84 (88%) found the HCT understandable and easy to fill out; and 54 (56%) reported they would continue using and updating the tool in the future (Figure 3). Most patients 73 (76%) expressed a favorable intention to recommend the tool to others.

Patients who completed the HCT experienced a statistically significant increase in key patient experience domains when compared to their prior healthcare encounter: their clinician taking their preferences into account (61% to 74%; $P = .01$); listening to them carefully (79% to 92%; $P < .001$); treating them with courtesy and respect (85% to 94%; $P < .001$); and knowing important information about them (43% to 52%; $P = .01$) (Figure 4a). Patients whose clinician used the HCT demonstrated a greater absolute increase in every experience metric besides feeling involved in their treatment discussion compared to patients whose clinician did not use the HCT, although there was no statistical significance (Figure 4b).

Qualitative patient feedback from the postcare survey reinforced the quantitative findings. Many patients described feeling heard and valued during their encounters, with comments such as, "[The clinician] took my input into account," and "[The clinicians] were the best—they really listened to me." Others highlighted improved communication, noting, "Everybody was honest and direct…I appreciated the conversations [the clinician] had with me," and "My doctor even sat down and talked through the survey…the experience was great."

In the subgroup analysis, patients who experienced

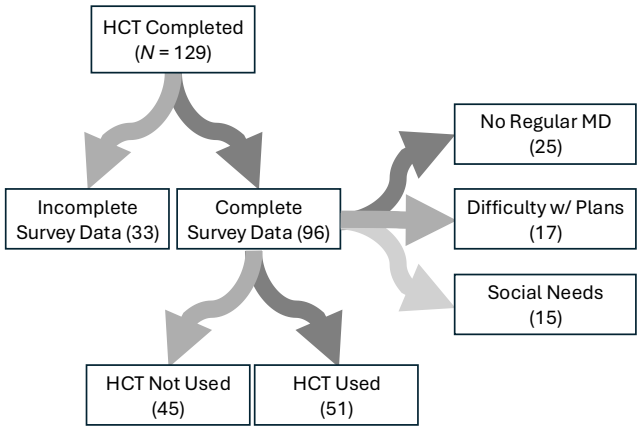


**Figure 2.** Participant flow chart for a study investigating the impact of the Humanistic Charting Tool.
*HCT,* Humanistic Charting Tool; *MD,* medical doctor.

barriers to healthcare—such as those who did not have a regular clinician, previously had difficulty following a treatment plan, or endorsed social needs— demonstrated a larger increase in many of their experience domains compared to patients who did not report barriers (Figure 5). For example, patients who did not have a regular clinician had a significantly greater increase in feeling involved in their treatment discussion (36% to 60% vs 59% to 66%; $P = .05$). Similarly, patients who endorsed at least one social need had a significantly greater increase in being listened to carefully (53% to 73% vs 84% to 95%; $P = .01$). While not statistically significant, patients with difficulty following a treatment plan had a greater increase in feeling involved in their treatment discussion (47% to 65% vs 54% to 64%; $P = .05$), and patients who endorsed at least one social need had a greater increase in reporting being treated with respect (53% to 87% vs 91% to 95%; $P = .13$).

## DISCUSSION

In the fast-paced and time-sensitive environment of the ED, patient encounters often prioritize efficiency and standardized protocols. Within this context, clinicians frequently struggle to balance these demands with the need to provide humanistic, individualized care, and the patient experience often suffers. The HCT represents one approach designed to help clinicians bridge this gap by supporting more personalized interactions and tailoring care to patient needs. Ultimately, our study demonstrates how such interventions are feasible in the ED and have the potential to enhance the patient experience, while also highlighting the practical challenges of implementing patient-centered tools within complex clinical workflows.

The results indicate that patients who filled out the HCT experienced a statistically significant improvement in their self-reported experience metrics. Although we did not explore outcome metrics, previous research strongly links patient experience with improved clinical effectiveness and outcomes.[11,12] These findings underscore the potential value of tools such as the HCT in the ED setting, where time pressures and fragmented encounters often limit opportunities for patient engagement. By enhancing patients' sense of being heard and involved in their care, such tools may support greater adherence to treatment plans and ultimately contribute to improved health outcomes.

Our study, however, found that this difference in experience was not significant when comparing patients whose clinicians used the HCT with those whose clinicians did not. This suggests that completing the questionnaire may make patients feel more heard, regardless of whether their clinician reviews the responses. One possible explanation for this finding is that completing a questionnaire prompts patients to reflect on their concerns and expectations and may prime them for the encounter by helping them articulate their needs more clearly. Another possible explanation is that clinicians in this study may have altered their behavior during the study period, as they were aware they were being observed and had been primed during study implementation to focus on humanism and patient experience.

| | Agree Number (%) | Average Score | SD |
|---|---|---|---|
| I think that doctors already know most of the information collected in the Humanistic Charting Questionnaire. | 39 (41%) | 3.2 | 1 |
| I find it important for my health care team to have access to the information I provided. | 74 (77%) | 3.98 | 0.8 |
| I find the Humanistic Charting tool understandable and easy to fill out. | 84 (88%) | 4.21 | 0.78 |
| This tool is something I would continue to use and keep up to date. | 54 (56%) | 3.62 | 0.89 |
| On a scale of 1 to 10, how likely are you to recommend this tool to another person? | 73 (76%)* | 7.45 | 2.22 |

**Figure 3.** Patient attitudes towards the Humanistic Charting Tool in a study of its impact on patient experience
*For this question, agree is considered to be a score of 7 or higher.
*SD,* standard deviation.

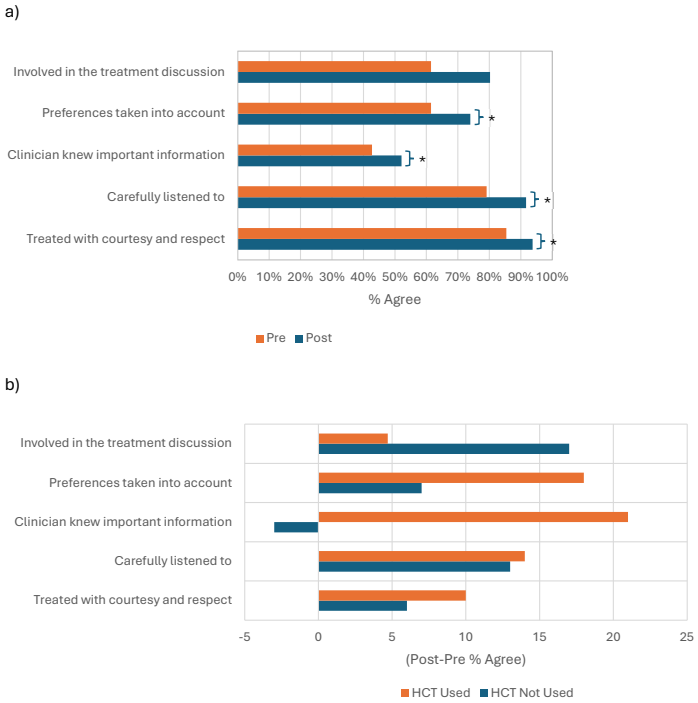


**Figure 4a.** Comparative analysis of patient experience preintervention and postintervention in a study on the impact of the Humanistic Charing Tool (HCT) on emergency department visits.
**Figure 4b.** Comparative analysis of the change in patient experience preintervention and postintervention when the HCT was used by their clinician in a study on its impact on emergency department visits.
*Denotes statistical significance of $P < .05$.

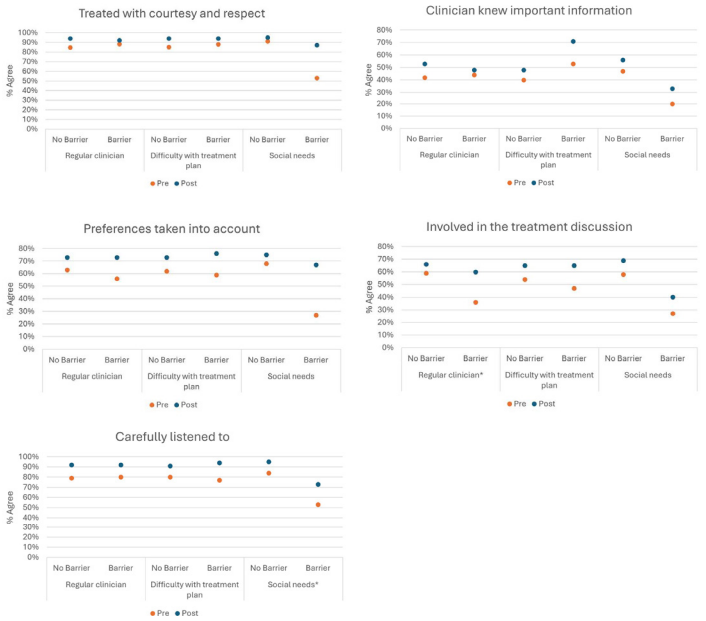


**Figure 5.** Subgroup analysis of patient experience preintervention and postintervention based on barriers to care in a study on the impact of the Humanistic Charting Tool on emergency department visits.
*Denotes statistical significance of $P < .05$.

The lack of statistical significance with clinical use makes it crucial to examine whether clinicians can realistically engage with the HCT. In fact, the fast-paced nature of the ED may limit their ability to meaningfully integrate the tool into their workflow. A study of patient-based questionnaires in a general medicine clinic showed improved chart completeness and problem-solving without a reduction in total encounter time.[13] It is possible that incorporating a patient questionnaire requires more time or cognitive bandwidth than emergency clinicians can reasonably accommodate if it does not reduce the total encounter time, which may explain why similar benefits were not observed in this setting. Although prior studies have noted positive feedback from both ED patients and clinicians regarding such interventions,[14] evidence evaluating their measurable effects in acute care settings remains limited. Achieving comparable benefits in the ED may require a more streamlined or condensed version of the tool that better fits the rapid workflow and competing demands of emergency care.

Although the use of the HCT by the clinician did not yield statistically measurable benefits in this study, this finding should not discourage EDs from pursuing strategies that promote humanistic, patient-centered care. Notably, patients who reported barriers to care—such as not having a regular clinician, difficulty following a treatment plan, or a social need—demonstrated greater improvements in their experience metrics. This pattern, which has not been previously described in the literature, suggests that tools like the HCT may help "level the playing field" and bring patients facing barriers in healthcare to a more equitable level with their peers. By prompting patients to articulate their needs and enabling clinicians to better understand those needs, such tools may help mitigate disparities in communication, trust, and engagement that disproportionately affect vulnerable populations. In doing so, the HCT has the potential both to enhance individual encounters and contribute to broader efforts aimed at reducing inequities in healthcare delivery.

An innovation such as the HCT represents a low-cost intervention with high impact. The tool is an open-source resource that does not incur direct licensing costs. The primary financial investment is associated with initial integration into clinical workflows and the EHR, which we estimate to require a one-time cost of 100 cumulative hours, or $10,000 of combined administrative and clinician time. Ongoing costs are expected to be minimal, consisting primarily of routine maintenance and periodic staff education, estimated at approximately 20 hours, or $2,000 annually.

Future studies should explore implementation strategies that optimize real-time use of patient questionnaires into the clinician workflow, evaluate their impact on clinical outcomes, and examine their utility across diverse emergency care environments.

Special attention should be given to the differential effects of such tools on patients who face barriers and how interventions such as the HCT may influence equity within the ED.

## LIMITATIONS

Several limitations impact the interpretation of these results. First, the study was performed at a single site and only included participants willing and able to use the HCT, limiting the generalizability of the findings. Second, clinicians were aware of the study and may have modified their behavior in response to being observed. Simultaneously, clinicians with a special interest in humanistic patient care may have used their patients' HCT more effectively in the ED encounter, leading to an inherent selection bias. Additionally, the study did not measure clinical outcomes, limiting our ability to determine whether improvements in patient experience translate into measurable health benefits. The sample size may also have been insufficient to detect smaller effect sizes, particularly when comparing the various subgroups. Future studies with larger sample sizes are needed to more definitively evaluate the effectiveness of the HCT and to confirm the generalizability of these findings.

## CONCLUSION

By honoring each patient's unique reality and values, the HCT embodies the philosophy of humanism and individualized care. This study demonstrates that the implementation of the HCT is feasible in the ED and suggests a potential to meaningfully improve patient experience, especially for those who face barriers to care. These findings underscore the potential of targeted interventions to strengthen communication, advance equity, and promote patient-centered care within the constraints of acute care settings.

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# From AUC to Action: AI Sepsis Alerts as Quality Improvement Tools in the Emergency Department

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Dear Editor:

Sepsis alert systems in emergency departments (ED) occupy a difficult interface: They are built as prediction models but succeed or fail as clinical decision support and quality improvement (QI) interventions. For that reason, a higher area under the receiver operating characteristic curve (AUC) should not be the endpoint of evaluation. The more relevant question for ED leaders is whether an alert changes care safely: earlier recognition; shorter time to lactate or cultures; faster appropriate antibiotics; acceptable alert burden; and no worsening of overtreatment or inequity.

The ED literature supports both promise and caution. Hwang and colleagues' *WestJEM* systematic review found that ED sepsis alerts had variable diagnostic accuracy and heterogeneous effects on downstream quality measures, highlighting that implementation design matters as much as detection performance.[1] More recently, Kim and colleagues' ED-focused meta-analysis of 22 studies including 19,580 patients found that sepsis alert systems were associated with lower mortality (risk ratio, 0.81; 95% CI, 0.71–0.91) and shorter time to key bundle elements, including fluid administration, blood cultures, antibiotic administration, and lactate measurement.[2] These findings support alert systems as potentially useful QI tools, but the included studies varied in design, definitions of "time zero," alert type, and bundled co-interventions.

That heterogeneity is exactly why we should avoid treating artificial intelligence (AI) sepsis alerts as diagnostic oracles. A model can look impressive retrospectively and still fail operationally if it alerts the wrong person, fires too often, lacks a clear expected action, or arrives after clinicians are already concerned. In low-prevalence ED populations, even a model with strong discrimination can generate many false positives, which may create alert fatigue, unnecessary reassessment, broad-spectrum antibiotic overuse, and crowding-related opportunity costs.[2,4] Conversely, an alert with modest AUC may be useful if it fires rarely, identifies patients before clinician suspicion, and reliably triggers sepsis bundle steps.

Implementation of the Targeted Real-time Early Warning System (TREWS), an AI-powered clinical decision support platform, illustrates the point. In a prospective multisite cohort, clinician confirmation of TREWS alerts within three hours was associated with lower adjusted in-hospital mortality (3.3% absolute reduction; 95% CI, 1.7%–5.1%) and earlier treatment among patients whose alerts fired before antibiotics.[3,5] This is encouraging, but it should be described as an adjusted association, not proof that the alert itself caused the outcome difference. Residual confounding remains possible: Clinicians may confirm alerts faster in patients whose clinical trajectory already appears more actionable, and local workflow, clinician engagement, and sepsis governance likely contributed to the observed benefit.

A practical ED evaluation framework should therefore shift from "How accurate is the model?" to "What happened after deployment?" At minimum, AI sepsis-alert pilots should prospectively track the following: (1) time-to-lactate, time-to-cultures, and time-to-antibiotics; (2) proportion of sepsis cases flagged before clinician suspicion; (3) alert volume, false-positive rate, and positive predictive value; (4) clinician response rate and override patterns; (5) antimicrobial stewardship balancing measures; and (6) subgroup performance by age, sex, race/ethnicity, language, and comorbidity when data are available. These metrics convert an AI model from a static classifier into a measurable QI intervention.

Governance should be specified before go-live. Each alert should have a defined recipient, a defined expected response, an escalation pathway, and prespecified thresholds for pausing or retuning the system if alert burden becomes unsafe. Local validation should precede broad deployment because transportability is not guaranteed across institutions, electronic health record builds, patient populations, and sepsis definitions. The pilot should be time-limited, with transparent review of benefit and harm rather than indefinite

continuation after technical installation.

There are also important limitations to this framing. Outcome studies of sepsis alert systems are often observational, confounded by co-interventions, and inconsistent in defining sepsis onset and time zero.[1,2] Alert performance depends on base rate and workflow context. Earlier antibiotics are not always better if alerts encourage treatment of noninfectious syndromes or low-risk patients without adequate clinical review. False positives can consume clinician attention and may undermine trust in clinical decision support more broadly.[4] These limitations do not argue against AI sepsis alerts; they argue for evaluating them as implementation-sensitive QI interventions rather than as self-sufficient diagnostic products.

The reframing is simple: the goal is not a higher AUC; it is safer, faster, measurable sepsis care. The AI sepsis alerts should function as co-pilots for process improvement, not autopilots for diagnosis. Their value should be judged by whether they improve ED workflow and patient outcomes without unacceptable noise, overtreatment, or inequity.

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## 1 From Backcountry to Bedside: Training EM Residents in Decision-Making Under Pressure

Sarah Petelinsek, Ethan Grant, Theodore Hartridge, Rowan Kelner, Patrick Hughes

**Objectives**: This study evaluated whether outdoor experiential learning improves clinical decision-making education. We hypothesized that outdoor activities would enhance student awareness of decision-making processes and increase confidence in recognizing cognitive biases.

**Methods:** Emergency medicine (EM) residents at our institution were invited to participate in an outdoor experiential workshop. Prior to the workshop, residents completed a pre-course survey and selected one of three activities: advanced backcountry skiing, beginner backcountry skiing, or a backcountry rescue/snowshoeing activity. Residents were paired with trained backcountry guides and engaged in facilitated discussions on decision-making and bias recognition. Following the experience, participants completed a post-course survey assessing decision-making processes, overall workshop experience, and key takeaways. Pre- and post-course survey results were analyzed using a one-tailed two-sample unequal variance t-test. Data were reported as means and standard deviations.

**Results**: Of 36 eligible residents, 32 (89%) completed the pre-course survey and 20 (62.5%) completed the post-course survey. Participants reported high enjoyment (4.91 ± 0.30), increased bias awareness (4.52 ± 0.60), greater awareness of decision-making processes (4.48 ± 0.60), and perceived educational value (4.67 ± 0.48). Pre- and post-course comparisons showed significant increases in recognition of clinical/non-clinical decision-making parallels (mean increase 0.85, P=0.001), cognition around biases (mean increase 0.35, P=0.02), and understanding of biases (mean increase 0.30, P=0.03). Thematic analysis highlighted increased cognitive bias awareness, clinical application, teamwork, hands-on learning, and big-picture thinking.

**Conclusion**: Outdoor experiential learning is a feasible, novel, and well-received method for teaching clinical decision-making, significantly enhancing bias recognition and cognitive awareness.

## 2 Assessment of Gender Bias of Emergency Medicine Resident Physicians

Corinne Espinosa, Nileena Johnkutty, Courtney Knieriem, Alicia Rouff, Chiamaka Eneh, Amanita Setari, Gregory Neyman, Alyssa McQuillan, Skarleth Moran

**Background**: The perception of female physicians in Emergency Medicine plays a crucial role in shaping the opportunities in a demanding medical specialty. Studies show female residents experience lack of mentorship and difficulties in establishing credibility. Initiatives have developed across residencies to promote diversity and we question whether they have been successful at implementing change.

**Objectives**: The purpose of this study is to assess the perception of gender bias within the emergency department, with an emphasis on female resident physicians.

**Methods**: A structured online, anonymous survey distributed to residents, advanced providers, and attending physicians involved in a 3-year emergency medicine program. They were asked to rate statements on a scale from 1-7 (1 is a strong disagreement and 7 is a strong agreement). Results were tabulated with counts, medians, IQRs, Mann Whitney U testing.

**Results**: Data from 48 participants, 50% identified as each gender and 56.3% are residents. The following questions were statistically significant in difference (p values 0.05-0.00007). Females were perceived more professional in behavior than men, men within the department can be patronizing to females (p=.001) and females opinions are overshadowed by males (p = .0009). Females felt co-workers perceived them as weaker members (p=.003) and males were seen as the leader in high stress situations (p=.00007). Females reported confidence was affected by how peers perceived them (p=.007), more gender bias (p=.001) and pushback from nursing p=.003). Only 24% report gender bias training.

**Conclusion**: Despite the emphasis on creating an inclusive environment, providers in emergency medicine still hold mixed perceptions of female emergency medicine physicians and data suggests female gender bias is present and may be a potential threat to female education. Further research is instrumental to determine steps necessary to create an equitable learning environment.

## 3 Patterns in Duration of Emergency Department Boarding and Variation by Sociodemographic Factors

Christiana K Prucnal MD, ScM, Melissa Meeker PhD, Martin Copenhaver PhD, Paul S. Jansson MD, MS, Rebecca E. Cash PhD, William Hillmann MD, Steven Knuesel MD, Wendy Macias-Konstantopoulos MD, MPH, MBA, Jonathan D. Sonis MD, MHCM

**Background**: Emergency department (ED) boarding negatively affects patient outcomes increasing length of stay, hallway care, and mortality. Prior research found disparities in capacity metrics like hallway care based on patient race/ethnicity, however whether boarding varies by sociodemographic factors is unclear.

**Objectives**: We examined whether duration of ED

boarding varied by sociodemographic factors in a hospital with a standardized bed prioritization process.

**Methods**: This single-center cohort study included all adult ED patients boarding after admission to the non-intensive care inpatient medicine service between February 2020 to February 2023 at an urban academic tertiary hospital with >110,000 annual ED visits. Primary outcome was time from admission order to inpatient bed transport. Patient demographics (age, sex, race/ethnicity, language, insurance, and housing status), visit characteristics (emergency severity index, time, and day), and bed request features (telemetry, sitter need, and active isolation precaution) were obtained via the medical record. We assessed bivariate relationships between boarding time and demographics with descriptive statistics and analysis of variance (ANOVA) using both adjusted and unadjusted regression analyses with generalized estimating equations (GEE) to account for patient level correlation.

**Results**: A total of 22,291 encounters were included. Average age was 64 (SD ±19) years and 47% were female. Approximately 12% identified as Hispanic, 70% as non-Hispanic White, and 10% as non-Hispanic Black. Non-Hispanic Black-identifying patients boarded 19 minutes longer (95% CI -27.66, 65.26) and non-English primary language speakers boarded 20 minutes longer (95% CI -12.43, 51.82) than Hispanic-identifying patients and English primary language speakers respectively, although these findings were not statistically significant. Patients aged 65-years waited 46 minutes longer than younger patients (95% CI 19.05, 72.64, p=0.001), and those with Medicaid insurance waited an additional 52 minutes compared to those with commercial coverage (95% CI 18.14, 85.55, p=0.003).

**Conclusion**: Among adult patients admitted to medicine, advanced age and Medicaid insurance were significantly associated with longer ED boarding, whereas race/ethnicity and primary language were not. Further study should determine whether these findings are replicated in other settings, how this impacts patients, and if targeted intervention can reduce inequities.

## 4 GEDI - Geriatric service in the ED. Feel the Force

George Braitberg, Abdi Osman, Cilla Haywood

**Background**: Older adults account for a high proportion of Emergency Department (ED) presentations due to complex health needs. In 2023–24, people aged 65 and over represented 23% of all ED visits in Australia despite comprising only 16% of the population.

**Methods**: To address this demand, we introduced the Geriatric Emergency Department Innovation (GEDI) service in our tertiary ED (95,000 annual visits). GEDI provides dedicated geriatric care, with a geriatrician present Monday to Friday (0900–1600) and weekends (0900–1230). From January 2023 to December 2024, GEDI assessed 3,232 patients (134 per month). Of these, 24.2% were admitted to an acute inpatient bed, 27.6% were discharged home or to their aged care facility, and 53.2% were admitted directly to geriatric or rehabilitation wards.

**Results**: To measure the impact of the service, we conducted an interrupted time series analysis using data from 1st August 2019 to 30th September 2023, covering pre- and post-GEDI periods. Our primary outcome was a reduction in acute inpatient admissions. Secondary outcomes included ED length of stay (EDLOS), admission rates, re-presentation rates, and Short Stay Unit (SSU) use. We analysed 53,020 pre-GEDI and 12,173 post-GEDI records.Overall, demographic characteristics were similar between the two time periods. Poisson and linear regression showed an increased monthly change in non-admissions post-GEDI (1.012; 95% CI: 1.004, 1.020) compared to pre-GEDI (1.001; 95% CI: 0.999, 1.002), with a median EDLOS reduction of -0.207 hours (95% CI: -0.344, -0.069).

**Conclusion**: The GEDI service reduced acute inpatient admissions and EDLOS. Future analyses will explore staff perceptions and cost-effectiveness.

## 5 Does Sharing Data On The Rate At Which Clinicians Work Alter Their Practice? A Study In A UK ED

Alexander Russell, Mark Harrison

**Objectives**: To assess whether sharing the number of patient's a clinician sees on average per shift with the clinicians in question increases the number of patient's they see per shift (hereafter called 'activity data') within a UK Emergency Department (ED).

To assess clinician perspectives on the sharing of such data.

**Background**: Several UK EDs are already sharing staff activity data with staff in an effort to drive up the rate at which clinicians see patients, but there is no published evidence that this is effective or of the impact of this upon clinicians.

**Methods**: A prospective quantitative and qualitative study looking at the number of patients seen per shift pre and post activity data being shared. Study took place from December 2024 to April 2025.

Quantitative analysis was done by weekly data supplied by the hospital's clinical information services on the number of patient's a clinician sees per shift – this was recorded by clinicians placing their name in the "seen by" column against a patient's name on the hospital electronic patient record system 'nervecentre'.

A 4-month period in which the same clinicians would be

in the department was chosen, with 2 months for baseline data collection, 1 month for data sharing and impact measurement and 1 month to see if activity returned to baseline to assess whether a Hawthorne Effect existed.

Qualitative analysis was done by means of an electronic survey sent to all ED clinicians. This was done with statements expressed on a Likert scale and some free text responses.

**Results**: Sharing activity data with clinicians increased the average number of patients seen per clinician per shift by 0.65 months between 2 and 3. This was a statistically significant change (p=0.001). Month 4 is currently ongoing to see if there is a return to baseline.

Survey results showed negative clinician perceptions on the sharing of activity data with the vast majority stating that it would have a negative impact on staff, with no change to the way or speed by which they work.

**Conclusions**: Sharing activity data with clinicians increases the number of patients that they see per shift on average. However, this is a modest increase relative to the potential negative impacts upon staff morale and working conditions.

Clinicians were of the perspective that knowledge of the data would not alter their practice, which conflicts with the reality which shows an increase in the number of patients seen on average per shift.

## 6 Expanding Stroke Screening for EMS Patients with Altered Mental Status: A Predictive Model Analysis

Joslyn Joseph, Gregory Neyman, Simcha Greenberg

**Background**: Stroke is a time-sensitive emergency in which early recognition and treatment significantly impact outcomes. Emergency Medical Services (EMS) play a vital role in early identification and hospital triage. EMS providers often determine transport destinations based on clinical impressions, protocols, and stroke center capabilities. Altered mental status (AMS) is a common reason EMS providers may miss acute ischemic strokes, but the value of performing stroke scales in all AMS patients remains unclear.

**Objectives**: This study assesses the utility of stroke screening in EMS patients with AMS by developing a predictive model based on stroke scale assessments and clinical factors.

**Methods**: We analyzed the 2022 National Emergency Medical Services Information System (NEMSIS) dataset, focusing on cases with AMS (ICD-10 code R41.82) as a primary or secondary symptom. Logistic regression models were applied to runs where a stroke scale was performed, incorporating demographics, vitals, response acuity, protocols, and symptoms. Two models—one for "Positive" and another for "Positive/Non-conclusive" stroke scales—were used to estimate outcomes for AMS patients not screened.

**Results**: AMS accounted for 10% of EMS stroke impressions. Among 1,973,095 AMS runs, 407,556 (20.7%) included stroke scale assessments, with 19.1% positive and 21.2% non-conclusive. Strong predictors included hemiplegia (OR 14.67), stroke symptoms (OR 13.26), and speech disturbances (OR 5.58). The model estimated a 13.5% probability of a positive stroke scale in unscreened AMS patients.

**Conclusion**: Routine stroke scale use in AMS patients may enhance stroke detection and triage. Future studies should incorporate hospital-confirmed outcomes and explore barriers to EMS stroke scale use.

## 7 Current State of Emergency Department Boarding: A Call to Reimagine Resources to Meet Patient Needs

Christine Chien, Peter Vajda, Howard Klausner, Namita Jayaprakash, Seth Krupp, Mit Patel, Jo Ann Rammal, Victoria Al Karaki, Jennifer Stevenson, Steven Rockoff, Dmitry Davydov, Satheesh Gunaga, Jennifer Stephens-Hoyer, Solomon Knicely, Jason Vieder, Anthony Cruz, Gust Bills, Jacob Sinkoff, Megan Cahill, Heather Cronovich, Anthony Colucci, Brittany Betham

**Background**: Emergency Departments (EDs) are experiencing an unprecedented increase in boarding patients which is impacting the ability to provide efficient and safe patient care. While this issue is recognized in tertiary care hospitals, it remains less explored in community and freestanding EDs.

**Objectives**: The objective of this study is to explore the relationship between annual patient visits and patient hours of care provided in EDs. We hypothesize that despite decreasing annual patient visits, more hours of patient care are being provided.

**Methods**: The electronic health record (EHR) in a Michigan health care system with 9 Emergency Departments were analyzed for 2018 and 2023. These include: 1 tertiary care hospital, 4 community EDs and 4 free standing EDs. Metrics includedTotal Annual Patient Volume, Daily census, and daily Patient Hours of Care (PHC). A descriptive analysis was used to identify trends and differences when comparing2023 to 2018, in these different types of EDs.

**Results**: For community EDs, total annual volumes decreased from 244,753 in 2018 to228,896 in 2023, while PHC increased from 2,944 to 3,810. Freestanding EDs saw a slight decline in total annual volume, from 129,547 in 2018 to 128,156 in 2023, but daily PHC rose from 845 to 1,041. The tertiary care hospital ED experienced the most pronounced decline in total annual volume, from 101,210 in 2018 to 84,792, yet daily PHC significantly increased from 1,601 to

2,056. While all EDs experienced increased PHC in 2023 compared to 2018, the tertiary ED had the most significant drop in total annual census (16.2%), compared to both free standing (1.1%) and community EDs (6.5%) [Figure 1]

**Conclusion**: This study demonstrates a paradigm shift in ED utilization in the post COVID-19 era, with decreased patient volumes but increased PHC across health system EDs (tertiary referral, community, and free standing). Freestanding and community EDs saw slight annual volume decreases but significant percentage increases in PHC (23.2% versus 29.4% respectively) [Figure 2]. This PHC increase was slightly less pronounce din the tertiary care setting which also experienced significant reduction in annual volume. These trends highlight evolving patient care needs in Emergency Medicine and stress the importance of resource allocation and workforce adjustments to manage the increase of PHC.

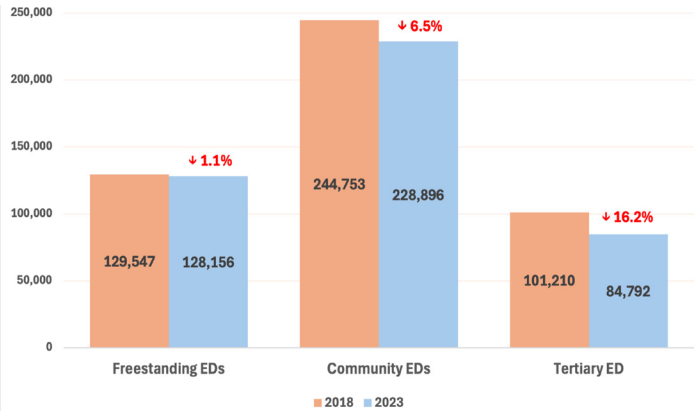


**Figure 1.** Comparison of ED daily PHC between site and year.

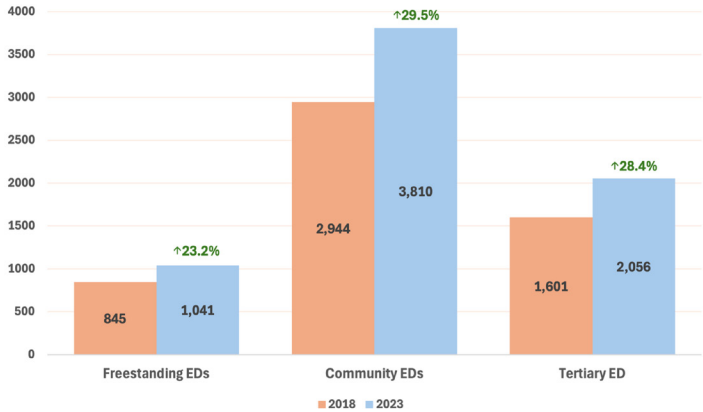


**Figure 2.** Comparison of ED total annual patient volume between site and year.

## 8 EMS Administration of Aspirin to Chest Pain and AMI/STEMI Patients: Disparities in Care?

Francis Mencl, Daniel Johnson, Kyle Fratta

**Objectives**: To determine and compare disparities in aspirin (ASA) administration to chest pain and presumed acute myocardial infarction (AMI) patients treated by EMS.

**Background**: AMI is a significant cause of morbidity and mortality worldwide. There are concerns about potential disparities in the treatment of patients based on gender and race. ASA is an essential prehospital treatment for cardiac patients. We examined its use by EMS for chest pain and AMI/STEMI patients using 2021 NEMSIS data.

**Methods**: This IRB-exempt retrospective study used the 2021 NEMSIS database, which contains over 48 million de-identified EMS calls across the USA. Impressions of chest pain (other and unspecified), myocardial infarction, or ST-elevation myocardial infarction (STEMI) were included. Those under 18 years old, or not transported, were excluded. The rate of ASA use was compared by age, sex, race, and ethnicity. Chi-square and odds ratios with confidence intervals were calculated.

**Results**: A total of 838,898 patients met the inclusion criteria. The mean and median age were 59 and 60, with 49% female. The majority were White (55%), followed by Black (18%), Hispanic (6%), and Asian (1%). Most (95%) were "chest pain", with 42,085 (5.0%) in the "AMI" group. Overall, in instances of chest pain and AMI, males receive ASA more often than females. (41% vs 36.7%) in chest pain and (57.1% vs 55.8%) in AMI ($p<0.0001$). However, the absolute difference in administration between genders is less in AMI. White male patients with chest pain are significantly more likely to receive ASA (42.7%) than any other chest pain group (28.3%-38.7%), $p< 0.0001$. In AMI, however, Black and Hispanic male patients get ASA (60.6% and 56.9%) more often than White males (56.7%). White females with AMI receive ASA (56.6%) as often as White males (56.7%). Hispanic females receive ASA at nearly the same rate as White women (56.1% vs. 56.6%), and Hawaiian/Pacific Islander women are somewhat more likely to receive ASA (58.7%) than White females (56.6%) or White males (56.6%). Hawaiian/Pacific Islander women and American Indian/Eskimo women are more likely to receive ASA than their male counterparts: 58.7% vs. 57.3% and 52.3% vs. 50.4%, respectively.

**Conclusion**: EMS is more likely to administer ASA when they suspect AMI. Differences in the prehospital administration of ASA seen in chest pain patients are minimized when EMS diagnoses an AMI, with some minorities and women actually getting ASA more often than White males.

## 9 Self-Directed Blended Learning- Novel Tool To Teach Neonatal Bag-Mask Ventilation To Students

Akash Bang, Urmila Dahake, Abhijit Choudhary, Shikha Jain, Meenakshi Girish

**Background**: Newborn mortality accounts for over 40% of under-5 deaths. Majority neonatal deaths occur in low and middle-income countries where birth asphyxia contributes to around 1/3. Trainings in Basic Neonatal Resuscitation (BNR) help reduce newborn mortality and is acknowledged as a core competency expected from a medical graduate. Bag-Mask Ventilation (BMV) is the most crucial skill in the BNR. Traditionally, standard DOAP (Demonstrate-Observe-Assist-Practice) is the instruction method recommended by the Indian National Medical Commission for skill-learning. In absence of a standard established training method, many medical schools resort to a 1-day training workshop module which is a resource intensive exercise.

**Objectives**: To evaluate the effectiveness of Self-Directed Blended Learning using video based tutorials as a novel tool to transfer Neonatal BMV skills to undergraduate (MBBS) medical students.

**Methods**: We randomly selected 2 clinical batches of medical students in a teaching public hospital. Consenting students underwent the learning session consisting of a video tutorial of BMV depicting correct rate, pressure, identification of ineffective ventilation and troubleshooting; and one-on-one guidance only for correct positioning of mask over the manikin. No hands-on training was provided to avoid inadvertent conversion of the blended self-directed learning into a traditional DOAP method of training. Pre- and post-test included an OSCE-based evaluation of BMV skills and a self-administered e-survey assessing their confidence about several aspects of BMV.

**Results**: Of the 32 consenting medical students, none had received any prior training in neonatal resuscitation. In the pre-test, only 3% passed the OSCE, 6% reported an above average (score of >3 on a scale of 1 to 5) confidence score in administering correct rate and pressure and 16% in identifying and troubleshooting ineffective ventilation. In the post-test, 97% passed the OSCE and reported an above average confidence score in overall BMV, in administering correct rate and identifying ineffective ventilation ($p<0.0001$). 100% students reported above average confidence in administering correct pressure and individual ventilation corrective steps ($p<0.0001$).

**Conclusion**: Self-directed blended learning involving video tutorial and a brief contact session was effective in teaching the BMV skills to medical students, enhanced their confidence and saved the time and human resources.

## 10 Artificial Intelligence is Capable of Accurately Detecting OMI in the ED

Alexander Bracey, Michael Waxman, Andrew Chang, Maaham Rehman

**Background/Objectives**: The STEMI/NSTEMI paradigm has long been accepted as the strongest indicator of acute coronary occlusion. However, 25-30% of NSTEMIs have unrecognized acute total occlusion; conversely, 15-35% of STEMIs are found to be false positives with no culprit lesion. There has been a shift towards a replacement paradigm, known as occlusion myocardial infarction (OMI), that includes ST-elevation in the criteria, among other ECG findings, to determine the need for reperfusion. A novel AI has since been developed presumed to improve the detection of OMI compared to using STEMI criteria alone.

**Methods**: We conducted a retrospective chart review to evaluate an AI ECG model's ability to detect OMI in high-risk acute coronary syndrome patients presenting to an urban, academic, tertiary care ED. The study period was from 11/24/23 to 7/24/24. Patients were classified as Heart Alert (HA)—patients who did not meet STEMI criteria—or STEMI activations (patients who met STEMI criteria). OMI was defined as either: 1) acute culprit lesion with TIMI 0-2 flow and confirmed OMI on catheterization, or 2) presumed OMI with significant cardiac outcomes, including a) non-occlusive culprit lesion with a High Sensitivity Troponin I (hsTnI) >1000, b) no angiography but elevated hsTnI and new wall motion abnormality on echocardiography, or c) STEMI-positive ECG with death before catheterization. We collected demographic and clinical data. Data analysis was performed using descriptive analytics.

**Results**: From the current dataset, 160 patients with apparent ACS were included. Of these 160 patients, 94 ultimately had OMI, of which 30 were Heart Alert patients and 64 were STEMI activations. The sensitivity of the AI tool in detecting OMI in the HA and STEMI activation groups was 73% (22/30) and 84% (54/64), respectively. The combined sensitivity of both the HA and STEMI activation groups was 81% (76/94). Between the HA and STEMI activation data, there were 18 false negatives (8 HA, 10 STEMI) where the AI tool incorrectly missed an OMI. The specificity of the AI tool in the combined HA and STEMI activation group was 70%.

**Conclusion**: In this small cohort of high-risk ACS patients presenting to the ED, the AI was able to detect 81% of OMIs based on initial ECG. Future prospective studies are necessary to confirm these results. Furthermore, comparative studies of AI vs human interpretation may be meaningful in delineating the clinical impact of this novel tool.

## 11 Development of a Geriatric Order Set in a Safety-Net Emergency Department

Lily Berrin, Julie Gesch

**Objectives**: To develop a standardized order set aimed at enhancing the comfort and safety of older patients by addressing common geriatric issues in a safety-net emergency department (ED).

**Background**: In the United States individuals aged 60 years and older account for 20% of all ED visits, or approximately 29 million visits annually. ED boarding is increasingly prevalent, particularly in safety-net hospitals. Older patients are especially susceptible to increased morbidity and mortality with prolonged ED stays.

**Methods**: We conducted a retrospective analysis of ED visits for patients aged 65 and older at Highland Hospital, an urban safety-net ED in Oakland, California, from January 1, 2023, to December 31, 2023. Data extracted from the electronic health record included total encounters, ED length of stay (LOS), patient disposition, and use of pharmacological and physical restraints. Additionally, we surveyed ED staff to assess current practices and identify areas for improvement in geriatric care. From this data we developed an evidence-based ED geriatric-specific order set, which was refined with input from a multidisciplinary team comprising ED physicians, nursing leadership, rehabilitation services, pharmacists, and the hospital's geriatrician.

**Results**: In 2023, the Highland Hospital ED saw an average of 716 patients aged 65 and older per month, representing 15% of total annual ED encounters. Hospital admission rates for this cohort were 25%, accounting for 34% of total admissions; notably, 38% of patients aged 85 and older were admitted. The average ED patient aged 65 and older spent an average of 13 hours in the ED; admitted patients aged 65 and older spent an average of 26 hours; and admitted patients with altered mental status spent 29 hours in the ED. A common theme in the staff survey was the lack of appropriate care given to older patients who spend a long time in the ED due to boarding.

**Conclusion**: The number of older patients seeking treatment and boarding in safety-net EDs is increasing. To improve ED care for this demographic we developed an evidence-based geriatric-specific order set. The order set includes sections on diet, medication reconciliation, analgesia guidelines, agitation management, mobility and activity recommendations, consultant referrals, safety measures, comfort items, and code status documentation. Our next step is to implement our order set and track care improvement.

## 12 Physician Attitudes on Integration of Prehospital Patient Care Report into Hospital Medical Record

Maren Smith, Caroline Given, Robert Katzer, Soheil Saddat, Julia Afrasiabi

**Introduction:** Pre-hospital information is a valuable resource that is often under-utilized by physicians. In both the emergency and inpatient settings, information about a patient's condition prior to their arrival at the hospital is fundamental to creating an optimal care plan. Historically, there has been no integration between pre-hospital providers' electronic patient care reports (ePCR) and the receiving hospital's electronic medical record (EMR). This study aims to assess provider attitudes towards the ePCR and patient care decisions before and after the integration of the ePCR and hospital EMR system. We hypothesize that this integration will cause an increase in accessibility and thus utilization of pre-hospital ePCR in patient care decision-making.

**Methods**: In 2023 our local academic health center implemented software that allowed pre-hospital documentation to be available to hospital staff within 30 minutes of patient arrival to the emergency department. Before the implementation of this new system, attendings, fellows, and residents from both emergency and internal medicine departments were surveyed on their current attitudes and behaviors regarding ePCR and clinical practice. The same survey was administered 6 months after implementation and responses were compared using a Wilcoxon signed-rank test.

**Results**: 66 physicians responded to the pre-survey including 39 (59.1%) from the emergency medicine (EM) department and 27 (40.9%) from the internal medicine (IM) department. 52 physicians completed the post-survey, including 33 (63.5%) EM physicians and 19 (36.5%) IM physicians. Change in rank was significant ($p<0.01$) for the following categories: knowledge of accessing the ePCR, ability to access the ePCR, ease of accessing the ePCR, time to access the ePCR, and frequency of accessing the ePCR. Change in rank was insignificant for: importance of ePCR in patient care, importance of ePCR in medical decision making, assessment of whether the ePCR would be used more frequently if it were easier to access.

**Conclusion**: Pre and post survey responses regarding accessibility did exhibit a significant change in rank, while the importance of the ePCR on clinical decision-making did not differ significantly. This suggests that while system integration increased accessibility to pre-hospital information, it did not significantly alter patient care decision making by in-hospital physicians.

## 13 Downstream effects of armed conflict on civilian inter-hospital transfer

Evan Avraham Alpert, Ahmad Nama, Koby Assaf, Aliza Goldman, Maximilian Nerlander

**Introduction**: Inter-hospital transfers play a critical role in mass casualty events (MCE). On October 7, 2023, three thousand Hamas terrorists invaded Israel from Gaza, killing 1200 and injuring 1455, triggering an ongoing military conflict between Israel and Hamas. In routine times, Israel's smallest hospital, Yoseftal Medical Center (YMC) in Eilat, transfers complex patients to the closest tertiary care hospital, Soroka Medical Center (SMC) in Beersheva. Being the closest tertiary medical center to Gaza, SMC has also been receiving many of the combat casualties from the ongoing military conflict. The Gaza war initially resulted in a disruption of inter-hospital transfer patterns such that patients routinely transferred from YMC to SMC were sent to a further hospital, Hadassah Medical Center-Ein Kerem (HMC-EK) in Jerusalem. This article describes the downstream effects of armed conflict on inter-hospital transfers.

**Methods**: This is a retrospective study of all patients received at HMC-EK from YMC from January 1, 2022, through January 2, 2024. All data was retrieved from the HMC centralized administrative database.

**Results**: In the study period, 21 patients transferred from YMC to HMC, all arriving after October 7, 2023. The mean age was 61.8 years (± 14.4 years) and 76.2% were male. Most (n=10, 47.6%) arrived in October with decreasing percentages in November (n=9, 42.9%) and December (n=2, 9.5%). The majority of patients received treatment from cardiology specialists (61.9%).

**Conclusion**: Inter-hospital transfers during an MCE or ongoing military conflict can impact the individual patient and the flow in a busy, chaotic ED. The transferred patient needs a higher level of care, which is unavailable at the local hospital. However, during an ongoing military conflict or disaster, the hospital where patients are usually transferred secondarily during routine times may be overwhelmed. Further research on the downstream effects of MCEs and disasters on inter-hospital transfers and ED utilization should be conducted, and protocols should be developed to improve patient care during these times.

## 14 Linking Personal Practices to Academic Success and Professional Development - A Qualitative Analysis

Sarah Petelinsek, Sarah Groves, Patrick G. Hughes, Megan Fix, Alyrene Dorey, Jorie Colbert-Getz

**Background**: Research on the success of medical students has mainly focused on academic measures such as test scores and Grade Point Averages (1). However, success in medical school encompasses more than academics; it should also include professional identity formation (PIF) and overall wellness (2).

**Methods**: AY2023-24 first year medical students (N = 127) at the Spencer Fox Eccles School of Medicine-University of Utah, were asked for the top three habits that supported their academic success and the top three habits that contributed to PIF. Two researchers coded responses thematically, with a third researcher resolving any discrepancies.

**Results**: 123 students responded to the survey (97% response rate), yielding 737 habits. After excluding unclear responses, 655 habits were analyzed. Thematic analysis showed overlap between habits that promoted academic success and those that fostered PIF. The main themes included study strategies, personal skill development, professional growth, community involvement, and wellness. Among these, personal skill development, community development, and wellness were the most commonly cited for both academic and professional success.

**Conclusion:** The findings suggest that habits supporting academic success can also enhance PIF. By emphasizing wellness, community development, and personal skill growth, medical students can succeed both academically and professionally. This preliminary project aims to continue by studying the cohort longitudinally and comparing responses from students and faculty.

## 15 Rekindling Curiosity: Harnessing Autonomy and Creativity to Revitalize Physician Engagement

Maia Winkel, Al'ai Alvarez, Mia Karamatsu

Emergency clinicians are expected to move faster, see more patients, and reduce errors—often at the cost of their own well-being. The constant pressure can erode the sense of purpose that drew many into the field. This busy environment creates a culture of undervaluing brief but meaningful patient interactions that strengthen care and restore connection. Over time, skipping these moments does not just affect patient trust; it also damages clinicians' relationships outside of work and their sense of personal fulfillment.

When exploring what supports physician well-being and effectiveness, several key factors stand out. Autonomy in how we work fuels motivation and unlocks creativity. Introducing small moments of play or curiosity can make the day feel lighter. A beginner's mindset keeps us open and engaged. The sense of disconnection many physicians feel often stems from losing sight of why their work matters. Reconnecting with our core values can shift how we present ourselves and emphasize the need for intention, reflection, and space to stay connected

to the work and to ourselves.

We will outline key challenges that limit autonomy, creativity, and human connection in clinical environments. This includes examining systemic pressures, cultural norms, and institutional barriers that contribute to burnout and disengagement. Then, we will introduce a practical framework for re-integrating playfulness, humanism, and intrinsic motivation into clinical routines. Drawing on evidence and real-world examples, we will illustrate how small, intentional changes can have a meaningful impact on well-being and effectiveness. To support sustained change, we will present a simple evaluation tool that helps clinicians assess the impact of these strategies over time and make adjustments as needed. Finally, we will summarize key takeaways and discuss broader implications for clinical leadership and workplace culture. We will conclude with an open Q&A, allowing participants to reflect, ask questions, and apply the material to their own contexts.

## 16 Accuracy of Parental Reporting in Pediatric Immunization Status in the Emergency Department.

Aneri Patel, Michael Waxman, Alexander Bracey, Ashar Ata, Susan Wojcik, Lauren Pacelli, Christopher Woll

**Objectives**: Describe the accuracy of parental recall in identifying under-immunized pediatric patients in the ED.

**Background**: Immunization status of pediatric patients in the emergency department often relies on parental reporting, typically limited to confirmation of "up-to-date" status.

**Methods**: A prospective, cross-sectional study was conducted at two urban tertiary care pediatric emergency departments in upstate New York State between June 2023 and May 2024. Parents of patients aged 2 months to 18 years were surveyed on their child's immunization status and compared to the gold standard of state immunization records or primary care physician report. Discordance was noted if parent identified the child as being immunized but the gold standard did not. Differences between reporting methods was assessed using McNemar's test.

**Results**: Of 441 patients who were screened, 32 had missing data, withdrew from the study or did not meet inclusion criteria, resulting in 409 patient who were enrolled. The immunization rates (defined by the gold standard) and discordance rates between parental report and the gold standard, in those with statistically significant differences, were as follows: Influenza immunization rate = 41.8% (discordance = 14.67% [95% CI 10.25%–19.09%], p<0.0001), COVID immunization rate = 16.6% (discordance = 13.45% [95% CI 8.29%–18.50%], p<0.0001), Hepatitis A immunization rate = 89.0% (discordance = 4.89% [95% CI 1.34%–8.44%], p=0.01), Hepatitis B immunization rate= 97.6% (discordance = 1.96% [95% CI 0.31%–3.61%], p=0.04).

**Conclusion**: The study findings suggest at least two points of interest. First, approximately one-third of pediatric emergency department patients were not up to date for their seasonal immunizations, suggesting an opportunity to provide referral to immunization services or to provide 'catch up' immunizations during the visit. Second, there was a modest discordance between parental and state-reported routine childhood immunizations and there was a significant discordance with seasonal immunizations. Therefore, in scenarios where immunization status influences clinical decision making, it may be warranted to clarify parentally reported status. Future research should focus on evaluating which clinical decision making scenarios are impacted by immunization status.

## 17 Indirect Exposure to Atrocities and PTSD among Aid Workers: Hemispheric Lateralization Matters

Einav Levy, Yori Gidron

**Background:** Humanitarian aid workers (HAWs) are indirectly exposed to atrocities relating to people of concern (POC). This may result in a risk of secondary traumatization demonstrated by post-traumatic stress symptoms (PTSSs). Previous studies have demonstrated that hemispheric lateralization (HL) moderates the relationship between threat exposure and post-traumatic stress symptoms (PTSSs).

**Objectives:** We hypothesized that indirect exposure to atrocities (IETA) would be positively correlated with PTSSs among HAWs with right and not left HL.

**Methods:** Fifty-four HAWs from several countries that provided humanitarian support in Greece and Colombia participated in this correlational and cross-sectional observation study. They completed scales relating to IETA, PTSSs were assessed using a brief, valid scale, and HL was measured.

**Results:** IETA was positively and significantly related to PTSSs ($r = 0.39$, $p < 0.005$). Considering HL, IETA was unrelated to PTSSs among people with right HL ($r = 0.29$, $p = 0.14$), while IETA was related to PTSSs among people with left HL ($r = 0.52$, $p = 0.008$). Right HL emerged as a protective factor in the relationship between IETA and PTSS.

**Conclusions:** An assessment of dominant HL can serve as one consideration among others when deploying HAWs in specific locations and roles, vis à vis IETA. Moreover, those found to have a higher risk for PTSSs based on their HL could be monitored more closely to prevent adverse reactions to IETA.

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