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Emergency medicine is a specialty which closely reflects societal challenges and consequences of public policy decisions. The emergency department specifically deals with social injustice, health and economic disparities, violence, substance abuse, and disaster preparedness and response. This journal focuses on how emergency care affects the health of the community and population, and conversely, how these societal challenges affect the composition of the patient population who seek care in the emergency department. The development of better systems to provide emergency care, including technology solutions, is critical to enhancing population health.

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VITAL STATISTICS

Western Journal of Emergency Medicine (*West*JEM): Integrating Emergency Care with Population Health (*West*JEM) is the premier open-access Medline-indexed EM journal in the world. As the official journal of the California Chapter of the American College of Emergency Physicians (ACEP), American College of Osteopathic Emergency Physicians (ACOEP), and the California chapter division of the American Academy of Emergency Medicine (AAEM), the journal focuses on how emergency care affects health and health disparities in communities and populations. Additionally, *West*JEM focuses on how social conditions impact the composition of patients seeking care in emergency departments worldwide. *West*JEM is distributed electronically to 19,000 emergency medicine scholars and 2,800 in print. This includes 83 academic department of emergency medicine subscribers and 7 AAEM State Chapters.

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Practical Diagnostic Accuracy of Nasopharyngeal Swab Testing for Novel Coronavirus Disease 2019 (COVID-19)

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Introduction: The novel coronavirus (SARS-CoV-2) is the cause of COVID-19, which has had a devastating international impact. Prior reports of testing have reported low sensitivities of nasopharyngeal polymerase chain reaction (PCR), and reports of viral co-infections have varied from 0-20%. Therefore, we sought to determine the accuracy of nasopharyngeal PCR for COVID-19 and rates of viral co-infection.

Methods: We conducted a retrospective chart review of all patients who received viral testing between March 1, 2020–April 28, 2020. Test results of a complete viral pathogen panel and COVID-19 testing were abstracted. We compared patients with more than one COVID-19 test for diagnostic accuracy against the gold standard of chart review.

Results: We identified 1950 patients, of whom 1024 were tested for COVID-19. There were 221 repeat tests for COVID-19. Among patients with a repeat test, COVID-19 swabs had a sensitivity of 84.6% (95% confidence interval (CI), 69.5-94.4%) and a specificity of 99.5% (95%CI, 97-100%) compared to a clinical and radiographic criterion reference by chart review. We found viral co-infection rates of 2.3% in patients without COVID-19 and 6.1% in patients with COVID-19. Rates of co-infection appeared to be related to base rates of infection in the community and not a specific property of COVID-19.

Conclusion: COVID-19 nasopharyngeal PCR specimens are accurate but have imperfect sensitivity. Repeat testing for high-risk patients should be considered, and presence of an alternative virus should not be used to limit testing for COVID-19 for patients where it would affect treatment or isolation. [West J Emerg Med. 2020;21(6)1-4.]

INTRODUCTION

Many patients with novel coronavirus disease 2019 (COVID-19) will be asymptomatic[1]; however, a small percentage of patients will become severely ill requiring hospitalization. Overall mortality estimates of COVID-19 vary due to variable access to systematic testing, but the most critically ill requiring intubation have high risk of death.[2,3] The most commonly used initial testing was a nasopharyngeal swab for polymerase chain reaction (PCR), although antibody testing has since become available. PCR is widely used to test for other viral illnesses. Limitations of PCR testing for COVID-19 include unknown risk of transmission from PCR-positive patients and anecdotal reports of lack of sensitivity.[4] Initial reports from China questioned the sensitivity of PCR for COVID-19 and reported it as low as 71%, especially in early illness.[5] Further, PCR tests for the presence of viral RNA, which may or may not be able to transmit infection.

Lack of availability of widespread testing for COVID-19 has been a controversial subject. One method proposed to initially allocate scarce testing resources was to cancel testing patients for COVID-19 if another virus was detected. This was

due to initial reports of a 0-4% co-infection rate with influenza and COVID-19.[6,7] However, since then reports of co-infection rates as high as 20% have been reported.[8] Therefore, we sought to examine our viral testing data for the diagnostic accuracy of patients tested more than once for COVID-19, as well as the rate of viral co-infections in patients tested for COVID-19.

METHODS

We conducted a retrospective review of all patients who had viral testing from March 1, 2020–April 28, 2020 at our tertiary academic medical center in central Pennsylvania. This study was approved by the institutional review board of Penn State Milton S. Hershey Medical Center. We identified charts using the specific order for respiratory viral pathogen panel testing, as this was uniformly used to obtain testing for all patients through April 25, 2020. Adults and children were included.

Availability and policies regarding COVID-19 testing at our hospital have changed often during the study period. Tests from four different sources have been available: ARUP Laboratories (Salt Lake City, UT), Quest Diagnostics (Secaucus, NJ), Pennsylvania Department of Health (Harrisburg, PA), and in-house testing at our clinical lab (Hershey, PA). During the entire time period, hospital recommendations were that all patients have traditional viral PCR testing with COVID-19 testing. Through March 14, viral panel results were used to determine whether or not a COVID-19 test was sent. All patients in this analysis had both tests sent.

PCR testing for in-house COVID-19, approved under the Food and Drug Administration's (FDA) Emergency Use Authorization, was targeted against two different regions of the SARS-CoV-2 genome, ORF1ab and S gene (Simplexa, Focus Diagnostics, DiaSorian Group, LLC, Cypress, CA). An RNA internal control is used to detect reverse transcription-PCR failure and/or inhibition. Respiratory viral pathogen multiplex PCR testing is done in house and tests for influenza A and B, respiratory syncytial virus, parainfluenza (types 1,2,3 and 4), adenovirus, coronavirus, human metapneumovirus, rhinovirus/enterovirus, and atypical bacterial pneumonias (*Bordetella pertussis* and *parapertussis*, Chlamydophila pneumonia, and *Mycoplasma pneumoniae*).

Data abstracted included age and gender of patients, results of respiratory viral panel (RVP), results of COVID-19 testing, site of COVID-19 testing, and date of testing. A single author abstracted data with questions checked by two other authors. Testing date was the date of the initial RVP test, and positivity was determined by lab report. All patients who had a repeat test during the study period were included in this analysis. We recorded the days between each test. Concordant results were considered accurate. Using documented history and all testing results, including labs and imaging, two independent, non-blinded, physician study team members conducted in-depth reviews of patient charts with discordant results to determine the true diagnosis at the time of each test,. The clinical case definition we used to determine COVID-19 positivity in a negative test was the broad definition used by our hospital at that time, which included any of the following:

1. any new shortness of breath, or hypoxemia without a compelling other cause;
2. computed tomography (CT) or radiograph findings reported as consistent with COVID-19;
3. fever, cough, or diarrhea with any new infiltrate on CT or radiograph not found to have another cause;
4. fever, cough, or diarrhea with a known exposure to a COVID-19-positive patient or high-risk travel.

The length of time between tests was also considered in determining positivity. Therefore, discordant tests could both have been determined to be accurate at the time of the test if there was a delay of more than one day between tests and the patient's clinical course or symptoms had changed. We had planned to use a third team member to adjudicate any discrepancies during the chart review, but there were none found. Patients who had discordant results also had symptoms recorded. We analyzed patients who had other viral infections both with and without COVID-19. Given more rapid availability of RVP testing, results of those with COVID-19 co-testing were only analyzed if the RVP test was positive.

Analysis

We managed data in Microsoft Excel (Microsoft Corporation, Redmond, WA). We reported diagnostic accuracy using standard definition, and reported rates of co-infection as percentages.

RESULTS

Our chart review identified 1950 patients, of whom 1024 (52.5%) were tested for COVID-19. The remainder were tested for other viral pathogens but not COVID-19. Our data goes through the beginning of March, when routine testing for COVID-19 had not begun in order to identify all cases where COVID-19 testing was done. In the sample, 53.3% (n = 1039) were female and the mean age was 43.7 years old (standard deviation ±26.2 years, range one month to 98 years old). One hundred sixty-eight patients were tested for COVID-19 more than once for a total of 221 tests. One hundred forty-eight patients with positive RVPs were co-tested for COVID-19. Of the 1024 patients tested for COVID-19, 10.9% (n = 111) were positive.

Of the 221 repeat tests for COVID-19, 181 (81.9%) were true negatives, 33 (14.9%) were true positives, six (2.7%) were false negatives, and one (0.5%) was a false positive (Table). Included in this were two inconclusive tests that were determined to be positive. This includes the only false positive result, which was initially reported as positive in a ventilator-dependent, 12-month-old male who had been hospitalized since birth. Over the next three days, four repeat tests were sent, and all were found to be negative. Of the patients with false negatives, symptoms were present at one day, two days, four days, seven days, and two

Table. Diagnostic accuracy of COVID-19 nasopharyngeal swab PCR testing (n=221), compared to a clinical and radiographic criterion reference by chart review. Prevalence of disease in the population of 17.6%.

Test	Value	95% confidence interval
Sensitivity	84.6%	69.5% to 94.4%
Specificity	99.5%	97.0% to 100%
Positive predictive value	97.1%	82.3% to 99.6%
Negative predictive value	96.8%	93.5% to 98.4%
Positive likelihood ratio	154.0	21.7 to 1092.4
Negative likelihood ratio	0.15	0.07 to 0.32
Diagnostic accuracy	96.8%	93.6% to 98.7%

COVID-19, novel coronavirus disease 2019; *PCR,* polymerase chain reaction.

weeks, respectively. No patient who had more than two tests had a change in testing from negative to positive. One patient had a maximum of six tests, all of which were negative.

The rate of positive viral panels and COVID-19 tests over time is presented in Figure. Of the 1950 patients, 44 (2.3%) had a non-COVID-19 infection, most commonly rhino/enterovirus. Of the 148 patients co-tested for COVID-19 and other viral/atypical pathogens, 6.1% (n = 9) had a co-infection with COVID-19 (Figure), including two patients with both COVID-19 and non-COVID-19 coronavirus and two patients with three simultaneous infections.

DISCUSSION

This study confirms that PCR testing for COVID-19 is highly reliable when positive; however, there are some false negative results, mostly clustered early in the disease course. This is important as testing is used to ease restrictions on patients and the public. In highly suspicious patients, a repeat test in 24-48 hours may be helpful. Based on our sample, however, repeat testing beyond two tests is of limited utility. This will be relevant for patients who work with the public, live with at-risk patients, and healthcare workers.

There are several potential mechanisms for imperfect sensitivity. The first is an inherent property of the test, for example, the primer used. Chan et al report that the COVID-19-RdRp/Hel assay was positive in 44% of patients, while the RdRp-P2 assay was only positive in 28% of patients.[9] The second possibility is that an inadequate sample was obtained. Nasopharyngeal swabs need to be deeply inserted and sit for 10-30 seconds to collect an adequate amount of viral RNA. Our nursing staff is highly trained in swab collection, and we have a dedicated "swab team" to further increase adequate specimen collection. It is imperative that patients not obtain their own samples (eg, at drive-through testing), as this increases the likelihood for an inadequate sample. It is known that coronaviruses rapidly mutate, and it is proposed that these genetic mutations may alter test characteristics of PCR.[10] This may also be due to the fact that a nasopharyngeal swab is not an adequate specimen type. For example, a bronchoalveolar lavage was the only positive sample in a critically ill patient who initially tested positive for influenza and negative for COVID-19 via nasopharyngeal PCR.[11] In a larger analysis, bronchoalveolar lavage and sputum samples outperform nasopharyngeal and oral

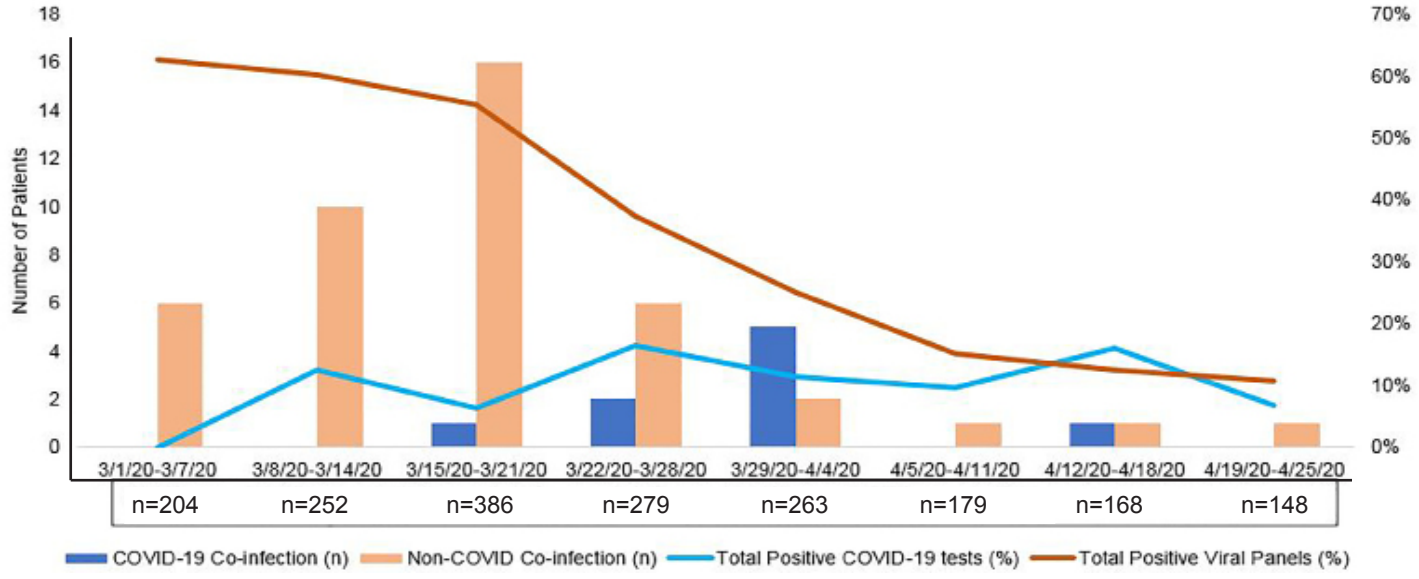

Figure. Number of viral co-infections versus viral positivity rates. *COVID-19,* novel coronavirus disease 2019.

samples.[12] In addition, a salivary PCR test was also approved by the FDA and has shown higher sensitivity than nasopharyngeal samples.[13] The final potential explanation, which our data supports, is that a significant enough viral load is not present to be identified in patients early in their disease course.

We found a greater number of viral co-infections with COVID-19 than those reported early out of China,[6,7] but much fewer than those reported out of Stanford.[8] A time-course analysis of our data (Figure) shows that viral co-infection is more a product of statistical probability than physiology, and that an alternate viral infection does not appear to be protective against COVID-19.

LIMITATIONS

Our study was limited by its retrospective design and limited sample size. In addition, systematic testing would have been more scientifically rigorous but was impractical due to limited clinical testing resources. High-risk patients were mostly re-tested when negative, which could have led to underestimation of our false negative rate. Re-testing was less commonly done for positive samples, which could also have introduced bias. Specificity might have been less if more positive patients had been re-tested. Nonetheless, biologically, the PCR primers used for COVID-19 are thought to be highly specific.[14] Finally, because no gold standard for the diagnosis of COVID-19 currently exists, we chose to incorporate PCR testing and chart review. This decision introduced incorporation bias for using the test in question as part of the reference standard, although it was essentially unavoidable for this situation.

CONCLUSION

Nasopharyngeal PCR specimens for COVID-19 appear to be highly accurate, but from our data, have a sensitivity of only 84.6%. Repeat testing for high-risk patients should be considered, or they should be assumed to be positive with no testing. The presence of an alternative virus should not be used to limit testing for COVID-19 for patients where it would affect treatment or isolation.

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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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Risk Stratification of COVID-19 Patients Using Ambulatory Oxygen Saturation in the Emergency Department

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Introduction: It is difficult to determine illness severity for coronavirus disease 2019 (COVID-19) patients, especially among stable-appearing emergency department (ED) patients. We evaluated patient outcomes among ED patients with a documented ambulatory oxygen saturation measurement.

Methods: This was a retrospective chart review of ED patients seen at New York University Langone Health during the peak of the COVID-19 pandemic in New York City. We identified ED patients who had a documented ambulatory oxygen saturation. We studied the outcomes of high oxygen requirement (defined as >4 liters per minute) and mechanical ventilation among admitted patients and bounceback admissions among discharged patients. We also performed logistic regression and compared the performance of different ambulatory oxygen saturation cutoffs in predicting these outcomes.

Results: Between March 15–April 14, 2020, 6194 patients presented with fever, cough, or shortness of breath at our EDs. Of these patients, 648 (11%) had a documented ambulatory oxygen saturation, of which 165 (24%) were admitted. Notably, admitted and discharged patients had similar initial vital signs. However, the average ambulatory oxygen saturation among admitted patients was significantly lower at 89% compared to 96% among discharged patients ($p<0.01$). Among admitted patients with an ambulatory oxygen saturation, 30% had high oxygen requirements and 8% required mechanical ventilation. These rates were predicted by low ambulatory oxygen saturation ($p<0.01$). Among discharged patients, 50 (10%) had a subsequent ED visit resulting in admission. Although bounceback admissions were predicted by ambulatory oxygen saturation at the first ED visit ($p<0.01$), our analysis of cutoffs suggested that this association may not be clinically useful.

Conclusion: Measuring ambulatory oxygen saturation can help ED clinicians identify patients who may require high levels of oxygen or mechanical ventilation during admission. However, it is less useful for identifying which patients may deteriorate clinically in the days after ED discharge and require subsequent hospitalization. [West J Emerg Med. 2020;21(6)5-14.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

Population Health Research Capsule

What do we already know about this issue?
The COVID-19 pandemic is rapidly evolving, and little is known about the ability to risk stratify patients based on ambulatory oxygen saturation.

What was the research question?
Can ambulatory oxygen (O_2 sat) saturation help guide disposition of emergency department (ED) patients with COVID-19?

What was the major finding of the study?
Ambulatory O_2 sat cannot rule out ED bounceback to admission, but does predict inpatient respiratory needs.

How does this improve population health?
At the pandemic's height, EDs lacked evidence-based ways to quickly risk stratify respiratory patients. This study provides early data for one approach.

INTRODUCTION

One of the most difficult challenges in the management of coronavirus 2019 (COVID-19) patients is identifying those with significant respiratory compromise.[1,2] Some patients without any visible respiratory distress can have severe hypoxemia, and there is substantial variability in the severity of illness among COVID-19 patients.[3-5] Therefore, there is a significant amount of uncertainty surrounding the care of these patients, particularly with regard to disposition from the emergency department (ED).[6] These decisions are made more complicated by the life-threatening nature of this illness and the massive burden that COVID-19 has placed on an already strained healthcare system.[7-9]

As the pandemic has evolved, several studies have identified patient characteristics and clinical markers that are correlated with poor outcomes among COVID-19 patients.[10-12] Many of these studies use an outcome of intubation or death to risk stratify patients. However, there are COVID-19 patients who will develop high oxygen requirements and may require admission to avoid these endpoints.[13-16] The criteria used to determine which ED patients should be admitted may not be the same as those factors that predict intubation or death. Furthermore, in the face of overwhelming patient volumes, many ED clinicians may find that they lack the capacity to perform comprehensive laboratory or radiologic testing on all patients presenting with COVID-19 symptoms.[17,18]

During the surge of ED patients in New York City, ED clinicians (physicians, residents, and physician assistants) at our institution developed the practice of performing ambulatory oxygen saturation measurements to aid the disposition of stable-appearing COVID-19 patients. Previously, oxygen desaturation while walking has been shown to be associated with poor outcomes in diseases such as pulmonary fibrosis and radiation pneumonitis.[19-22] The goal of this study was to provide data on our early experience using ambulatory oxygen saturation to determine whether this relatively quick assessment can help guide the disposition of ED patients with COVID-19.

METHODS

Study Design, Setting, and Population

We performed a retrospective chart review of ED patients seen at New York University (NYU) Langone Health at our four EDs, located in Manhattan, Brooklyn, and Long Island. We studied ED visits during the month (specific dates below) that corresponded to the peak of the COVID-19 pandemic in New York State. Charts were reviewed to identify ED patients who had a documented oxygen saturation while ambulating. We then analyzed the association between recorded ambulatory oxygen saturation and patient outcomes among patients admitted and discharged from the ED.

Data Sources

We queried the health network's electronic health record (EHR) (Epic Systems, Verona, WI) via Oracle SQL Developer (Oracle Corporation, Redwood Shores, CA) in our Epic Systems Clarity database. We exported initial ED clinician notes along with demographic variables (ie, age and gender) and clinical variables (ie, body mass index [BMI], medical comorbidities, and initial ED vital signs) for all ED patients presenting with COVID-19 symptoms from March 15, 2020–April 14, 2020. In addition, we abstracted additional clinical outcomes (.e, supplemental oxygen flow rates and devices and bounceback admissions to our facilities) for confirmed COVID-19 positive patients admitted as inpatients to the hospital from the ED. We performed data abstraction on April 29, 2020, to ensure that at least two weeks of outcome data were available for each patient.

Ambulatory Oxygen Saturation

When the initial ED clinician note for a patient contained the key words walk/walked/walking or "ambul" to capture ambulatory/ambulation/ambulated/ambulating, we reviewed

the chart to determine whether a numeric ambulatory oxygen saturation had been documented in any of the ED notes. When a range of values was charted, we used the lowest number. In several cases, ED clinicians noted that the patient's oxygen saturation while walking was greater than some number (eg, ">93%"). When we asked our ED clinicians, the consensus was that this should be interpreted to mean equal to or greater than that number as it is difficult to type a greater than or equal to sign in the EHR. In a minority of cases, ED clinicians wrote partially numeric values (eg, "high 80s" or "mid 90s"). These values were reinterpreted as follows: high 90s (two instances of this phrase assigned 98%); low-mid 90s (one assigned 93%); low 90s (two assigned 92%,); high 80s (five assigned 88%); mid-high 80s (one assigned 87%); mid 80s (three assigned 85%); low 80s (four assigned 82%).

Primary Outcomes

For admitted ED patients, our clinical outcome was a high oxygen requirement, defined as an oxygen flow rate above four liters per minute (L/min) at any point during hospitalization, which included the need for mechanical ventilation. We used this value as a cutoff given that most patients on home oxygen are generally not at rates higher than four L/min. For discharged ED patients, our clinical outcome was bounceback admission, defined as a subsequent ED visit within 10 days of the initial ED visit that resulted in an inpatient hospitalization. Notably, we were not able to track whether a patient had a bounceback admission at other area hospitals.

Statistical Analysis

We initially described our retrospective cohort of patients who had a documented ambulatory oxygen saturation based on demographic variables, BMI, medical comorbidities, initial ED vital signs, and documented ambulatory oxygen saturation. We analyzed categorical variables by chi-square tests, and continuous variables by t-tests and rank-sum tests as appropriate. A p-value of 0.05 was used to identify statistically significant differences in the characteristics of ED patients with a documented ambulatory oxygen saturation who were admitted vs discharged.

We then analyzed the association between the documented ambulatory oxygen saturation and our clinical outcomes using logistic regression. Since there were two main analyses in this study (among admitted patients and separately among discharged patients), we used a Bonferroni correction and an adjusted p-value of 0.025 to test for a significant association between ambulatory oxygen saturation and our clinical outcomes. Finally, we also analyzed the performance of ambulatory oxygen saturation in terms of sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) at different ambulatory oxygen saturation cutoffs. Statistical analyses were performed in Stata 16.1 (StataCorp, College Station, TX). This study was approved by the institutional review board at NYU Grossman School of Medicine.

RESULTS

Study Population

Of the 17,123 ED patients seen at our four EDs in Manhattan, Brooklyn, and Long Island between March 15–April 14, 2020, 6194 (36%) had a chief complaint of either fever, cough, or shortness of breath. Of the patients presenting with these symptoms, 1071 (17%) had the key words: walk, walked, walking, ambulatory, ambulation, ambulated, or ambulating. When we reviewed these charts with the key words present, 684 (64%) had a documented number for an ambulatory oxygen saturation and 165 (24%) of these patients were admitted.

Comparing admitted and discharged ED patients with a documented ambulatory saturation, admitted patients were approximately 10 years older than discharged patients and more frequently had a history of hypertension, hyperlipidemia, diabetes, cirrhosis, or immunosuppression (Table 1). As for initial triage vital signs, there was a statistically significant difference between the initial temperature, diastolic blood pressure, and triage oxygen saturation between admitted and discharged ED patients. In general, these differences in triage vital signs were not necessarily clinically significant. Although the ranges of their initial triage oxygen saturation values were the same, the average and median ambulatory oxygen saturation of discharged ED patients was 96% (range of 86-100%) compared to 89% (range of 71-95%) among admitted ED patients (Figure 1).

Clinical Outcomes

Of the 165 admitted ED patients with a documented ambulatory oxygen saturation, 103 (62%) did not require more than four L/min of oxygen during their hospitalization, 49 (30%) required more than four L/min of oxygen, and 13 (8%) required mechanical ventilation. Of the 519 discharged ED patients with a documented ambulatory oxygen saturation, 50 (10%) had a subsequent ED visit at our health system that resulted in an inpatient hospitalization, which is higher than our typical bounceback rate or overall bounceback rate during this time period. Of these bounceback admissions, 24 (48%) had a low oxygen requirement, 19 (38%) had a high oxygen requirement, and 7 (14%) required mechanical ventilation. We also stratified these outcomes by different ambulatory oxygen saturation levels in Figure 2 and Table 2.

Prediction Based on Ambulatory Oxygen Saturation

In our univariable logistic regression analyses, a higher ambulatory oxygen saturation among admitted ED patients was associated with lower odds of high oxygen requirement or mechanical ventilation ($p<0.01$). Similarly, a higher ambulatory oxygen saturation among discharged ED patients was associated with a lower odds of bounceback admission ($p<0.01$).

We also provide a range of performance characteristics (ie, sensitivity, specificity, NPV, and PPV) for different cutoffs for ambulatory oxygen saturation for these outcomes in Table 3, along with receiver operating characteristic curves in Figures 3 and 4. For example, an ambulatory oxygen

Table 1. Characteristics of admitted and discharged ED patients with a documented ambulatory oxygen saturation.

Patient characteristics	Admitted N (%) or Mean (SD)	Discharged N (%) or Mean (SD)	Significance P-value
Total patients	165	519	
Age			
Mean	56	47	< 0.01
Median	58	47	< 0.01
Interquartile range	47 to 66	37 to 57	
18 to 29	5 (3%)	53 (10%)	
30 to 39	17 (10%)	119 (23%)	
40 to 49	30 (18%)	108 (21%)	
50 to 59	36 (22%)	137 (26%)	
60 to 69	51 (31%)	72 (14%)	
70 to 79	23 (14%)	26 (5%)	
80 and up	3 (2%)	4 (1%)	
Sex			
Male	94 (57%)	270 (52%)	0.27
Female	51 (43%)	249 (48%)	
Body-Mass-Index*			
20 to 25	22 (16%)		
25 to 30	53 (39%)		
30 to 35	31 (23%)		
40 to 45	18 (13%)		
45 and Up	4 (9%)		
Comorbidities			
Hypertension	73 (44%)	97 (19%)	< 0.01
Hyperlipidemia	43 (26%)	88 (17%)	0.01
Diabetes	34 (20%)	57 (11%)	< 0.01
Coronary artery disease	7 (4%)	20 (4%)	0.82
Congestive heart failure	2 (1%)	5 (1%)	0.78
Asthma	20 (12%)	42 (8%)	0.12
COPD	1 (1%)	4 (1%)	0.83
Cancer	9 (5%)	28 (5%)	0.98
Cirrhosis	2 (1%)	0 (0%)	0.01
Chronic kidney disease	6 (4%)	13 (3%)	0.44
End-stage renal disease	2 (1%)	2 (0%)	0.23
Immunosuppression	10 (6%)	6 (1%)	< 0.01
Triage vital signs			
Temperature	99.8 (1.5)	99.5 (1.3)	< 0.01
Heart rate	97 (17)	97 (16)	0.58
Systolic blood pressure	132 (18)	132 (17)	0.74
Diastolic blood pressure	77 (11)	81 (11)	< 0.01
Respirations	20 (3)	20 (3)	0.02
Triage oxygen saturation			
Average	95 (2)	97 (2)	< 0.01
Median	95	97	< 0.01
Range	90 to 100	90 to 100	

COPD, Chronic obstructive pulmonary disease.

Table 1. Continued.

Patient characteristics	Admitted N (%) or Mean (SD)	Discharged N (%) or Mean (SD)	Significance P-value
Ambulatory oxygen saturation			
Average	89 (4)	96 (2)	< 0.01
Median	89	96	< 0.01
Range	71 to 97	86 to 100	< 0.01

*Only 24 of the 519 discharged patients had a height and weight measurement to calculate a body-mass-index, therefore these values are not reported.

saturation of 92% or less among admitted ED patients had a 92% sensitivity, 29% specificity, 86% NPV, and 44% PPV for requiring a high level of supplemental oxygen or mechanical ventilation. For discharged patients, even those with high oxygen saturations (up to 98%) on ambulation had a chance of representing with subsequent admission.

DISCUSSION

Our goal in this study was to evaluate whether the measurement of ambulatory oxygen saturation could help predict outcomes among admitted and discharged ED patients. It should be noted that our study population included only ED patients who were able to tolerate ambulation and therefore likely excludes patients who were critically ill or had a high oxygen requirement at baseline. This study population is critically important to examine since it represents a population of relatively stable-appearing ED patients. Because of the clinical characteristics of COVID-19, it can be difficult to differentiate patients with respiratory compromise given that some patients do not present with increased work of breathing and may appear clinically well.[1,2] In fact, in our study population, the resting vital signs of admitted and discharged ED patients were relatively similar. Ambulatory oxygen saturation values differed between these two groups significantly, which is expected, given that our ED clinicians were making admission decisions based on these values.

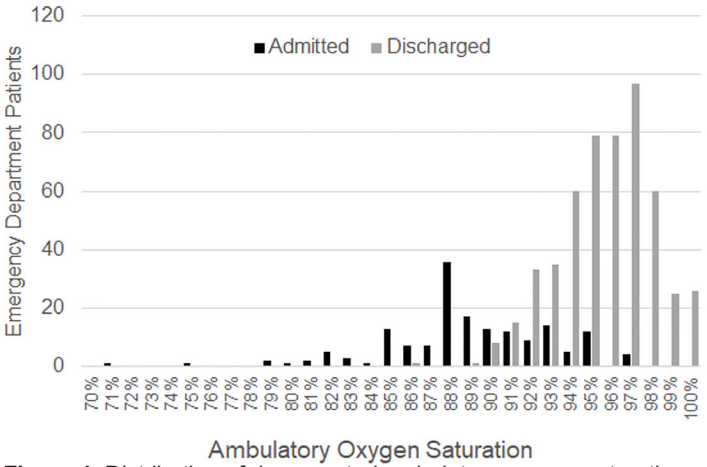


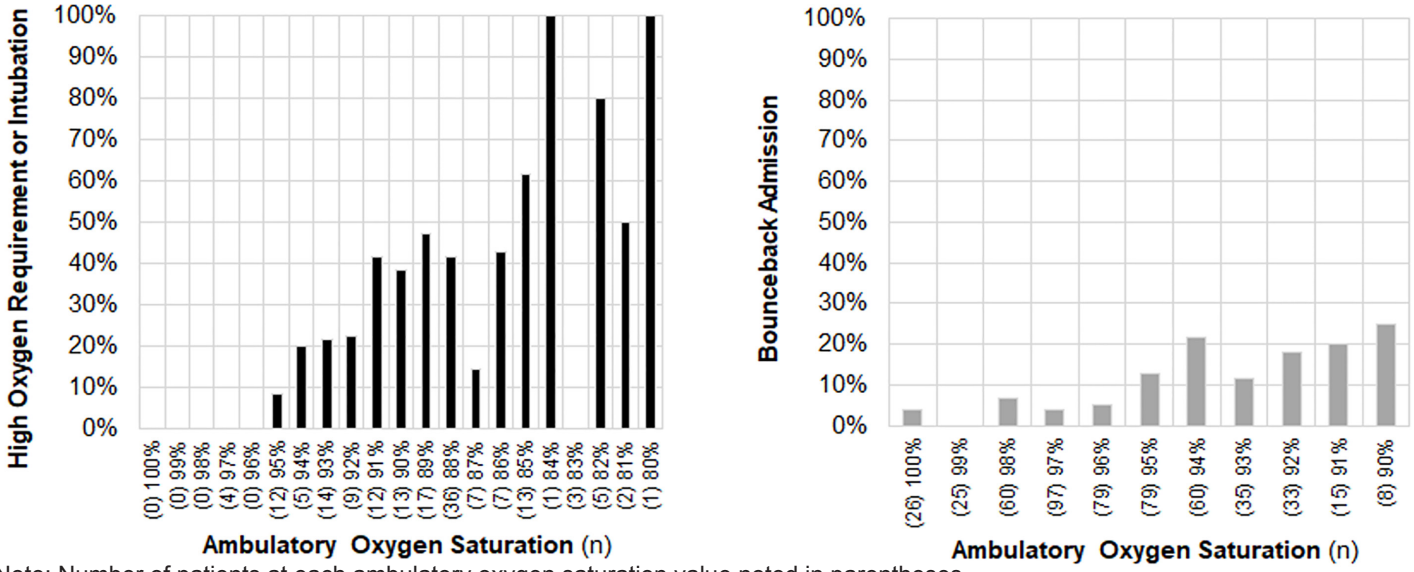
Figure 1. Distribution of documented ambulatory oxygen saturation among admitted and discharged ED Patients

In this study, we found that a lower ambulatory oxygen saturation was strongly associated with a requirement of high oxygen supplementation or mechanical ventilation among admitted ED patients. In our study population, no patient with an ambulatory oxygen saturation of 96% or higher required high oxygen supplementation, and no patient 95% or higher required mechanical ventilation during their hospitalization, although it should be noted that our sample of such patients was not large. The proportion of patients who eventually required these treatments appears to increase consistently below these values, especially around 92% and below, which would be consistent with the transition to the steeper portion of the oxyhemoglobin dissociation curve.

Guidelines from the World Health Organization at the time of this publication recommend hospitalization for suspected COVID-19 patients with an oxygen saturation less than or equal to 93%.[23] This standard applied to only 41% of the patients actually admitted in our study population. This criterion would have had a 55% sensitivity, 68% specificity, 71% NPV, and 51% PPV for high oxygen requirement or mechanical ventilation. In comparison, using only an ambulatory oxygen saturation cutoff of less than or equal to 93%, approximately 87% of the admitted patients would have met this ambulatory oxygen saturation criterion, which would have had a 97% sensitivity, 18% specificity, 90% NPV, and 42% PPV for high oxygen requirement or mechanical ventilation. While there were other factors that determined whether patients in our study population were admitted, it appears that ambulatory oxygen saturation can help identify additional COVID-19 patients who may have poor outcomes and warrant inpatient hospitalization.

Of discharged ED patients with a documented ambulatory oxygen saturation, 9.6% returned to one of our institutions for a subsequent ED visit resulting in hospital admission. Of these patients with a bounceback admission, over 50% required a high level of oxygen or mechanical ventilation. This bounceback admission rate of 9.6% in our study population compares to an overall rate of approximately 1.5% at our institution, which suggests that our study population of patients with a documented ambulatory oxygen saturation was generally a higher risk group even though they did not present critically ill or

Figure 2. Proportion of emergency department (ED) admissions with high oxygen requirements or intubation and proportion of ED discharges with bounceback admission.



Note: Number of patients at each ambulatory oxygen saturation value noted in parentheses.

with an obvious oxygen requirement. It is possible that ED clinicians were more likely to perform an ambulatory oxygen saturation if they thought that the patient was more concerning and wanted additional data to make a disposition decision. Furthermore, we should note that these bounceback admissions were only tracked at our institution and likely underestimate the true bounceback rate, given that patients might have been subsequently admitted to other hospitals.

In this study, we did find that a lower ambulatory oxygen saturation was associated with a higher likelihood of bounceback admission. However, our analysis of the performance of different cutoffs suggests that the ambulatory oxygen saturation would probably not be clinically useful in predicting the future clinical trajectory of patients (eg, only 28% sensitivity and 15% PPV for bounceback admission at an ambulatory oxygen saturation of 93% or less during the first ED visit). In addition, there were discharged ED patients who required high levels of oxygen or mechanical ventilation on a subsequent inpatient hospitalization at a variety of ambulatory oxygen saturation levels at the first ED visit. These findings are likely indicative of the high variability in clinical outcomes among COVID-19 patients and that a single one-time measurement of ambulatory oxygen saturation in isolation will not be able to predict whether a patient will develop worsening respiratory compromise in the days after discharge from the ED. We believe this is an extremely important point for emergency clinicians, given that spikes in respiratory volume during potential future waves of COVID-19 may necessitate simple and quick risk stratification strategies. Ambulatory oxygen saturation, in isolation, does not definitively predict future respiratory compromise given the unpredictable disease course among COVID-19 patients.

We also performed a post-hoc case review of ED patients in our study who had a bounceback admission that resulted in the need for mechanical ventilation. In this analysis, although some patients had a normal ambulatory oxygen saturation, a few of these patients developed some level of tachycardia or tachypnea during ambulation despite maintaining a normal oxygen saturation. In our clinical experience, many of our ED clinicians used these other cues during the measurement of ambulatory oxygen saturation to inform their clinical decision-making. For instance, some patients were admitted if they developed severe tachycardia, exertional lightheadedness, or were otherwise unable to tolerate ambulation during these tests. However, we do not have any data on how well these other factors predict poor outcomes. The reliance on any single number is likely suboptimal compared to its inclusion with a physician's clinical gestalt and other objective findings.

Measurement of ambulatory oxygen saturation has been used in the evaluation of patients in other disease states, including pulmonary fibrosis and radiation pneumonitis.[19,20] There is some suggestion in the literature that exertional hypoxemia is more commonly a feature of restrictive, rather than obstructive, pulmonary pathology.[24-26] Therefore, the disposition decision for COVID-19 patients with chronic obstructive pulmonary disease (COPD) may require a different set of factors or measures. While the pathophysiology of COVID-19 is still unclear, our study demonstrates that ambulatory oxygen saturation may have some prognostic value among COVID-19 patients.[15] Some methodological data regarding risk stratification for COVID-19 patients is

Table 2. Patient outcomes stratified by ambulatory oxygen saturation among admitted and discharged ED patients.

Patient outcome	Admitted on first ED Visit (n = 165)	Bounceback admission (n = 50)
Among all patients		
Low oxygen requirement	103 (62%)	24 (48%)
High oxygen requirement	49 (30%)	19 (38%)
Mechanical ventilation	13 (8%)	7 (14%)
Ambulatory oxygen saturation 98% to 100%		
Low oxygen requirement	0 (0%)	2 (40%)
High oxygen requirement	0 (0%)	2 (40%)
Mechanical ventilation	0 (0%)	1 (20%)
Ambulatory oxygen saturation 95% to 97%		
Low oxygen requirement	15 (94%)	9 (50%)
High oxygen requirement	1 (6%)	6 (33%)
Mechanical ventilation	0 (0%)	3 (17%)
Ambulatory oxygen saturation 93% to 94%		
Low oxygen requirement	15 (79%)	9 (53%)
High oxygen requirement	3 (16%)	7 (41%)
Mechanical ventilation	1 (5%)	1 (6%)
Ambulatory oxygen saturation 90% to 92%		
Low oxygen requirement	22 (65%)	4 (40%)
High oxygen requirement	10 (29%)	4 (40%)
Mechanical ventilation	2 (6%)	2 (20%)
Ambulatory oxygen saturation 89% and below		
Low oxygen requirement	51 (53%)	0 (0%)
High oxygen requirement	35 (37%)	0 (0%)
Mechanical ventilation	10 (10%)	0 (0%)

ED, emergency department.

emerging, but much of it requires additional studies, such as laboratory bloodwork.[27-29] At the height of the pandemic wave in our institution, it would have been nearly impossible to perform this type of risk stratification given the high volume of COVID-19 patients presenting to the ED.

While we provide evidence for the use of ambulatory oxygen saturation among ED patients, we acknowledge that the threshold for admission might depend on a number of factors and may change in different phases of the pandemic depending on the balance between ED patient arrivals and inpatient hospital capacity. Furthermore, among patients who are already hospitalized, the use of ambulatory oxygen saturation to determine when to discharge inpatients may differ from our results given that most of these hospitalized patients have already been through a period of observation in which the patients may have already clinically deteriorated or demonstrated the clinical stability and improvement for a safe inpatient discharge.

Although it might be tempting to apply broad recommendations regarding disposition decisions based on our data, it is important to note that this was a retrospective study, and the characteristics of our hospital system in terms of capacity and patient population may be different from other hospital settings. Hospital guidelines and policies need to consider multiple factors, especially whether there is an ability to send discharged ED patients home with supplemental oxygen and home monitoring or be sent to a lower acuity environment for further observation. Acceptable rates of bounceback admissions and escalation of care are undoubtedly dependent on many factors, particularly in the midst of a pandemic. Therefore, it is probable that some flexibility in the deployment of guidelines on ambulatory oxygen saturation prior to ED disposition would be important as well.

Further research is needed to identify COVID-19 patients who are likely to have poor outcomes with a focus on ED patient populations who appear clinically stable given the difficulty in identifying COVID-19 patients with respiratory compromise. Several research initiatives are trying to develop clinical risk stratification tools, but few focus on the ED and its patient population, even though the ED has been the central point of critical disposition decisions. Abnormal vital signs, patient risk factors, laboratory findings, imaging, and clinical gestalt together inform clinical decision-making. Our study suggests that measuring an ambulatory oxygen saturation can

Table 3. Performance characteristics of a range of ambulatory oxygen saturation cutoffs among admitted and discharged ED patients.

Ambulatory oxygen saturation	Sensitivity	Specificity	Negative predictive value	Positive predictive value
High oxygen requirement or intubation among admitted ED patients				
95% or less	100%	4%	100%	39%
94% or less	98%	15%	94%	41%
93% or less	97%	18%	90%	42%
92% or less	92%	29%	86%	44%
91% or less	89%	36%	84%	45%
90% or less	81%	43%	79%	46%
89% or less	73%	50%	75%	47%
88% or less	60%	59%	71%	47%
87% or less	35%	80%	67%	51%
86% or less	34%	85%	68%	58%
Bounceback admission among discharged ED patients				
99% or less	98%	5%	96%	10%
98% or less	98%	11%	98%	10%
97% or less	90%	23%	95%	11%
96% or less	82%	42%	96%	13%
95% or less	74%	58%	95%	16%
94% or less	54%	73%	94%	18%
93% or less	28%	83%	92%	15%
92% or less	20%	90%	91%	17%
91% or less	8%	96%	91%	16%
90% or less	2%	98%	90%	10%

ED, emergency department.

be another tool to support ED clinicians who may face limited data on which to make clinical decisions during this pandemic, but it will not be able to predict all potential decompensations.

LIMITATIONS

Our study was a retrospective review of patients at a single, large, academic health system during the height of the COVID-19 pandemic. During this period, patients may have been treated in triaged in non-conventional ways. Although our four EDs and three hospitals have different patient populations, our study findings may not be generalizable to ED patient populations at other institutions or areas of the country. Furthermore, there were no standardized protocols in place at our institution for how to use the ambulatory oxygen saturation. Some clinicians may have ambulated their patients for a longer distance or time period and used a different cutoff for disposition decisions, which is reflected in the variation in our study population. In addition, ambulatory oxygen saturation was likely used to risk stratify those who were more ill than the typical well-appearing respiratory patients, which may have introduced a component of selection bias in our cohort of admitted vs discharged patients. The timing of ambulatory oxygen saturation measurement may have been different. Some patients may have been at earlier or later stages of disease, and this may add some uncertainty to the study findings.

Given that our study was retrospective, the use of ambulatory oxygen saturation needs prospective validation. However, this study provides data in a practice environment where front-line healthcare clinicians must make clinical decisions with a paucity of data to support them. Additionally, during this period of peak COVID-19 volume in New York City, hospitals did not have testing capacity to confirm COVID-19 disease in all patients. This allows for the possibility that our outpatient sample may have included other disease processes, such as bacterial pneumonia.

In addition, we do not have data for patients who were subsequently admitted to other hospitals outside our institution; therefore, the rate of bounceback admissions was very likely underestimated. Whereas ambulatory oxygen saturation may identify additional patients who need to be admitted to the hospital, its use alone will definitely not identify all COVID-19 patients who will require a future admission. Statistically, there may have been a non-linear relationship between ambulatory oxygen saturation and our primary outcome, especially given the shape of the oxyhemoglobin dissociation curve. Finally, our retrospective electronic chart abstraction was limited by our

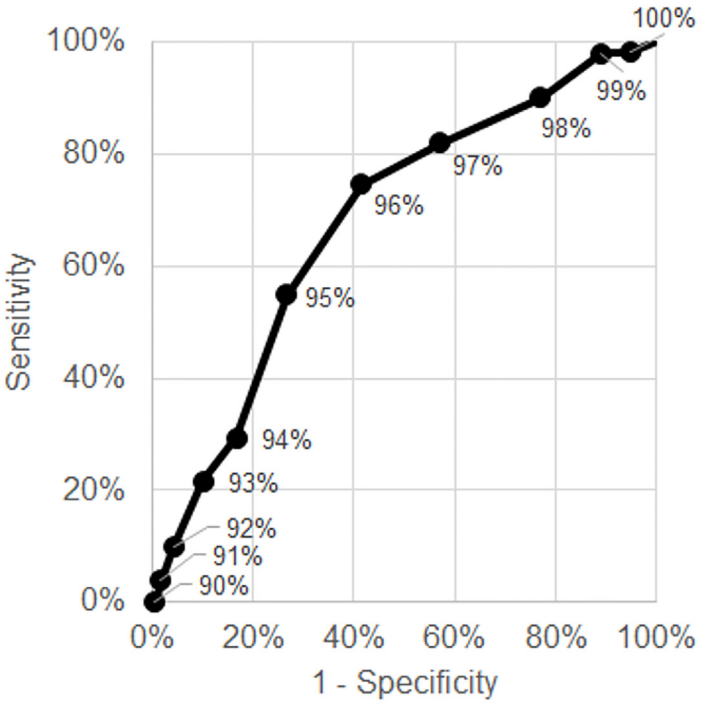


Figure 3. Receiver operating characteristics curve for bounceback admission among discharged emergency department patients.

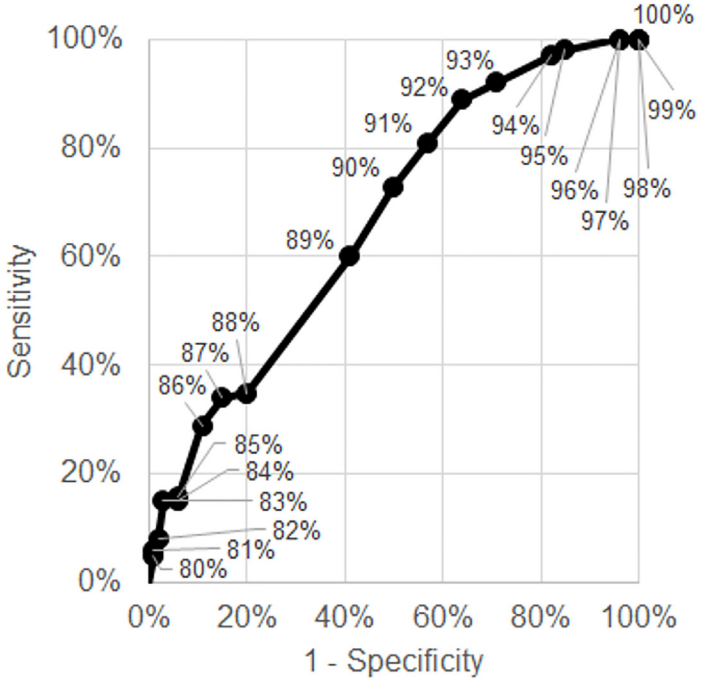


Figure 4. Receiver operating characteristics curve for high oxygen requirement or intubation among admitted emergency department patients.

search parameters, so charts that included ambulatory oxygen saturation with other unique abbreviations, or an ambulatory saturation documented by other ED staff, may have been missed.

CONCLUSION

Measuring ambulatory oxygen saturation can help ED clinicians identify patients who may require high levels of oxygen or mechanical ventilation during admission. However, it less useful for identifying which patients may deteriorate clinically in the days after ED discharge and require subsequent hospitalization.

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Underutilization of the Emergency Department During the COVID-19 Pandemic

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Introduction: The novel coronavirus 2019 (COVID-19) pandemic in the United States (US) prompted widespread containment measures such as shelter-in-place (SIP) orders. The goal of our study was to determine whether there was a significant change in overall volume and proportion of emergency department (ED) encounters since SIP measures began.

Methods: This was a retrospective, observational, cross-sectional study using billing data from January 1, 2017–April 20, 2020. We received data from 141 EDs across 16 states, encompassing a convenience sample of 26,223,438 ED encounters. We used a generalized least squares regression approach to ascertain changes for overall ED encounters, hospital admissions, and New York University ED visit algorithm categories.

Results: ED encounters decreased significantly in the post-SIP period. Overall, there was a 39.6% decrease in ED encounters compared to expected volume in the pre-SIP period. Emergent encounters decreased by 35.8%, while non-emergent encounters decreased by 52.1%. Psychiatric encounters decreased by 30.2%. Encounters related to drugs and alcohol decreased the least, by 9.3% and 27.5%, respectively.

Conclusion: There was a significant overall reduction in ED utilization in the post-SIP period. There was a greater reduction in lower acuity encounters than higher acuity encounters. Of all subtypes of ED encounters, substance abuse- and alcohol-related encounters reduced the least, and injury-related encounters reduced the most. [West J Emerg Med. 2020;21(6)15-23.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) is an ongoing global crisis with far-reaching social consequences. First reported in Wuhan, China, in December 2019, COVID-19 quickly spread across that country, despite a government-man-

dated lockdown of Wuhan on January 23, 2020.[1-4] By the time the World Health Organization (WHO) officially recognized the pandemic status of COVID-19 on March 11, 2020, there were over 118,000 confirmed cases globally and over 4,200 deaths.[5] As of July 27, 2020, there were more than 4.2 million cases in the United States (US), with 146,546 related deaths.[6]

The large-scale social impact of COVID-19 has not been seen since the influenza pandemic of 1918 when non-pharmaceutical interventions – banning large public gatherings, school closures, and voluntary quarantine of diseased households – were most notably implemented on a large scale to decrease disease transmission.[7-8] The disproportionally high mortality rate due to COVID-19 in Spain and Italy is partly attributed to those countries' healthcare systems becoming quickly overwhelmed by the volume of critical patients. Specifically, these countries experienced severe shortages of intensive care unit beds and ventilators.[9-13] The impact of the virus was projected to also overwhelm the US healthcare system, which resulted in widespread implementation of shelter-in-place (SIP) restrictions.[14] As early as March 19, 2020, state governments within the US began issuing SIP directives with the goal to "flatten the curve," a term used by the Centers for Disease Control and Prevention (CDC) referring to strategies to slow the rate of disease progression to avoid overwhelming the healthcare system.[15-16]

Since the implementation of SIP directives, there have been reports of a significant drop in emergency department (ED) volumes by 40-50%.[17] News media have reported alarming reductions in ED visits related to acute coronary syndrome and cerebral vascular accidents.[17-20] Recent studies have corroborated these reports from the media regarding reductions in non-COVID-19 related ED visits.[21-25] Similar findings in Europe and China have also been reported, with the hypothesis that fear of coming to the hospital may be preventing patients from seeking care, especially those experiencing less severe symptoms.[26-29] A recent poll from the American College of Emergency Physicians (ACEP) aligns with these suspicions, reporting that nearly a third of American adults have deferred medical care to avoid contracting COVID-19.[30] A high proportion of those polled (73%) were concerned about burdening the healthcare system or not receiving adequate care during pandemic conditions.[31] This may be contributing to "excess deaths without COVID-19," which the CDC defines as the rise in non-COVID-19 related deaths beyond what would be expected.[32] In fact, a recent, single-center US study showed that 0% of stroke patients who arrived to the ED following SIP orders were within the window for tissue plasminogen activator, which is much lower than the national average of 3.71%.[33,34] Consequently, ACEP is urging providers to reach out to the public to avoid further delays in care.[35]

To date, there is limited literature assessing the impact of the current COVID-19 pandemic on ED volumes across various encounter types in the US. An accurate assessment of the collateral effects beyond COVID-19 infection is crucial to guiding current and future public health management. We sought to determine whether there was a significant change in overall volume and proportion of various types of encounters in the ED since COVID-19 containment measures began. This study was an epidemiological analysis using retrospective billing data across 141 EDs comparing numbers before and after the first SIP orders in the US on March 16, 2020.[36] We subdivided ED encounters into four categories (non-emergent; emergent-primary care treatable; emergent-preventable; and emergent). Our analysis also included a separate categorization of mental health, alcohol, substance abuse, and acute injury-related encounters, in hopes of shedding light on possible behavior-driven emergencies during pandemic circumstances.

Population Health Research Capsule

What do we already know about this issue?
The coronavirus disease 2019 (COVID-19) pandemic resulted in widespread social distancing measures, leading to concern for decreased emergency department (ED) visits.

What was the research question?
Was there a change in overall volume and proportion of various types of ED visits following shelter-in-place (SIP) orders?

What was the major finding of the study?
Total ED volumes decreased, with the greatest reduction in low acuity visits and the least in drug- and alcohol-related visits.

How does this improve population health?
This study shows the link between SIP orders and ED use during the initial weeks of the COVID-19 pandemic.

METHODS

Study Design and Data Source

This study was approved by the Arrowhead Regional Medical Center Institutional Review Board. Using a retrospective, observational, cross-sectional design, we analyzed ED log and billing data associated with a physician services billing company. Select demographic information provided by hospital medical record data was used to supplement the ED log data, in addition to coded billing data on primary diagnoses and procedures. Each patient billing record could hold up to four diagnosis codes and four procedure codes. Charges encompassed the physician services billing portion of the patient ED encounter, not the hospital billing charges. Dates where SIP orders were

instituted make up the pre- and post- SIP periods (see Appendix A).[15] For the purposes of this study, pre- and post-SIP periods were determined by state-specific dates in the state in which the hospital was located.

The study data set consisted of billing data from January 1, 2017–April 20, 2020, which encompassed 26,223,438 encounters across 141 EDs in 16 states within the US. Hospitals represented seven of the 10 Centers for Medicare and Medicaid Services (CMS) regions. Because the study data set is at the encounter level, patients could be represented multiple times within the data set if they returned to the ED for care. Patient characteristics, such as gender, age, hospital disposition, type of provider seen during encounter (physician or advanced practice provider), and Emergency Severity Index (ESI) level for the encounter are presented in Table 1. The ESI is a five-level ED triage algorithm that provides clinical stratification on the basis of acuity and resource needs, with level one being the most urgent and level five the least urgent.

Table 2 shows hospital characteristics of the 141 EDs included in the analysis. Hospital characteristics, including state, ownership, urban/rural, and teaching status, were taken from the 2018 American Hospital Association Annual Survey. Hospital characteristics were null if survey data was not submitted. Hospital ownership typology was standardized from 14 to nine categories for ease of computations (see Appendix B). Hospitals were allowed to self-select the subcategory type of organization (eg, non-federal government; non-government, not-for-profit; investor-owned, for-profit; federal government) that best described their hospital's policies and operations.

Categorization of emergent and non-emergent ED encounters was done using the New York University (NYU) ED visit algorithm (EDA).[37-39] Per the NYU EDA methodology, we used the diagnosis weights to calculate the number of emergent, emergent-preventable, emergent-primary care treatable, and non-emergent encounters per day per site,

Table 1. Emergency department encounter distribution before and after shelter-in-place orders by patient characteristics.

	Pre-SIP encounters (n)	Pre-SIP encounters (%)	Post-SIP encounters (n)	Post-SIP encounters (%)
Gender				
Female	14,091,085	54.4	172,307	50.8
Male	11,793,299	45.6	166,747	49.9
Disposition				
Admit	4,455,299	17.2	68,775	20.3
Discharge	20,629,288	79.7	259,090	76.4
Transfer	799,797	3.1	11,189	3.3
ESI Level*				
1	159,801	0.8	2,822	1.2
2	2,697,452	14.0	38,238	16.0
3	10,164,404	52.7	129,558	54.2
4	5,614,369	29.1	60,251	25.2
5	658,951	3.4	8,131	3.4
Provider type				
Physician	18,639,401	72.0	250,972	74.0
Advanced practice provider	7,227,121	27.9	87,865	25.9
Age Group				
Age < 1	485,097	1.9	3,291	1.0
1 ≤ Age < 18	3,697,234	14.3	25,103	7.4
18 ≤ Age < 35	5,793,875	22.4	77,276	22.8
35 ≤ Age <65	6,357,256	24.5	89,196	26.3
Age > 65	9,548,938	36.9	144,113	42.5
Total	25,884,384	98.7	339,054	1.3

*ESI level is coded from 1 to 5, where 1 represents most urgent and 5 represents least urgent.
Note: Within each characteristic, total percentages may not sum up to 100 due to null values. All differences in pre- and post-SIP categories significant at p<.001 due to high sample size.
SIP, shelter in place; *ESI,* Emergency Severity Index.

Table 2. Encounter distribution by hospital characteristics.

	Pre-SIP encounters (n)	Pre-SIP encounters (%)	Post-SIP encounters (n)	Post-SIP encounters (%)
CMS region - regional office				
Region 3 - Philadelphia	709,649	2.7	5,866	1.7
Region 4 - Atlanta	425,961	1.7	2,772	0.8
Region 5 - Chicago	2,590,841	10.0	41,731	12.3
Region 6 - Dallas	1,577	0.0	396	0.1
Region 7 - Kansas City	705,385	2.7	4,459	1.3
Region 9 - San Francisco	19,874,290	76.8	263,555	77.7
Region 10- Seattle	1,576,681	6.1	20,275	6.0
AHA teaching status				
Major (2)	556,472	2.2	6,078	1.9
Minor (31)	12,714,363	49.1	170,158	50.2
Non-teaching (51)	4,900,455	18.9	68,991	20.4
AHA location				
Rural (4)	281,445	1.1	4,452	1.3
Urban (88)	17,889,845	69.1	240,775	71.0
Ownership				
Non-profit (42)	8,777,429	33.9	118,962	35.1
For-profit (12)	2,247,155	8.7	30,213	8.9
Religious (26)	4,044,370	15.6	53,300	15.7
Hospital district (6)	1,277,315	4.9	18,655	5.5
County (6)	1,825,021	7.1	24,097	7.1
Total (141)	25,884,384	98.7	339,054	1.3

*Within each characteristic, total percentages may not sum up to 100 due to null values. All differences in pre- and post-SIP categories significant at p<.001 due to high sample size.
SIP, shelter in place; *AHA,* American Hospital Association.

in addition to the "alcohol," "drug," "injury," "psychiatric," and "unclassified" diagnostic categories.

The NYU EDA sets specific criteria for each category of ED encounter regarding how emergent the encounter is. **Emergent** care represents care for an acute condition where ED care was required. **Emergent-preventable** care represents care where ED care was required for an acute exacerbation but could have been treated or prevented with ready access to primary care. **Emergent-primary care treatable** is care that should be administered within 12 hours of presentation, but care could have been safely and effectively delivered within a primary care setting. **Non-emergent** care represents an encounter where care was not needed for at least 12 hours. For the NYU EDA diagnostic categories, **Alcohol** represents care for alcohol intoxication-related care. **Substance Abuse** represents care for non-alcohol substance use (eg, opioid, cannabis, sedatives) intoxication or complications. **Injury** represents care for trauma, such as accidents and lacerations. **Mental Health** represents care for various psychiatric disorders (eg, schizophrenia, bipolar, major depressive, and intentional self-harm). **Unclassified** represents care for diagnoses that could not otherwise be categorized per above.

We used hospital discharge dispositions from billing data to ascertain admission status. ED encounters with admit or transfer discharge disposition were counted as a hospital admission. Hospital admission was limited to patients who presented through the ED and did not include directly admitted patients.

Data Analysis

Descriptive statistics of patient and hospital characteristics are presented in Table 1 and Table 2, respectively. Percentages represent the proportion of ED encounters that fell within each respective pre-SIP or post-SIP category. Using a random effects generalized least squares (GLS) modeling approach, we ran regression analyses using Stata, version 16.1 (StataCorp, College Station, TX). A GLS approach was used to control for correlations in utilization patterns within hospitals and across time, ie, seasonality. In addition, to correct for known utilization patterns in ED encounters, we averaged encounters by site per month and per day of

week to create an "expected" number of encounters. The dependent variable was then calculated as percent variance from the expected encounter volume per site, calculated as [(Observed – Expected) / Expected]. The GLS regression included the intercept and coefficient for SIP. In the GLS results, we interpreted positive coefficients as the percent increase compared to pre-SIP expected levels, whereas we interpreted negative coefficients as the percent decrease compared to pre-SIP expected levels (Table 3).

RESULTS

Characteristics of Study Subjects

The data shows that there was a shift in the types of patients who used the ED in the pre- and post-SIP periods. Women and patients in the 35-64 and 65+ age groups made up the majority of patient encounters overall. The percentage of pediatric encounters (birth–18 years old) decreased from 16.2% to 8.4% in the post-SIP period. The distribution of patients across ESI levels demonstrated a bell-shaped distribution both pre- and post-SIP periods, where the majority of cases had ESI levels between 2-4. However, ED encounters with ESI levels 1-3 were proportionally higher in the post-SIP period. There was an increase in the proportion of patients who had an admit or transfer disposition following an initial ED encounter in the post-SIP period, 23.6%, vs 20.3% in the pre-SIP period.

Of the seven CMS regions represented in our study data, the largest proportion of ED encounters came from Region 9 (San Francisco) with 76.8% of total patient encounters for the study period. The majority of patient encounters occurred in hospitals that were minor teaching (49.1%) or non-teaching (19.0%) hospitals in urban locations. Hospitals that were non-profit, either religious-affiliated (15.6%) or other non-profit (33.9%), represented the plurality of patient encounters with the remaining encounters spread relatively evenly across county (7.1%), for-profit (8.7%), and hospital district (4.9%) hospitals. The remaining 29.8% of patient encounters occurred in hospitals that did not report hospital organization type.

ED Encounters and Shelter-in-Place

There was a significant reduction in the number of ED encounters in the post-SIP period. Overall, there was a 39.6% decrease (95% confidence interval (CI). -40.8%, -38.5%) in all ED encounters compared to what would have been expected in the study period. The greatest decrease was seen in the non-emergent encounters (-52.1%), followed by emergent-primary care treatable encounters (-47.5%), emergent-preventable encounters (-43.0%), and then emergent encounters (-35.8%) (Table 3, Figure 1). Hospital admissions saw an overall decrease of 37.4% (95% CI, -38.4%, -36.5%) compared to pre-SIP period. The group of diagnoses that saw the biggest decrease in the post-SIP period was injury with a 56.1% decrease compared to the pre-SIP period (Figure 2). Encounters for substance abuse and alcohol-related treatment saw the smallest reduction, at 9.3% and 27.5%, respectively (Figure 2).

DISCUSSION

Our analysis demonstrates that, after SIP orders were implemented, there was a 39.6% reduction in overall ED utilization. There are several, well-publicized theories as to why such a pronounced drop in volume occurred. One reason might be a true reduction in disease burden, especially a decline in traumatic injuries, due to the SIP order. However, other factors certainly contributed. An April 2020 ACEP poll suggested that public fear of potentially contracting COVID-19 from a hospital visit deterred patients from visiting EDs for conditions that they would have sought ED treatment under non-pandemic circumstances.[30] Additionally, the public health campaign to discourage "over-burdening the healthcare system" may have also contributed to the overall decrease in the frequency of ED visits.[31]

The proportion of patients admitted or transferred from the ED was higher post-SIP (23.6%) compared to pre-SIP

Table 3. Regression results.

Dependent variable	% Change compared to pre-SIP	Standard error (SE)	95% confidence interval (CI)
All encounters	-39.6	0.006	-40.8, -38.5
Admission encounters	-37.4	0.005	-38.4, -36.5
Emergent	-35.8	0.005	-36.9, -34.6
Emergent-preventable	-43.0	0.005	-43.9, -42.0
Emergent-primary care treatable	-47.5	0.003	-48.1, -46.9
Non-emergent encounters	-52.1	0.004	-52.8, -51.4
Alcohol	-27.5	0.017	-30.4, -24.6
Substance abuse	-9.3	0.020	-13.2, -5.4
Injury	-56.1	0.004	-56.9, -55.2
Psychiatric	-30.2	0.011	-32.3, -28.1
Unclassified	-31.4	0.005	-32.4, -30.5

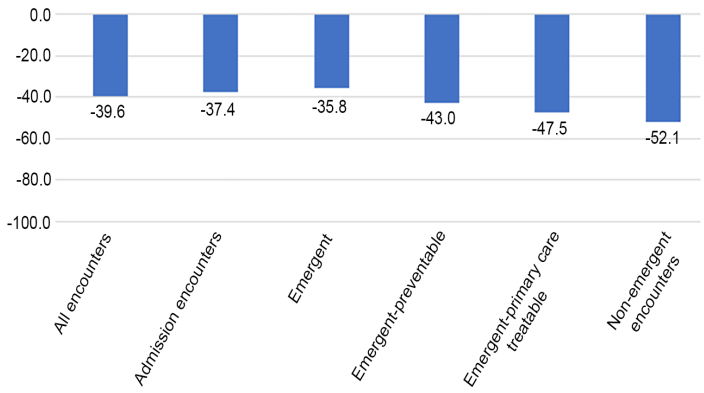

Figure 1. Percent change from pre-shelter in place.

(20.3%). Additionally, there was an increase in the proportion of patients with higher acuity ESI levels presenting to the ED post-SIP. The proportion of ESI levels 1, 2, and 3 increased with respect to ESI levels 4 and 5 post-SIP. This would suggest that the patients presenting to the ED post-SIP generally had self-selected for more serious conditions as compared to pre-SIP, and more of the "missing" visits were associated with lower acuity complaints.

There were also differences in regard to the age of patients presenting to the ED before and after the SIP. The proportion of pediatric patients (birth–18 years old) presenting to the ED declined from 16.2% pre-SIP to 8.4% post-SIP. Conversely, the proportion of older patients (>35 years old) presenting to the ED increased from 61.5 % pre-SIP to 68.8% post-SIP. It would be difficult to determine exactly why such trends were noted. One possibility is that a parent's weighing of the risk exposure to COVID-19 in the ED vs the benefit of being evaluated, as it relates to the decision to bring their child to the ED, is different than that of an independent adult deciding on their own care. Also, despite recent literature suggesting a potential rise in non-accidental trauma due to increased stressors at home during the pandemic, non-accidental trauma remains difficult to identify and often is under-reported.[40] Another possibility is that older patients tend to present more often with higher acuity medical conditions, who may be less likely to forego ED visits.[41-42]

Our study found that all categories of ED encounters set forth by the NYU EDA experienced a significant reduction post-SIP compared to pre-SIP. The reduction seen in the most emergent group (emergent-ED care needed-not preventable) was smaller when compared to all other categories. Furthermore, we found that as the acuity levels increased, there was less of a reduction of ED utilization in the post-SIP period. Despite this, the observation of a 35.8% drop in emergent encounters is a concerning finding. The long-term consequences of this large drop in emergent ED encounters is difficult to quantify, but clearly could have the potential to be far-reaching. This significant reduction in volume indicates that the most emergent patients are foregoing necessary treatments, raising concerns for an increase in overall morbidity and mortality.[32-34]

Interestingly, ED encounters related to substance and alcohol abuse experienced the lowest reduction in the post-SIP period. For example, substance abuse-related ED encounters dropped by only 9.3% in the post-SIP period, while alcohol-related encounters dropped by 27.5%. This effect may be explained by the previously well-documented relationship between large-scale disasters and increased drug and alcohol abuse. Studies that looked at previous large-scale disasters such as Hurricane Katrina, the 2004 Southeast Asia tsunami, and the 2001 September 11 attacks, all reported an increase in either drug or alcohol abuse.[43-45] This raises the question as to whether we will see an increase in ED encounters related to drug and alcohol abuse as the COVID-19 pandemic continues to unfold.

Similarly, the 30.2% decline in visits with psychiatric diagnoses was smaller than the decline in emergent (-35.8%) and non-emergent (-52.1%) visits. Several studies suggest that depressive disorders and post-traumatic stress disorder have increased as a result of COVID-19.[46-47] Perhaps any decline in baseline psychiatric visits was mitigated by an upward trend in mental health issues provoked by pandemic.

On the contrary, injury-related ED encounters experienced the greatest reduction (-56.1%) between pre- and post-SIP. We suspect this may in part be explained by the fact that injury is heavily dependent on individual behavior, and that behaviors promoted by pandemic measures have made people more cautious and less prone to experiencing injury. There may have been fewer motor vehicle accidents because people generally drove less due to SIP measures. Similarly, there may have been fewer work-related injuries due to more people working from home.[48] Traffic and community activity reports in the US show a correlation with a drop of 48% in personal traffic and transit stations compared to baseline.[49] A recent study in New Hampshire supports these findings, reporting a 57% decrease in trauma admissions and 80% decrease in motor vehicle accidents.[50] Another possible explanation is that cancellations of high-risk sports may have contributed to a reduction in blunt trauma.[51] Other studies postulated that reductions in orthopedic trauma may also be partly due to social distancing measures limiting social interactions.[52-53] We suspect that reductions in injury-related ED encounters is likely a multifactorial phenomenon.

While the focus of this and several other recent studies has been on the alarming reduction of emergent cases presenting at hospitals during the post-SIP period, the other side of the coin is a reduction in non-emergent and emergent-primary care treatable encounters that are best treated outside of high-cost hospital EDs. It is likely that a large proportion of patients who would have presented to the ED as non-emergent and emergent-primary care treatable encounters chose to forego care entirely. Another research question is to what extent did those patients choose to receive care in non-acute settings, such as urgent care or primary care clinics.

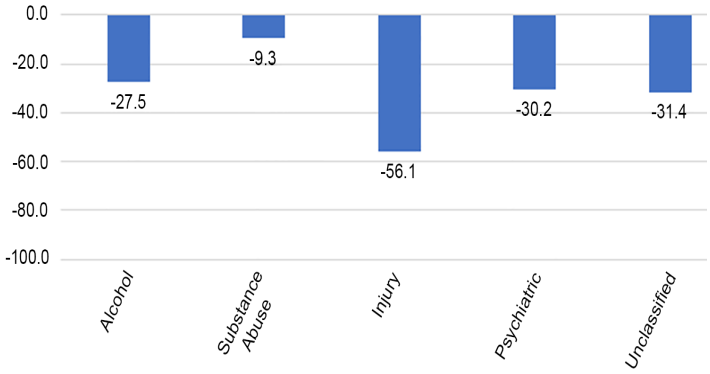

Figure 2. Percent change from pre-shelter in place.

While the study results have high external validity given the breadth of patient encounter data from 16 different states in the US, wider generalizability to international health systems may be limited by the particular insurance-based/fee-for-service payment system that is characteristic of the US healthcare system. Furthermore, the study data had a large proportion of encounters from the CMS Region 9, which may impact generalizability to other regions of the US.

There are several follow-up research questions that could be asked from these findings. Future studies could investigate whether inadequate access to primary care offices due to SIP-related closures affected ED utilization. Findings would have far-reaching implications on primary care preparations in anticipation of a possible "second wave" of SIP closures or future pandemic planning. Another interesting topic to explore is whether rates of substance and alcohol abuse, and any complications thereof, will increase as the COVID-19 pandemic unfolds. A future study might explore whether ED utilization was absorbed by telehealth encounters, and to what extent. Future survey studies could explore perceptions of ED care during the post-SIP period and whether there were substantial changes in behaviors, such as engagement in hazardous activities, to reduce exposure to injury and hospitalization. Additionally, the long-term impact of the pandemic on the public's utilization of the ED for low-acuity visits should be assessed. Lastly, another important topic to explore is whether the delays in care due to not presenting to the ED correlated with an increase in morbidity and/or mortality, not directly related to COVID-19.

CONCLUSION

There was a 39.6% reduction in all ED encounters in the post-SIP period across all ED sites. The largest proportional reduction in ED encounters came from preventable and non-emergent ED encounters that could most likely have been treated at primary care offices. However, the large reduction in emergent ED encounters may potentially have delayed treatment and increased mortality seen outside of the ED. Of the five diagnostic categories in the NYU ED algorithm, injury-related ED encounters had the greatest reduction (-56.1%). This is may be a result of less motor vehicle travel and fewer hazardous work activities that contributed to the prevention of injuries. Substance and alcohol abuse-related encounters had the lowest reduction in the post-SIP period (-9.3% and –27.5%, respectively), describing the relatively unchanging nature of these disorders in needing emergent interventions, or possibly related to increased substance use associated with the pandemic.

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Point-of-care Lung Ultrasound Is Useful to Evaluate Emergency Department Patients for COVID-19

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Introduction: Coronavirus disease 2019 (COVID-19) can be a life-threatening lung disease or a trivial upper respiratory infection depending on whether the alveoli are involved. Emergency department (ED) evaluation of symptomatic patients with normal vital signs is frequently limited to chest auscultation and oro-nasopharyngeal swabs. We tested the null hypothesis that patients being screened for COVID-19 in the ED with normal vital signs and without hypoxia would have a point-of-care lung ultrasound (LUS) consistent with COVID-19 less than 2% of the time.

Methods: We performed a retrospective, structured, blinded ultrasound review and chart review in patients 14 years or older with symptoms prompting ED evaluation for COVID-19. We excluded those with known congestive heart failure or other chronic lung conditions likely to cause excessive B-lines on LUS. We used a two-sided exact hypothesis test for binomial random variables. We measured LUS diagnostic performance using computed tomography as the gold standard.

Results: We reviewed 77 charts; 49 met inclusion criteria. Vital signs were normal in 30/49 patients; 10 (33%) of these patients had LUS consistent with viral pneumonitis. We rejected the null hypothesis (p-value <0.001). The treating physicians' interpretations of their own point-of-care LUS had a sensitivity of 100% (95% confidence interval (CI), 74%, 100%), specificity 88% (95% CI, 47%, 100%), likelihood ratio (LR) positive of 5.8 (95% CI, 1.3, 25), and LR negative of 0.05 (95% CI, 0.03, 0.71) when compared to CT findings.

Conclusion: LUS had a meaningful detection rate for pneumonitis in symptomatic ED patients with normal vital signs who were being evaluated for COVID-19. We recommend at least LUS be used in addition to polymerase chain reaction testing when evaluating symptomatic ED patients for COVID-19. [West J Emerg Med. 2020;21(6)24-31.]

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) causes a variety of respiratory symptoms ranging from pharyngitis or rhinitis, through bronchitis to multifocal peripheral pneumonitis extending to the alveoli.[1-3] Two clinically important characteristics of SARS-CoV-2 infection are that auscultatory findings may be subtle or normal even in the presence of advanced lower airway disease, and chest radiographs (CXR) are inadequate for diagnosis.[4] In common with other coronaviruses and influenza, SARS-CoV-2 is likely spread by both the droplet and airborne routes.[5-7] When aerosolized, the resulting respirable particles less than 10 microns (μ) in aerodynamic diameter contain viable virus and can reach adult alveoli directly.[8] Smaller aerosols (5μ) reach the alveoli without also being deposited in the bronchi.[8] This can lead to a clinical picture where a patient has serious lower respiratory tract infection with little or no concomitant upper respiratory tract infection.[6] Consequently, respiratory tract coronavirus disease 2019 (COVID-19) must

be thought of as two separate entities. The first is upper airway disease, which generally poses little risk to the individual patient but places those around them at risk of infection. The second is lower airway disease where the patient is potentially at grave risk but who may shed little or no virus for much of his or her illness. These entities may coexist, but because transmission can occur by either the droplet or airborne routes, they may not. Nasopharyngeal swabs, even if correctly collected, can therefore fail to detect SARS-CoV-2 and provide false reassurance despite ongoing alveolar destruction.

Testing for SARS-CoV-2, therefore, frequently but not always includes both viral swabs from the oro-nasopharynx and imaging of the lower respiratory tract. This has included CXR, computed tomography (CT) imaging, and sometimes point-of-care lung ultrasound (LUS). Chest CT in the presence of lower respiratory tract involvement has a characteristic appearance and has been shown to be useful for diagnosing patients with COVID-19 pneumonia, including in the presence of negative nucleic acid testing. Some experienced centers even advocate CT imaging as a primary testing modality. However, CT imaging is slow, exposes the patient to ionizing radiation, and exposes additional staff to SARS-CoV-2.[4,9]

Point-of-care LUS can detect SARS-CoV-2-induced lung disease, is readily available in most emergency departments (ED), does not expose the patient to ionizing radiation, and does not require the staff, expertise, and time necessary for traditional CT imaging.[10] Nonetheless, point-of-care LUS does add to the duration of patient evaluation, increases the treating physicians' exposure to SARS-CoV-2, and decreases the number of patients seen hourly by that physician. This raises the question as to whether lung imaging could be deferred if the patient being evaluated for SARS-CoV-2 has normal vital signs. Conversely, if the presence of normal vital signs does not preclude ultrasound evidence of lung disease then some current practices of swab-only testing must be considered inadequate. Patents with lung involvement have been shown to be at risk for subsequent, sometimes rapid, deterioration.[9] Patients are often not aware of this deterioration and attendant hypoxia. Consequently, such patients require at least home pulse oximetry.

Our null hypothesis was that among symptomatic patients being screened for COVID-19 in the emergency department (ED) that the LUS would be consistent with COVID-19 less than 2% of the time if vital signs were normal. We also measured the diagnostic performance of LUS compared with CXR and CT chest. For comparative purposes we also measured the diagnostic performance of CXR and crackles or rales on auscultation with CT chest.

Population Health Research Capsule

What do we already know about this issue?
Auscultation and chest radiograph mostly fail to detect lung involvement in coronavirus disease 2019 (COVID-19).

What was the research question?
Do normal vital signs mean lung imaging is unnecessary when evaluating patients for COVID-19 in the ED?

What was the major finding of the study?
In symptomatic patients with normal vital signs 33% had lung ultrasound (LUS) evidence of alveolar involvement.

How does this improve population health?
Point-of-care LUS can aid in risk stratifying symptomatic ED patients in whom COVID-19 is suspected.

METHODS

Ethical approval

The institutional review and privacy boards for Sutter Health approved this study and granted a waiver of informed consent (approval number 1597263).

Study Design

This was a cross-sectional study with structured chart and ultrasound imaging review.

Subjects

Subjects were a consecutive sample of patients, 14 years of age and older, who received LUS and were evaluated for COVID-19 in an adult ED and a pediatric ED between March 4, 2020–May 19, 2020. We identified subjects from the imaging archive of the ED ultrasound machine. Patients had LUS performed if the treating physician was facile in point-of care LUS, presumably believed that lung imaging should form part of the COVID-19 evaluation, and did not send the patient for immediate CT of the chest.

Ultrasound Imaging Protocol

The physicians performing the LUS typically imaged the posterior acoustic windows by running the ultrasound probe down the patient's back midway between the scapula and vertebral column. Axillary and anterior windows were typically interrogated with single views of each. Physicians sometimes chose to not interrogate all possible windows if they had already reached their diagnosis on the windows already imaged. Images were captured with a Zonare Z One ULTRA portable ultrasound machine (Zonare Medical Systems, Mountain View, CA). The probes available for use were linear 10-5 megahertz (MHz), linear 4-1 MHz, and

curvilinear 9-3 MHz. For our primary analysis we used the interpretation of the LUS as documented in the chart.

We also performed a second interpretation of the stored ultrasound images blinded to any clinical information and the original bedside interpretation. For this interpretation of the ultrasound images we considered the following findings to be consistent with viral pneumonitis: more than three simultaneous long coalescent B-lines per intercostal space occurring in more than one intercostal space; moth-eaten or irregular pleura in two or more interspaces or in one interspace with adjacent pleura showing excessive short B lines (comet tails). We considered A-lines, isolated short B-lines (comet tails) without adjacent moth-eaten pleura, and Z-lines (defined here as horizontal reverberation lines at a higher frequency than A lines) to be normal. Focal consolidations or effusions were taken as evidence against viral pneumonitis.

Inclusion Criteria

We included subjects if they met the following criteria: they were 14 years of age or older; they had had ultrasound images archived with adequate identifiers; and they were being evaluated for SARS-CoV-2 infection causing a COVID-19 illness.

Exclusion Criteria

Patients were excluded for a prior medical history of congestive heart failure, based on chart review, or other chronic lung disease likely to affect LUS interpretation (ie, disease likely to cause B lines or pleural thickening) and if the point-of-care LUS was performed for a reason other than evaluating for COVID-19. We did not exclude patients with a history of asthma or chronic obstructive pulmonary disease. Patients were also excluded if we could not pair the written record of their ED visit with the ultrasound images. This happened when ultrasound images were saved without identifiers.

Study Definitions

We defined "symptomatic" as the documentation of any of the following in the electronic health record (EHR): cough; subjective fever; fatigue; weakness; sore throat or shortness of breath; nausea or vomiting; diarrhea; sore throat; fatigue; or headache. We defined "abnormal" vital signs as pulse or respiratory rate at or above the 98th percentile for age for children.[11] For adults, tachycardia was defined as pulse at or above 100 beats per minute, tachypnea as respiratory rate above 22 breaths per minute, fever as temperature as ≥38° Celsius, and hypotension as systolic blood pressure at or below 80 millimeters of mercury (mm Hg).[12] We did not have an upper limit for blood pressure. We included oxygen saturation measured by pulse oximetry as a vital sign and defined hypoxia as oxygen saturation of less than 92%.

We accepted the interpretation of the ultrasound by the performing physician as consistent with COVID-19 or viral pneumonitis for our primary analysis. On three occasions when the performing physician did not document an interpretation we substituted the blinded reading.

Data Abstraction

One investigator (PW) performed a blinded reading of all LUS images using a structured template prior to performing chart review. Another (AH) extracted data from the EPIC/Clarity EHR (Verona, WI) using SQL Server Management Studio (Microsoft Corporation, Redmond, WA). Vital signs for each visit and polymerase chain reaction (PCR) results of swabs were extracted from their respective fields in the EHR. Only the first set of vital signs was retained. Vital signs and lab results were directly extracted from the EHR. The full text of the ED visit was downloaded into a text file. EPIC EHR periodically automatically saves even incomplete notes as they are entered. The time of each (even incomplete) note is recorded. This allowed us to ensure the ultrasound note was entered before the CT resulted.

The ultrasound note was typically entered either in free form or using personalized, physician-created templates. These were in various locations in the chart. Some were typed into distinct, stand-alone progress notes and others were included in the main chart, while still others were included in progress notes that included another patient's information. We used a simplified sentiment analysis (sentimentr) in R (R Foundation for Statistical Computing, Vienna, Austria) to locate the bedside ultrasound report in the chart.[13] This created an HTML page highlighting text that sentiment analysis considered to be an ultrasound report. In three cases a bedside ultrasound report could not be found using either this semi-automated technique or a manual chart review, and we substituted the blinded interpretation.

CT and CXR results have standardized headers and were located using regexm functions in Stata (StataCorp, College Station, TX) and then manually reviewed and data abstracted using a standardized template by an author (PW). Because there was only one chart reviewer, inter-rater reliability was not a concern. We did not attempt intrarater reliability measurement of the chart abstraction process.

Data and Statistical Analysis

We tested the null hypothesis using the bitest command in Stata. This performs exact hypothesis tests for binomial random variables. The null hypothesis was that the probability of a positive ultrasound was 2%. Our sample size calculations are shown in Appendix 1. We compared inter-rater reliability between the treating physician and reader relying on only the archived images using Gwet's agreement coefficient (AC1). The validity of Gwet's AC1 does not depend upon the hypothesis of independence between raters and it does not result in unexpectedly low values (as seen in Cohen's κ) when agreement is expected to be high.[14,15] We have previously shown how Cohen's κ can be misleading in pediatric emergency medicine research and why alternatives such as Gwet's AC1

should often be used instead. [16] We used kappaetc in Stata to calculate Gwet's AC1.[17] We measured diagnostic performance of the point-of-care LUS using board-certified radiologists' interpretations of the CT chest as the gold standard using the diagt command in Stata.[18] Data and statistical analysis was performed using Stata 16.1 and R.

RESULTS

We identified 77 point-of-care LUS with associated medical records of which 49 met our inclusion and exclusion criteria. All 77 scans were used to measure inter-rater reliability and diagnostic performance characteristics. All the point-of-care LUS were performed before the CTs. Figure shows patient flow through the study. The demographic characteristics of subjects are shown in Table 1.

The treating physician interpreted 18/49 (37%) point-of-care LUS as being consistent with COVID-19. Vital signs were normal in 30 patients, and 10 (33%) of these patients had LUS consistent with COVID-19. We therefore reject the null hypothesis that among symptomatic patients being screened for COVID-19 in the ED that the point-of-care LUS would be consistent with COVID-19 less than 2% of the time if vital signs were normal (p-value <0.001). We accept our alternative hypothesis that point-of-care LUS would be consistent with COVID-19 more than 2% of the time even if the vital signs were normal.

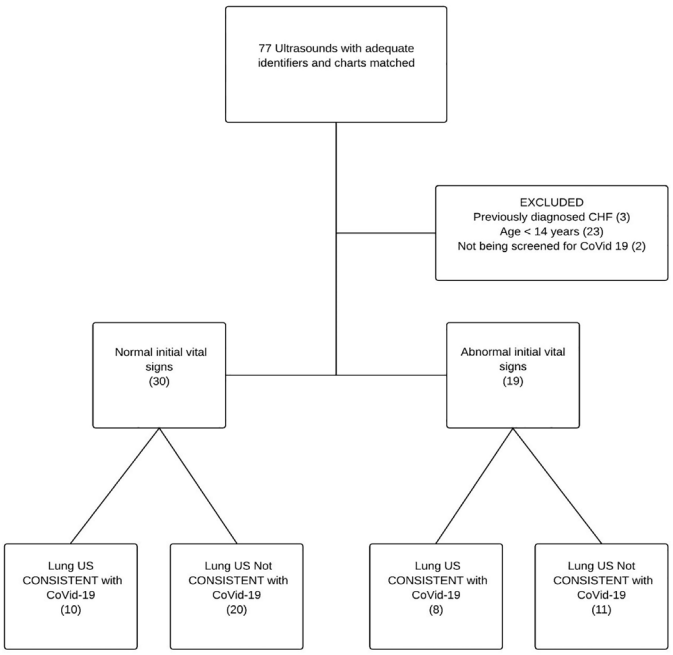

Figure. This figure shows patient flow through the study. Given the clinical context of evaluating suspected COVID-19 the presence or absence of lung ultrasound findings consistent with viral pneumonitis was interpreted as consistent with COVID-19. *COVID-19,* coronavirus disease 2019; *US,* ultrasound; *CHF,* congestive heart failure.

When compared with the subsequent CT, the treating physicians' interpretation of their own point-of-care LUS had a sensitivity of 100% (95% confidence interval [CI], 74%-100%) and specificity of 88% (95% CI, 47%-100%). For the over-reading physician relying only on archived images the sensitivity and specificity were 92% (95% CI, 62%- 100%) and 37% (95% CI, 25%,-50%), respectively. All but one of the CTs that were interpreted as positive reported multiple, ground-glass opacities. One CT report that did not explicitly report ground-glass opacities did report "bilateral interstitial changes" and an explicit radiology opinion that the CT lung appearance was consistent with COVID-19. The performance characteristics of point-of-care LUS using CT chest as the gold standard are detailed in Table 2.

Inter-rater agreement measured using Gwet's AC1 between the bedside physician who performed the point-of-care LUS and the over-reading physician using only archives was 68%. Most characteristics showed acceptable inter-rater reliability between the bedside read and images that were over-read (Table 3). Excess short non-coalescent B-lines and pleural thickening showed poor agreement likely reflecting both the subjectivity of these items and the difference between reviewing saved and real-time images.

PCR testing for SARS-CoV-2 was not always available, but when it was a variety of tests performed at different sites were used. The results are shown in Table 4.

DISCUSSION

LUS detected lesions consistent with alveolar involvement in 33% of symptomatic patients with normal vital signs who were being screened for COVID-19. A key underlying assumption of our work was that a negative nasopharyngeal swab does not exclude COVID-19. This assumption has been repeatedly shown to be valid with studies finding negative nasopharyngeal swabs but positive bronchoalveolar lavage for SARS-CoV-2, SARS-CoV-1, and Middle East respiratory syndrome.[19-21]

Our findings are consistent with published case series and social media reports of the utility of LUS in the diagnosis of COVID-19.[22,23] The use of point-of-care LUS in COVID-19 evaluation has been spontaneous and sporadic practice typically occurring in emergency medicine and critical care. Some radiologists have also found LUS useful.[22,23] Regardless of the specialty, point-of-care LUS practices in the detection of COVID-19 have necessarily evolved ahead of their published evidence base. The peer-reviewed literature is sparse. Previous literature has comprised case reports, and case series of 12 and 20 patients.[23-25] Scanning techniques, and images of patients with proven COVID-19 have spread among clinicians on Twitter and blogs[26,27] among others, and at least one COVID-19 ultrasound scoring system has been proposed.[28]

LUS has emerged as a clinical tool in human and veterinary medicine and in animal research with some advocates calling for it to replace the stethoscope.[29-32] Others have shown ultrasound to complement rather than

Table 1. Clinical characteristics of study patients overall, and the presence or absence of lung ultrasound findings consistent with viral pneumonitis.

		Total (N=49)	LUS not suggestive of viral pneumonitis (N=31)	LUS suggestive viral pneumonitis (N=18)
Gender	Male	25(51%)	13(42%)	12 (67%)
Age (years)	Median (IQR)	25 (15-46)	22 (14-52)	31 (16-46)
Duration (days)	Median (IQR)	4 (2-7)	3 (2-7)	5(3-8)
Subjective fever at home	Present	16 (33%)	9 (29%)	7 (39%)
Cough	Present	26 (53%)	15 (48%)	11 (61%)
Dyspnea	Present	29 (59%)	18 (58%)	11 (61%)
Sore throat	Present	9 (18%)	7 (23%)	2 (11%)
Fatigue	Present	9 (18%)	6 (19%)	3 (17%)
Headache	Present	14 (29%)	7 (23%)	7 (39%)
Myalgias	Present	5 (10%)	4 (13%)	1 (6%)
Diarrhea	Present	6 (12%)	2 (6%)	4 (22%)
Nausea/vomiting	Present	8 (16%)	5 (16%)	3 (17%)
Vital signs	Abnormal	30 (61%)	20 (65%)	10 (56%)
Tachycardia	Tachycardia	14 (29%)	10 (32%)	4 (22%)
Tachypneic	Tachypneic	4 (8%)	2 (6%)	2 (11%)
Hypotension	Normotensive	49 (100%)	31 (100%)	18 (100%)
Hypoxic	Hypoxia	5 (10%)	2 (6%)	3 (17%)
Lungs clear on auscultation	Present	35 (71%)	23 (74%)	12 (67%)
Crackles/rales on auscultation	Present	4 (8%)	3 (10%)	1 (6%)
Wheezing/ronchi on auscultation	Present	6 (12%)	3 (10%)	3 (17%)

LUS, lung ultrasound; *IQR,* interquartile range.

replace the physical exam and to correlate reasonably well with lung findings at necropsy. Ultrasound decreases CT utilization in inpatients with suspected COVID-19.[33] Descriptive papers have found that ultrasound correlates well with CT and clinical characteristics in COVID-19 patients.[34,35] Recommendations for training novices to identify COVID-19 have started to appear.[33] Ultrasound cannot be expected to replace CT imaging; but the ease with which it can be performed serially, at the bedside, makes it a useful tool for detecting alveolar level disease in SARS-CoV-2 infection.

We believe that knowing whether a patient has alveolar involvement with COVID-19 is clinically important. Patients' initially mild lung disease has been shown to progress, sometimes rapidly, on serial CTs as the disease progresses.[36] LUS does give a semi-quantitative estimate of how extensive the lung involvement is. When the lung is not involved discharge is likely safe. When there is only mild lung disease

Table 2. Comparison of diagnostic performance of bedside point-of-care lung ultrasound, chest radiograph, and crackles on auscultation for diagnosis of lung involvement of SARS-CoV-2 using CT chest as the gold standard. These diagnostic performance characteristics are applicable only in the context of a patient who is symptomatic and was being specifically evaluated for COVID-19. Patients with known chronic heart failure and chronic lung disease, apart from asthma, have been excluded.

	Sens %	95% CI	Spec %	95% CI	PPV %	95% CI	NPV %	95% CI	LR+	95% CI	LR-	95% CI	AUC	95% CI
Modality														
Ultrasound	100	74-100	88	47-100	92	64-100	100	93-100	5.8	1.3-25	0.1	0.0-0.7	0.94	0.82-0.99
Chest radiograph	25	5-57	88	47-100	75	19-99	44	20-70	2.0	0.3-16	0.9	0.6-1.3	0.56	0.39-0.74
Crackles/rales	8	0-38	71	29-96	33	1-91	31	11-59	0.3	0.0-3	1.3	0.8-2.1	0.40	0.20-0.60

Sens, sensitivity; *CI,* confidence interval; *Spec,* specificity; *PPV,* positive predictive value; *NPV,* negative predictive value; *LR+,* likelihood ratio positive; *LR-,* likelihood ratio negative; *AUC,* area under the receiver-operating characteristic curve.

Table 3. Inter-rater agreement between a blinded over-read relying only on saved images and the bedside interpretation of the treating physician. Where the readings differed, the interpretation of the bedside physician ultrasonographer was used.

Ultrasound finding	% Agreement	95% CI	Gwet AC_1	95% CI
Normal study	71	59-82	0.44	0.22-0.66
Excess coalescent (long) B lines	75	65-85	0.51	0.31-0.71
Excess short B lines (comet tail)	55	43-66	0.15	-0.10-0.39
Effusion	91	84-97	0.90	0.81-0.98
Air bronchograms	69	58-79	0.51	0.31-0.72
Thickened/moth-eaten pleura	53	42-65	0.11	-0.13-0.35
Atelectasis	69	58-79	0.51	0.31-0.71
Consolidation	80	71-90	0.74	0.60-0.88

CI, confidence interval; AC_1, agreement coefficient.

and vital signs are normal our practice is to discharge these patients with a home pulse oximeter. But if ultrasound shows that the patient has widespread pneumonitis then he or she should be investigated further. Patients frequently are unaware of their own deterioration and may present, or fail to re-present with critically low oxygen saturation without overt symptoms. These patients frequently have negative PCR tests unless bronchoalveolar lavage is performed. Such patients risk being falsely reassured about their own impending fate, and continue to infect others when, inevitably, they cough.

LIMITATIONS

This was a single-center study and was not a random sample. Whether a patient was seen by a physician who both believed that the COVID-19 evaluation should include lung imaging and was facile with ultrasound was a matter of luck rather than randomization. This adds uncertainty to estimates of the prevalence of pneumonitis that point-of-care LUS can detect among patients being screened for COVID-19. Other limitations of our work include its small sample size, and a single chart reviewer. Patients with mild disease, and especially those with normal vital signs, did not always have CT imaging performed. PCR testing for SARS-CoV-2 was not always available; and even when PCR testing was available, the gold standard of bronchoalveolar lavage to obtain a specimen was not performed.

Our use of CT as a gold standard is imperfect as CT diagnosis of COVID-19 has its own limitations.[37] It is difficult to conceive of an alternative gold standard that does not fall afoul of circular reasoning (by, for example, using "two out of three" imaging methods positive as the gold standard). Another limitation is that CT was likely reserved for patients perceived as being sicker or having more extensive lung disease on ultrasound. This could have created a spectrum bias that would have increased the apparent accuracy of LUS. However, CT cannot be justified on patients simply to better determine the test characteristics of LUS. Finally, because of the false negative rates of PCR testing, CT rather than PCR testing has been recommended as the primary diagnostic modality in high prevalence settings.[38]

Our assessment of the performance characteristics of ultrasound is limited by our sample size. The relative subjectivity of LUS is also a limitation. We observed much less agreement between the blinded reviewer looking only at ultrasound images and the treating physician performing the LUS. We speculate that pleural findings were more subjective and the decision that pleural findings were abnormal might have been influenced by the clinical picture. However, describing the performance characteristics of LUS was not the primary aim of this study. Although falling out of favor, null hypothesis testing is well suited to answering our primary question when the sample size is small – after all, a single "red" (brown) Holstein cow demolishes the hypothesis that all cows are black and white, and careful planning minimizes the number of cows that need to be seen.

Despite these limitations, we can be assured that the prevalence of pneumonitis in these patients was more than the 2% "acceptable miss rate" for high morbidity conditions, and this may be sufficient to adjust practice accordingly.[39] Other limitations include the use of abbreviated LUS imaging protocols and the variability in image-saving practices with some doctors saving many cine-clips, while others saved only one or two still images. These differences in practice style could decrease inter-rater agreement between the blinded and bedside readings. Much more detailed and formalized LUS protocols and ultrasound scoring systems specifically for use in SARS-CoV-2 patients have been described.[28,35] Abbreviated protocols are inevitable in community practice and could lead to missed diagnoses. This would have biased our study in the opposite direction of our actual findings.

CONCLUSION

In this small, single-center study, point-of-care lung ultrasound had a meaningful detection rate for pneumonitis in symptomatic ED patients with normal vital signs who were being evaluated for COVID-19. Test characteristics were as follows: sensitivity 100%; specificity 88%; PPV 92%; NPV 100%; LR+ 5.8; and LR- 0.1 with broad confidence intervals when compared to CT. We recommend at least point- of- care lung ultrasound be

Table 4. PCR results from nasal, nasopharyngeal, and oropharyngeal swabs, and lung ultrasound results. Although the overall number of polymerase chain reaction tests was the same, some patients received SARS-CoV-2 testing alone, while others had a panel of respiratory pathogens ordered without SARS-CoV-2 due to lack of test availability at the time. The panel of respiratory pathogens tested included adenovirus, parainfluenza viruses 1-4, *Mycoplasma pneumoniae*, *Bordetella pertussis*, coronaviruses 229E, HKU1, N163 and OC43; respiratory syncytial virus; human metapneumovirus; *Chlamydophila*; and *Chlamydophila pneumoniae*.

	PCR testing positive (%)	PCR testing negative (%)	US consistent with viral pneumonitis (%)	US not consistent with viral pneumonitis (%)
N = 49			18/49 (37)	31/49 (63)
Testing performed (N =42)			17/18 (94)	25/31 (81)
SARS CoV-2	5(12)	37 (88)	4 (24)	1 (4)
Influenza A	1 (2)	41 (98)	0 (0)	1 (4)
Chlamydophila	1 (2)	41 (98)	0 (0)	1 (4)

PCR, polymerase chain reaction; *US,* ultrasound; *SARS CoV-2,* severe acute respiratory syndrome coronavirus 2.

used in addition to PCR testing to identify lower airway disease when evaluating symptomatic patients in whom SARS-CoV-2 infection is suspected.

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Emergency Department Management of COVID-19: An Evidence-Based Approach

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The novel coronavirus, SARs-CoV-2, causes a clinical disease known as COVID-19. Since being declared a global pandemic, a significant amount of literature has been produced and guidelines are rapidly changing as more light is shed on this subject. Decisions regarding disposition must be made with attention to comorbidities. Multiple comorbidities portend a worse prognosis. Many clinical decision tools have been postulated; however, as of now, none have been validated. Laboratory testing available to the emergency physician is nonspecific but does show promise in helping prognosticate and risk stratify. Radiographic testing can also aid in the process. Escalating oxygen therapy seems to be a safe and effective therapy; delaying intubation for only the most severe cases in which respiratory muscle fatigue or mental status demands this. Despite thrombotic concerns in COVID-19, the benefit of anticoagulation in the emergency department (ED) seems to be minimal. Data regarding adjunctive therapies such as steroids and nonsteroidal anti-inflammatories are variable with no concrete recommendations, although steroids may decrease mortality in those patients developing acute respiratory distress syndrome. With current guidelines in mind, we propose a succinct flow sheet for both the escalation of oxygen therapy as well as ED management and disposition of these patients. [West J Emerg Med. 2020;21(6)32-44.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

It took just over two months for the novel coronavirus, SARs-CoV-2 to be declared a global pandemic by the World Health Organization (WHO). In the immediate week following this announcement, more than 400 papers were published pertaining to COVID-19. Just two months later, this number had increased to over 2000 releases per week in the literature.[1] Keeping up with ever-changing information can be quite difficult. The purpose of this clinical review is to provide the emergency physician (EP) with a summary of current literature and supporting societal guidelines relevant to the management of the COVID-19 patient in the emergency department (ED). Finally, we propose an ED-based algorithm for the work-up and initial management of patients with suspected COVID-19 infections.

METHODS

We systematically searched the PubMed, LitCovid, Ovid, Cochrane Library, MEDLINE, Google Scholar, and Embase for literature related to "COVID-19," "SARS-CoV-1," and "SARS-CoV-2." We included retrospective studies, case reports, case series, systematic reviews, meta-analyses, and clinical guidelines from the Society of Critical Care Medicine (SCCM), the Surviving Sepsis Campaign (SSC), the National Institutes of Health (NIH), and the European Society of Intensive Care Medicine (ESICM). We included relevant literature if it contained data on epidemiological characteristics, biomarkers, imaging, oxygenation and ventilation management, procedural aerosolization, pathology

reports, hematologic abnormalities, and treatment outcomes related to care commonly seen in the ED).

DISCUSSION

Risk Stratification

Risk stratification in the ED can be difficult for a novel virus such as SARS-CoV-2 as we do not have the luxury of years of research and understanding that we are offered with most disease processes. Decompensation of the otherwise well appearing COVID-19 patient can occur rather rapidly as many patients develop early lung injury and hypoxia before clinical deterioration is appreciated.[2] The ability of the EP to identify features that recognize those patients most at risk for clinical deterioration would be ideal. While many risk-stratification models have been proposed in response to COVID-19, most lack COVID-19-specific data, mainly focus on in-hospital mortality. and lack validation in the literature.[3-6]

National Institutes of Health (NIH) Definition of Disease Severity

Currently, evidence-based practices support using epidemiological, laboratory, radiographic, and clinical features to help us determine who is at risk for decompensation.[7] The NIH describes a mild clinical course as those with various symptoms (eg, fever, fatigue, cough, myalgias, headache) but without dyspnea and with normal imaging.[7] There is insufficient data for the NIH panel to recommend specific lab evaluation or treatment modalities in patients fitting this profile.[7] Based on current evidence, considerations should include discharge home with recommendations of antipyretics, hydration, and rest with self-isolation until afebrile for 72 hours without the need for antipyretics and improving symptoms.[7] Patients with moderate disease are defined as those with evidence of lower respiratory tract pathology based on imaging or clinical assessment, but still have pulse oximetry readings greater than 93%.[7] These patients should be admitted for close observation. Empiric antibiotics for community-acquired pneumonia should be considered if a bacterial pneumonia or sepsis is suspected.[7] The NIH classification of ***severe*** disease includes those with a respiratory rate greater than 30; blood oxygen saturation level equal to or less than 93% on room air, a ratio of arterial oxygen partial pressure to fractional inspired oxygen < 300 or > 50% of lung involvement on imaging.[7] These patients will require supportive oxygen therapy and hospital admission.[7]

Epidemiological Risk Factors as Predictors of Disease Severity

The largest case series assessing epidemiological risk factors includes a 72,314-patient report from the Chinese Center for Disease Control and Prevention.[8] They noted independent risk of death in patients was 10.5% for cardiovascular disease, 7.3% for diabetes mellitus, 6.3% for chronic respiratory diseases, 6% for hypertension, and 5.6% for underlying malignancy. This is compared to an overall case fatality rate of 0.9% in those without these comorbid conditions. A meta-analysis of six studies assessing a total of 1558 patients showed that hypertension, diabetes, chronic obstructive pulmonary disease (COPD), cardiovascular disease, and cerebrovascular disease were all independent risk factors associated with increased disease severity and intensive care unit (ICU) admission.[9] They found no association between COVID-19 risk and liver disease, renal disease, or malignancy. In a case series of 700 patients hospitalized with COVID-19 in New York City, the most common comorbidities among patients requiring hospitalization include hypertension (56.6%), obesity (41.7%), and diabetes (33.8%) with 88% of patients having more than one comorbidity.[10]

An article published by Guo and colleagues showed that COVID-19 patients with diabetes but without other comorbidities were at an independently high risk of severe pneumonia, uncontrolled inflammatory response, and hypercoagulable state.[11] Serum D-dimer, interleukin (IL)-6, C-reactive protein (CRP), and ferritin were significantly higher in patients with diabetes mellitus showing susceptibility to rapid deterioration in COVID-19. A retrospective observational study of 1122 adults with laboratory-confirmed COVID-19 showed a mortality rate of 41.7% in diabetic patients with uncontrolled hyperglycemia defined as greater than two blood glucose readings greater than 180 milligrams per deciliter within a 24-hour period.[12]

Several studies have linked obesity and a body mass index (BMI) greater than 30 kilograms (kg) per meter squared (m^2) with increased risk of mechanical ventilation, severe pneumonia, and death associated with COVID-19.[13,14] Further, a BMI greater than 30 kg/m^2 in those younger than 60 has been noted to be an independent risk factor with a twofold higher rate of acute care and ICU admission when compared to those with a BMI less than 30 kg/m^2.[15]

In the March 2020 Morbidity and Mortality Report from the US Centers for Disease Control and Prevention (CDC), patients above the age of 65 had a particularly significant increased risk of death when compared to their younger counterparts with up to 80% of deaths occurring in those over the age of 65.[16]

Finally, a single-center study of 1193 patients in Lombardia, Italy, showed patients on biologics had a higher rate of hospitalization, but this was not associated with an increased risk of ICU admission or death.[17] Until more is known, most sources including the CDC recommend close monitoring of immunocompromised patients, those with untreated or uncontrolled human immunodeficiency virus, and those on biologics. This recommendation is based on mostly anecdotal concern that these patients may remain infectious for longer periods of time.

The EP should maintain a baseline level of caution when determining disposition of these patients, especially in patients

with more than one comorbid condition. In a prediction model from Wang et al, hypertension, advanced age, and coronary heart disease, their model appears to confer the highest risk of in-hospital mortality with an area under the curve of 0.88; sensitivity, 92.31%; specificity, 77.44%; and negative predictive value (NPV) of 99.34%).[18]

Lab Values as Predictors of Disease Severity

Many serum biomarkers have been studied with COVID-19 infections. Alanine transaminase (ALT) and aspartate aminotransferase (AST) tend to be elevated and albumin low. Elevations in lactate dehydrogenase (LDH), CRP, procalcitonin, and abnormalities in coagulation parameters such as ferritin, D-dimer, fibrinogen, activated partial thromboplastin time and prothrombin time all tend to be elevated in patients with poor progression of disease.[19] Measurements of these values should be considered in any patient with moderate to severe disease for their prognostic value. It is important to note that while guidelines recommend consideration in obtaining these markers, they are not considered part of standard care.[7] While many of these lab values are non-specific to COVID-19, they may serve as a tool for the EP until more robust prediction models are further studied and validated in the future.

Absolute Lymphocyte Count (ALC)

An ALC less than $0.8x10^9$ per liter (L) has been consistently shown to correlate with disease severity, ICU admission, and death.[19] Those with values greater than 1 $x10^9$/L tend to have a milder disease process, and values below this could perhaps help identify those at risk for disease progression. A summary of literature addressing ALC has been summarized in Appendix 1.

Neutrophil to Lymphocyte Ratio (NLR)

An elevated neutrophil count has been shown to correlate with disease severity. However, an absolute value to determine severity is not as apparent in current literature. The NLR may offer greater clinical insight. Normal values of the NLR range between 0.78-3.53 with a mean value of 1.65.[20] A study by Xia et al of 10 patients identified that those with non-severe cases had a calculated NLR in the range of 1.29-6.14, while all three patients with more severe cases had values greater than 10.[21] An elevated NLR has been show to predict poor outcomes in COVID-19 with a specificity of 63.6% and a sensitivity of 88%.[22] For each increase in NLR tertile, hospital mortality increases by 8%.[23] A summary of literature addressing neutrophil count has been summarized in Appendix 1.

D-dimer

An elevated D-dimer has been shown to be an independent marker of unfavorable disease progression in multiple studies.[24-31] In the retrospective study from Zhou et al 81% of patients who died had a D-dimer greater than 1 microgram per milliliter (μg/mL) on admission. In a retrospective study of 343 hospitalized patients in Wuhan, China, the optimum cutoff value for D-dimer to predict all-cause death was 2.0 μg/mL using receiver operating characteristic curve with a sensitivity and specificity of 92.3% and 83.3%, respectively.[32] In fact, a prospective study of 183 consecutive patients by Tang and colleagues showed that 71.4% of non-survivors demonstrated disseminated intravascular coagulation (DIC) during their hospital stay, while only 0.6% of survivors did. While an optimum cutoff has not been validated, a twofold increase in values has consistently been shown to predict disease severity in numerous studies.[25,28,29,33-38] An elevated D-dimer used for risk stratification does not currently warrant routine investigation for acute venous thromboembolism (VTE) in absence of clinical manifestations or other supporting information in favor of VTE.[39] A summary of the literature addressing D-dimer has been summarized in Appendix 2.

Lactate Dehydrogenase (LDH)

In the previously discussed study by Zhou and colleagues, an LDH greater than 245 was seen in 98% of all patients who did not survive, with an odds ratio for in-hospital mortality of 45.43.[24] However, this elevation was also seen in 54% of those who survived. While an elevated LDH has shown an increased association with those requiring ICU admission and predicting in-hospital mortality in multiple studies, a normal value has also been shown to predict those who ultimately had a more mild to moderate disease process.[24,25,29,30,36,37,40,41] A summary of the literature addressing LDH has been summarized in Appendix 3.

C-reactive Protein (CRP)

CRP is non-specific and frequently elevated in patients with mild disease.[28,36-38,42,43] However, the degree of increase has been associated with worse outcomes and in-hospital mortality as levels increase greater than 100 milligrams (mg)/L. Less significant elevations (50-75 mg/L) were seen in patients ultimately discharged home.[44] A summary of the literature addressing CRP has been summarized in Appendix 3.

Ferritin

Ferritin is another nonspecific marker with elevations seen in up to 63-80% of COVID-19 patients admitted to the hospital.[24,45] Ferritin levels greater than 300 nanograms (ng)/mL have been associated with in-hospital mortality at an odds ratio of 9.10. A recent retrospective, multicenter study of 150 COVID-19 cases in Wuhan showed a mean elevation of 1297.6 ng/mL in non-survivors versus 614.0 in survivors.[44] A summary of the literature addressing ferritin has been summarized in Appendix 3.

Creatine Kinase (CK)

Creatine kinase (CK) appears to be elevated in a minority of COVID-19 patients regardless of severity.[25,38,45,46] In the Zhou et al study, a CK greater than 185 units (U)/L was seen in 21% of

non-survivors and 9% of survivors with an in-hospital mortality odds ratio of 2.56.[24] Certain patients may benefit from having CK levels checked, especially those with significant myalgias ,as COVID-19-related myositis has been described in the literature.[47]

Imaging as a Marker of Disease Severity

There is a lack of evidence in published literature to suggest that laterality of infiltrates on imaging accurately correlates with disease severity. In a retrospective cohort study out of Wuhan, bilateral infiltrates were seen in 72% of survivors and 83% of non-survivors.[24] However, multiple studies have shown bilateral involvement in as high as 91-100% of all patients admitted to various hospitals across China, regardless of disease severity.[25,29,37,41,42]

In a multinational consensus statement from the Fleischner Society, chest imaging is recommended in those patients with mild symptoms and any risk factors of disease progression, in all patients with moderate to severe features, or when rapid COVID-19 testing is not available.[48] Current guidelines from the American College of Radiology (ACR) recommends considering portable chest radiographs (CXR) to avoid bringing patients into radiography rooms and recommends against computed tomography (CT) unless clinically indicated for another reason.[49]

Bedside lung ultrasound (LUS) may offer some advantages in the ED for patients with suspected COVID-19.[50] A recently published article of 391 patients showed that LUS had a higher sensitivity when compared to CXR in patients diagnosed with COVID-19 pneumonia.[51] Considering COVID-19 reverse transcription polymerase chain reaction (RT-PCR) has a sensitivity as low as 60-70% and CT findings can be delayed, LUS findings may add increased sensitivity to diagnosis.[52] Further, ultrasound has safety advantages including absence of radiation, low cost, and rapid bedside availability.[53]

Focal B-lines in the posterior and inferior lung fields appear to be the primary finding.[54] As disease progresses, the pleura becomes thickened and irregular with multifocal or confluent B-lines.[54,55] In a study of 20 patients with moderate to critical severity COVID-19 pneumonia, pleural line abnormalities and B-lines were present in 100% of study participants.[56] LUS findings have been shown to highly correlate with findings on CT.[54]

Management of The Critically Ill Adult

Current guidelines for the management of the critically ill adult with COVID-19 have been issued by the SCCM, the SSC, the NIH, and the ESICM. These guidelines are quite similar, if not identical, in regard to most recommendations and will be summarized here.[7,57,58]

Hemodynamic Support

Current guidelines favor a conservative approach to fluids in these patients. Utilization of early vasopressors is recommended to keep a mean arterial pressure (MAP) of 60-65 millimeters of mercury (mm Hg), although this is based on low quality of available evidence.[7,57,58] Instead, it is based on the historical approach to patients with ARDS while in the ICU, largely after initial resuscitation in the ED, suggesting that a conservative approach to fluids leads to more ventilator-free days and shorter ICU stays, but has failed to show mortality benefit.[59-63] The initial resuscitation fluid should be a buffered/balanced crystalloid, avoiding colloidal fluid and albumin.[7,57,58] Guidelines are consistent in their recommendation of norepinephrine as the first-line agent and suggests adding vasopressin as a second-line agent early instead of titrating norepinephrine to higher doses.[7,57,58] Epinephrine or vasopressin is the recommended first-line agent if norepinephrine is not available.

Dobutamine should be considered a second-line agent after norepinephrine only if there is evidence of cardiac dysfunction and persistent hypoperfusion.[7,57,58] Dopamine should be avoided if norepinephrine is available due to an increased risk of arrhythmias.[7,57,58,62] In patients with refractory shock despite vasopressors, administration of stress-dose steroids (ie, intravenous hydrocortisone 200 mg per day) are recommended; however, this has not specifically been studied in COVID-19.[7,57,58,63,64]

Oxygen and Ventilation

Early discussion of hypoxic patients with COVID-19 prioritized intubation based on the hypothetical risk of patient self-induced lung injury resulting from excessive intrathoracic negative pressure from strong respirator effort and aggressive positive pressure ventilation strategies.[65-70] Further, data suggest that ARDS patients with severe hypoxemic respiratory failure who received noninvasive ventilation (NIV) had a higher ICU mortality.[71] Limited data from the severe acute respiratory syndrome and Middle East respiratory syndrome outbreaks show a high failure rate of NIV coupled with concern of virus aerosolization made early intubation for all who were hypoxic seem more veracious.[65-67] Currently there is a lack of evidence identifying the ideal time of intubation, and this area would benefit from additional research.

The FLORALI trial randomly assigned patients who had acute hypoxemic respiratory failure to either high-flow oxygen therapy or standard oxygen therapy delivered through a face mask, or noninvasive positive-pressure ventilation.[72] There was no significant difference in the intubation rates between groups; however, there was a significant difference in favor of high-flow oxygen in 90-day mortality. An unblinded, retrospective study of hospitalized COVID-19 patients concluded that high flow nasal oxygen (HFNO) therapy provided more patient comfort and was non-inferior to NIV for intubation rate.[73] The ANZICS guidelines on COVID-19 state that HFNO appears to be at least non-inferior to NIV and may even offer survival benefit.[74] HFNO is a recommended therapy for hypoxia associated with COVID-19 disease, as long as staff are

wearing optimal airborne personal protective equipment where the risk of airborne transmission to staff is low.[57,68]

Early case reports described COVID-19 patients presenting with ARDS and a ventilatory management strategy typically employed in ARDS was recommended by the WHO and SCCM.[57,68] However, observations from Italy described a subset of patients who met Berlin criteria for ARDS and presented with rather profound hypoxemia without the expected degree of observed dyspnea.[75,76] This observation suggests that there may be more than one phenotypic presentation of COVID-19-induced lung injury.

Those with "type-H" phenotype present with a clinical picture characteristic of typical ARDS (low compliance, high lung weight and high positive end-expiratory pressure [PEEP] response).[67,75] In patients with COVID-19 and ARDS, using lower tidal volumes (4-8 mL/kg predicted body weight), lower inspiratory pressures (plateau pressure < 30 centimeters of water (cmH20) and higher PEEP for recruitment is currently recommended by the SCCM and WHO.[57,68]

Those with the observed "type-L" phenotype frequently have minimal dyspnea and remain alert and conversational despite the degree of observed hypoxia.[77] This process is thought to be due to a loss of hypoxic vasoconstriction and impaired regulation of pulmonary blood flow leading to a ventilation-perfusion (V/Q) mismatch.[76] In these patients, lung compliance remains relatively normal and can accept larger tidal volumes (7-8 mL/kg ideal body weight) to help avoid reabsorption atelectasis and hypercapnia from hypoventilation.[67,76,77] Recruitability is minimal and, therefore, a high PEEP strategy is unlikely to improve oxygenation and may be detrimental.[66,67,76] HFNO and prone positioning may help redistribute pulmonary perfusion and improve the V/Q mismatch.[76] In patients who are alert, allowing them to self-prone has been shown to improve oxygenation and is a reasonable approach for those not otherwise requiring intubation.[67]

This phenotype model is untested and there is a paucity of societal guidelines for patients with preserved compliance requiring mechanical ventilation. We believe a blanket ARDS ventilatory strategy for all patients could have detrimental consequences.[75] Given the variable differences in observed lung compliance in clinical presentations of COVID-19, it is reasonable to consider a targeted ventilatory strategy unique to the observed lung mechanics and not simply the degree of hypoxia (Figure 1).

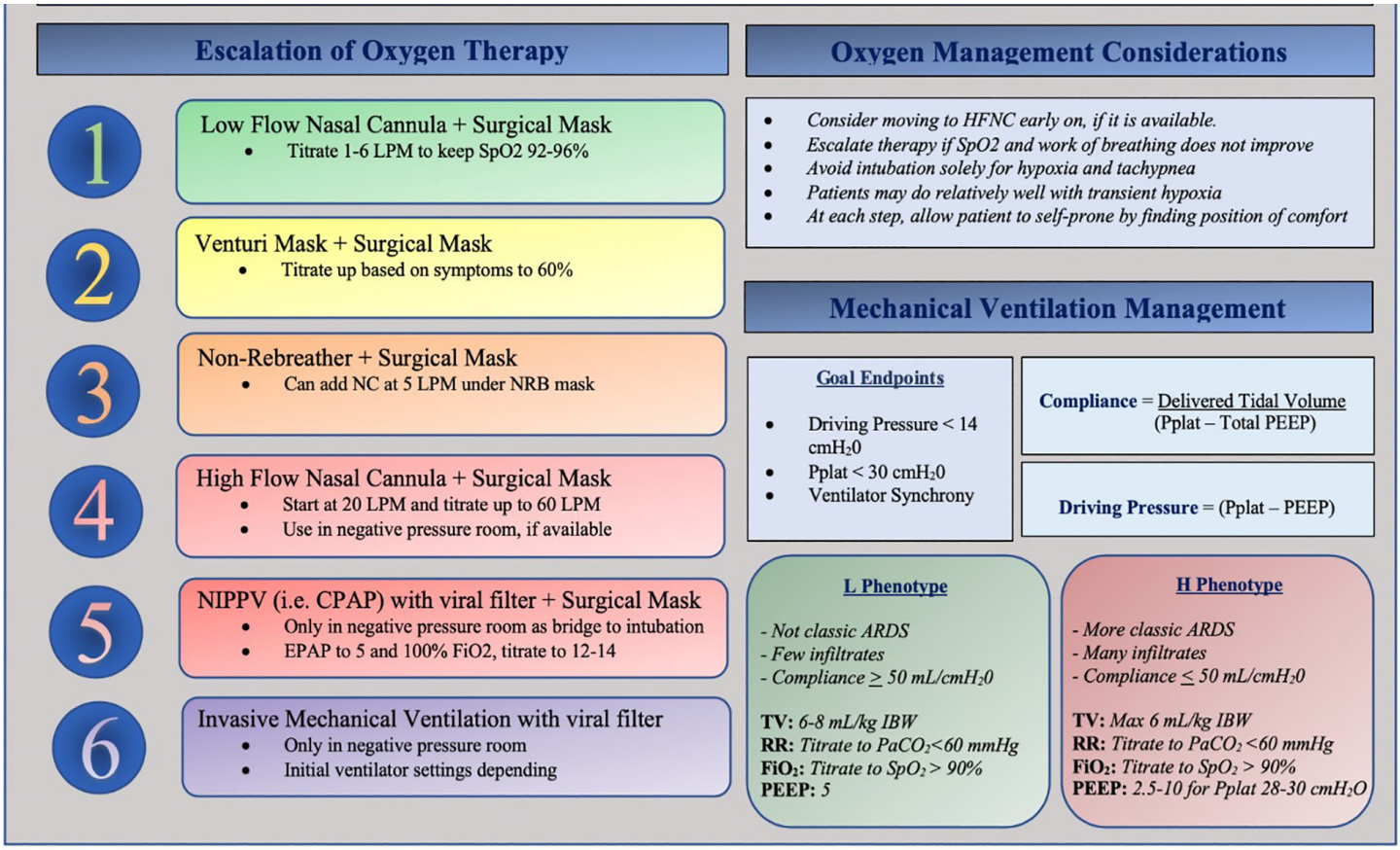

Figure 1. Respiratory management in coronavirus 2019 disease.
LPM, liters per minute; NRB, non-rebreather mask; *NIPPV,* noninvasive positive pressure ventilation; *CPAP*, continuous positive airway pressure; *EPAP,* expiratory positive airway pressure; *SpO_2,* peripheral capillary oxygen saturation; *RR,* respiratory rate; *Pplat,* plateau pressure; *PEEP,* positive end-expiratory pressure.

Surface Stability and Aerosolization of SARS-CoV-2

While the presence of viral particles does not confer transmission, it certainly supports our need to exercise caution to maximize protection to ourselves and our staff. A meta-analysis of 10 studies published in the *Journal of Infectious Disease* reported that shows droplets from coughs and sneezes can travel up to eight meters, with SARS-CoV-2 detected in the air up to 3-5 hours after aerosolization.[78,79] In a study from the University of Nebraska Medical Center, SARS-CoV-2 RNA has been isolated throughout patient rooms, their personal items, in the air ducts, and even outside in the hallway suggesting aerosolized transmission.[80]

Exhaled air dispersion during high-flow nasal cannula therapy was compared to continuous positive airway pressure (CPAP) in a study by Hui et al.[81] The mean air dispersion was up to 172 +/- 33 mm along the sagittal plane via HFNO at 60 L/minute (min), and similar leakage distances could be detected up to 264 and 332 mm for CPAP used up to 20 cm H20. A properly fitted, heated HFNO appears to be the safer option in regard to dispersion of aerosols, and therefore may be the safer option to minimize risk to staff. The Vapotherm study performed a simulation with HFNO and a surgical mask on the patient to assess dispersion.[82] The results showed that by placing a simple mask over a patient receiving high-flow therapy, 87.2% of particles were effectively filtered. Those particles that did leak around the mask,had a final path length of less than one meter.

Aerosolization Risk Based on Oxygen Modality

HFNO at a maximal flow rate of 60 L/minPM actually has a lower dispersion distance than a non-rebreather or venturi mask.[83] A study by Whittle et al showed NIV had the longest range of dispersal at 85-95 cm. Nebulized medications were similar at 80 cm.[84] HFNO has an average of approximately 5-17 cm with low flow nasal cannula reaching up to 40 cm in some studies. A summary of dispersion distances in relevant literature is shown in Figure 2.

Thrombotic and Thromboembolic Disease

Patients with COVID-19 are at an increased risk of VTE. Current documented rates of incidental VTE in hospitalized patients with COVID-19 ranges from 20-69%, despite the use of pharmacological thromboprophylaxis.[85-90] The DIC observed in severe COVID appears to be solely prothrombotic, and patients with the most severe disease at most risk.[88] Nearly 15% of thrombotic events are asymptomatic.[91]

Diagnosing Incidental Venous Thromboembolism

In a study of 81 patients with COVID-19 infections, a D-dimer greater than 1.5 µg/mL had a sensitivity of 85.0%, a specificity of 88.5% with a NPV of 94.7% at predicting VTE.[86] However, this is a rather small study and lacks validation. While a threshold value for an elevated D-dimer in COVID-19 has not yet been established, a significant elevation has shown to correlate with the presence of VTE and an increase in mortality.[92] The *Journal of the American College of Cardiology*

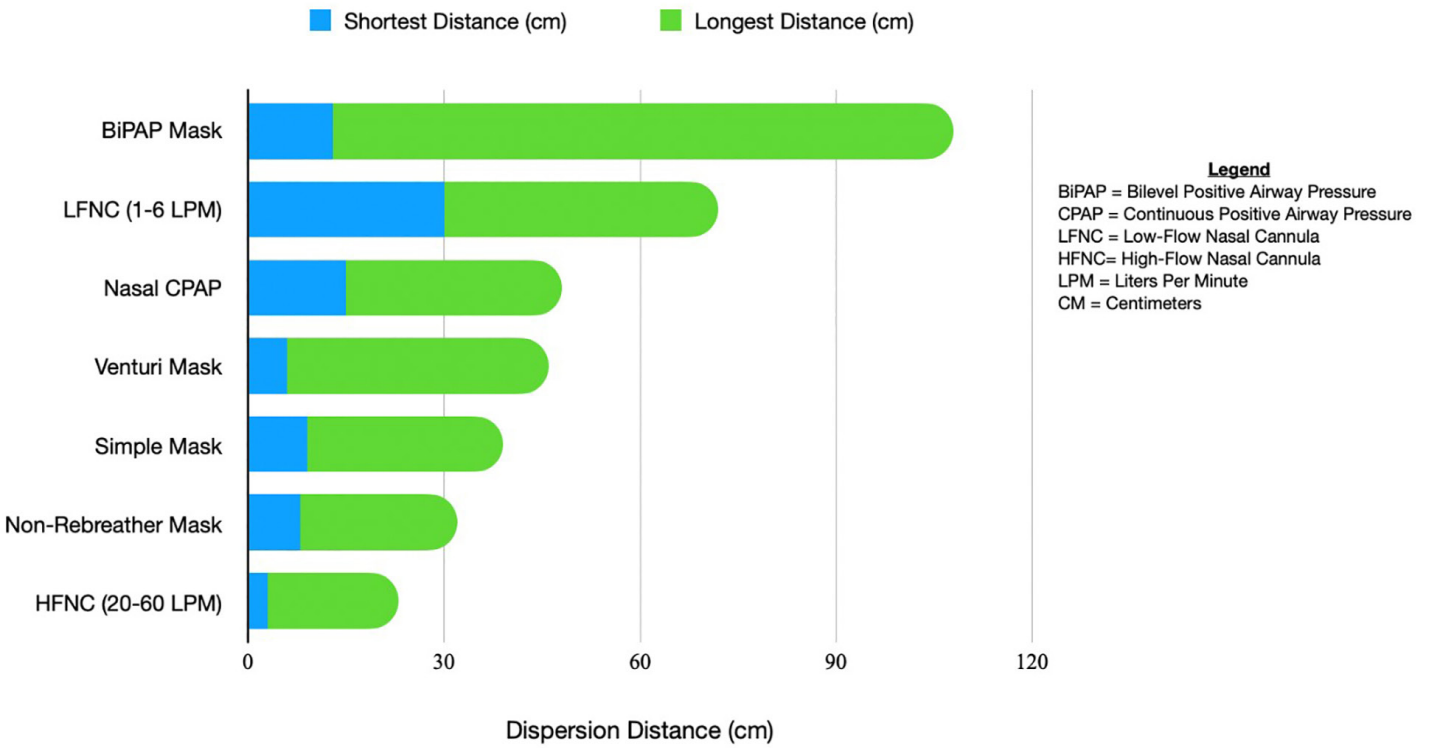

Figure 2. Oxygen modality dispersion distances. (Li et al; Whittle et al; Hui et al)

(*JACC*) panel recommends against routine screening for VTE and recommends against pursuing an elevated D-dimer when it is being used for risk stratification.[39]

Patients with Mild COVID-19 Treated as Outpatient

The *JACC* panel does not recommend routine use of prophylactic anticoagulation as its role has not yet been well established in the literature.[39] Patients who are on chronic antiplatelet agents or anticoagulants should be encouraged to continue taking these medications. For patients on Vitamin K antagonists who will be unable to get routine international normalized ratio measurements, switching them to a direct oral anticoagulant or low molecular weight heparin is a reasonable option.

Patients with Moderate to Severe COVID-19 Requiring Hospitalization

Patients with ARDS secondary to COVID-19 are at a higher risk of thrombosis when compared to non-COVID-19 ARDS patients.[85] Further, the development of incidental VTE in patients with severe COVID-19 is lower in those treated with therapeutic dose anticoagulation over prophylactic dosing.[90] Based on a paucity of evidence at the time of publication, the majority of *JACC* panel members recommend prophylactic anticoagulation for hospitalized COVID-19 patients without a diagnosis of VTE, while a minority of the panel gives consideration to intermediate- or full-dose anticoagulation.[39] Some hospital systems are currently using a higher prophylactic dose such as enoxaparin 1 mg/kg once daily or enoxaparin 0.5 mg/kg twice daily.[92] We anticipate future guideline adjustments in regard to therapeutic anticoagulation in select patients as more robust evidence on its impact on mortality emerges.

Adjunctive Therapy

Antipyretics and NSAIDs

Controversy surrounds the use of nonsteroidal anti-inflammatory drugs (NSAID) in COVID-19 stemming from a correspondence published on March 11, 2020, in the *Lancet* describing a theoretical risk of worsening infection through increased ACE-2 expression with ibuprofen based on animal studies.[93] Initial WHO recommendations were to avoid ibuprofen based on this concern, and on March 19 the US Food and Drug Administration issued a statement suggesting a lack of scientific evidence in connection with NSAIDs and worsening COVID-19 symptoms.

When the SSC released its guidelines on March 27, they acknowledged the debate on NSAIDs use for fever, and recommended the use of acetaminophen/paracetamol over NSAIDs until more data becomes available. On April 19, the WHO released a systematic review of 73 studies of adults and children with viral respiratory infections, including COVID-19, MERS, and SARS and concluded that, "At present there is no evidence of severe adverse events, acute health care utilization, long-term survival, or quality of life in patients with COVID-19, as a result of the use of NSAIDs."[94] The NIH guidelines were initially released on April 21 and recommended there be no difference in the use of antipyretics (acetaminophen or NSAIDs) in patients with COVID-19.[7] It is important to point out that it has been well documented outside of COVID-19 that fever control has not been shown to reduce the risk of death or ICU length of stay in a critically ill adult.[57]

Steroids

Initial concerns in regard to the use of corticosteroids in COVID-19 were based on studies specific to SARS-CoV-1 showing prolonged viral shedding with early corticosteroid treatment and an increased risk of adverse effects such as steroid-induced psychosis, avascular necrosis osteoporosis, and diabetes without an apparent mortality benefit.[95-98] It is important to note that these early studies focused on rather high doses of steroids and despite prolonged viral shedding (12 days vs eight days), those who received corticosteroids were less likely to clinically deteriorate.[95,99] A 2020 study using low-dose corticosteroids (mean dose approximately 40 mg methylprednisolone daily) in patients with COVID-19 showed steroids had no impact on viral shedding.[100]

A 2016 retrospective review of 5327 patients from the SARS-CoV-1 database in China showed that patients initially treated with an average of 80 mg methylprednisolone daily had a lower mortality with a hazard ratio (HR) of 0.47.[101]

Results from randomized trials in regard to steroids in ARDS from non-coronavirus causes have shown mixed outcomes. High dose (30 mg/kg every 5-6 hours for 24 hours) failed to show improvement in mortality or pulmonary function and was associated with an increased rate of secondary infection.[102,103] However, a study looking at a more prolonged and lower dose course (2 mg/kg/day for two weeks, and then tapered for a total of 32 days of treatment) showed improvement in lung injury and a reduced hospital-associated mortality when compared to placebo (12% vs 62%, respectively) in patients with severe ARDS who failed to improve by seven days.[104]

Data specific to COVID-19 and ARDS is limited. A retrospective study of 201 COVID-19 patients in Wuhan showed that of the patients who developed ARDS, those who received methylprednisolone in some fashion had a decreased risk of death with HR of 0.38.[30] Another retrospective study of 46 patients out of Wuhan showed that early, low-dose and short-term corticosteroid use (1-2 mg/kg/d for 5-7 days), was associated with faster wean off supplemental oxygen (8.2 days vs 13.5 days) and faster improvement of infiltrates on CXR.[105] However, neither study was a randomized controlled trial (RCT), and improvements seen could have been from variations in other

aspects of treatment strategies. A recent meta-analysis from Ye et al of seven RCTs of non-COVID-19-related ARDS and one small cohort study of COVID-19-related ARDS showed that corticosteroids may reduce mortality with a risk ratio of 0.72.[106] In the meta-analysis from Ye et al, data from two observational studies showed that corticosteroid use in patients with COVID-19 infection but without ARDS resulted in an increase in mortality with a HR of 2.30 and a mean difference of 11.9% more.[106]

In summary, corticosteroids may decrease mortality in COVID-19 patients with ARDS. The SSC recommends steroids for mechanically ventilated patients with COVID-19 and evidence of ARDS or for refractory shock despite vasopressors.[57] The NIH guidelines recommend a case-by-case approach to steroids in critically ill patients with ARDS, citing insufficient evidence to recommend blanket use for all mechanically vented patients with ARDS.[7] The most recent update of the Infectious Disease Society of America guidelines recommend dexamethasone 6 mg daily for up to 10 days in hospitalized patients with pulse oximetry readings ≤ 94% on room air. If dexamethasone is unavailable, methylprednisolone 32 mg, or prednisone 40 mg may be used.[7,107] Guidelines do not currently recommend the use of steroids in patients with COVID-19 in the absence of hypoxia or ARDS unless they have a history of chronic underlying lung disease (ie, asthma, COPD, or pulmonary fibrosis).

For patients on chronic oral or inhaled corticosteroids, these should not be discontinued, and stress-dose steroids may be indicated on a case-by-case basis.[7] Specific to pregnancy, betamethasone and dexamethasone are known to cross the placenta and should therefore be reserved for situations when fetal benefit is needed. However, other systemic corticosteroids do not cross the placenta, and pregnancy status alone should not be a reason to restrict their use.[7]

Antimicrobials

A recent meta-analysis of patients admitted with COVID-19 reported 72% receive empiric antimicrobials, while only 8% of patients develop a bacterial or fungal co-infection.[108] The SCCM guidelines recommend empiric antibiotics for mechanically ventilated patients with COVID-19 and respiratory failure based on low-quality evidence.[57] The NIH has stated there is insufficient data to recommend empiric broad-spectrum antibiotics in the absence of another indication.[7] If empiric antibiotics are initiated, they should be de-escalated as soon as clinically possible.

Numerous studies done in vitro have reported antiviral and anti-inflammatory effects of azithromycin, although the exact mechanism of antiviral activity is unknown.[109] There are currently no guideline recommendations in favor of azithromycin. Further, there is a theoretical possibility that doxycycline could have anti-inflammatory action against IL-6 and perhaps offer benefit in COVID-19.[110] While these medications are frequently prescribed out of the ED, there are no specific societal guidelines recommending their use in COVID-19 at this time.

Inhaled Nitric Oxide

Inhaled nitric oxide (NO) is a pulmonary vasodilator with theoretic antiviral effects.[111] In a 2004 study of 14 patients with SARS being treated in the ICU with noninvasive pressure support, NO use for three days was associated with improved oxygenation and a decrease in severity of infiltrates on imaging.[112] As with most treatments, data with NO use in COVID-19 is lacking. Therefore, SSC and NIH guidelines recommend against routine pulmonary vasodilator use but recognize that a trial of inhaled NO as a rescue therapy is reasonable and should be discontinued if there is no rapid improvement in oxygenation.[7,57]

Renin-Angiotensin-Aldosterone System (RAAS) Inhibitors

Early reports suggested an association of severe COVID-19 with renin-angiotensin-aldosterone system (RAAS) antagonist use leading to advice to discontinue this medication.[113] Three studies were recently published, with a total of 21,076 confirmed COVID-19 patients looking at RAAS inhibitors and risk of COVID-19. These studies did not demonstrate increased severity of illness with patients taking angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, calcium channel blocker, beta blocker, or thiazide diuretics.[114,115] The Heart Failure Society of America, the American College of Cardiology and the American Heart Association released a joint statement recommending these medications be continued in patients who take them for chronic medical conditions unless for actions based on standard clinical practice.[116]

Controversial Therapies

Aspirin

Currently, no guidelines specifically mention aspirin in their recommendations. Aspirin has a theoretical benefit for its antiplatelet, anti-inflammatory, and antipyretic effects. Studies have shown that aspirin has in vitro antiviral activity against influenza A, human rhinoviruses, and human cytomegalovirus.[117,118] Further, indomethacin has been shown to have a potent antiviral activity against SARS-CoV-1.[119] Multiple studies are currently enrolling and assessing the effects of aspirin in COVID-19 (NCT04365309, NCT04343001, NCT04363840, NCT04333407). Future research should focus on potential preventative effects of aspirin and its effects on disease severity, particularly in patients being discharged home from the ED.

LIMITATIONS

This paper has a few notable limitations. First, with the large volume and rapid publication of literature on this previously unknown subject, most lack validation. Some articles

regarding COVID-19 have been retracted after publication, although every effort has been made to be sure each citation was valid at the time of publication of this manuscript. Finally, only articles published in English were reviewed.

CONCLUSION

Evidence-based practice in the approach to COVID-19 is mercurial. Current literature focuses on the inpatient evaluation, treatment, and disposition of these patients. Interpretation and adaptation of current recommendations to patients in the ED is a crucial target for future literature. After our review of available literature, we have proposed an ED-specific flowsheet to assist clinicians during this time of medical ambiguity (Figure 3).

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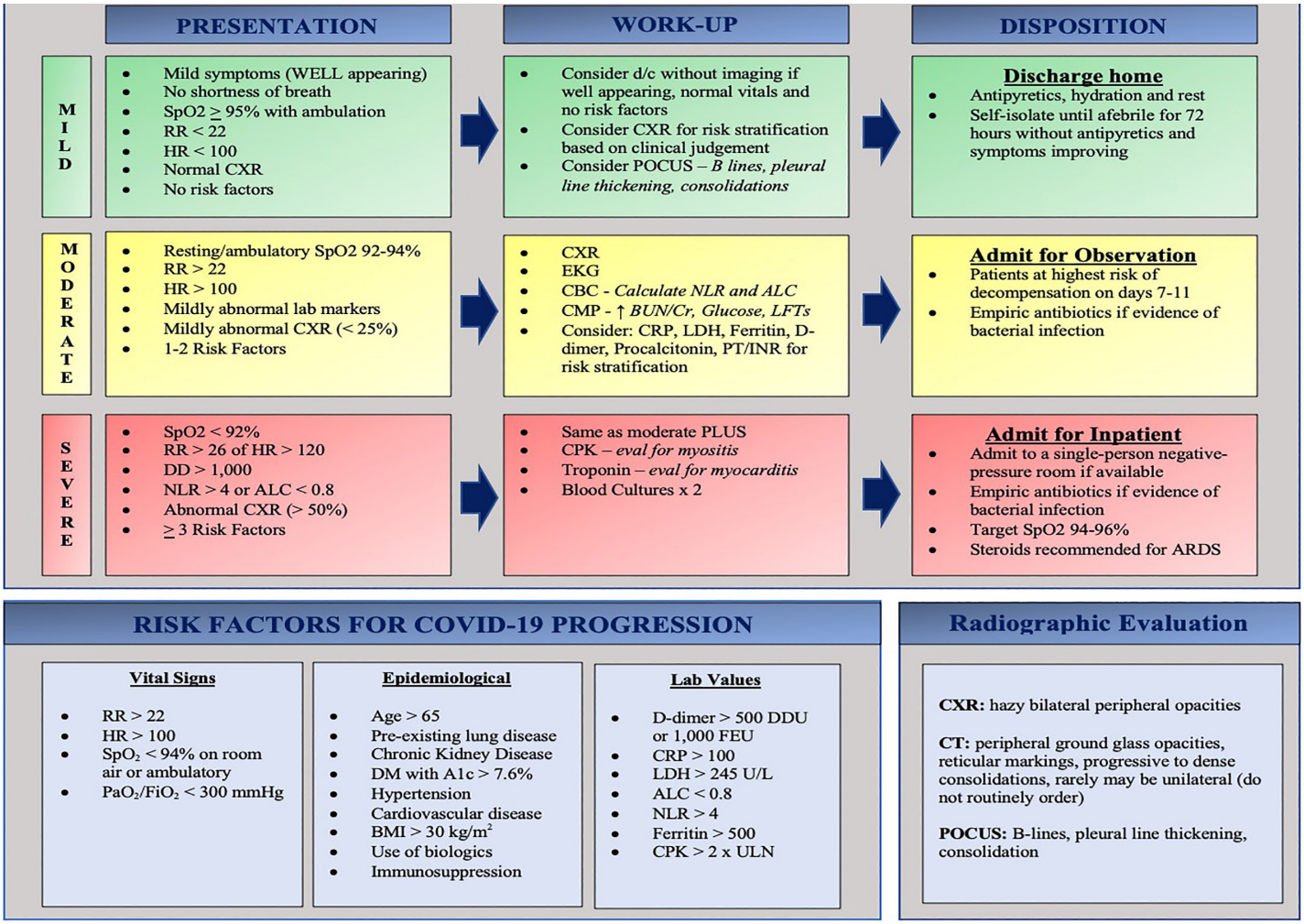

Figure 3. COVID-19 emergency department evaluation.
SpO_2, peripheral capillary oxygen saturation; RR, respiratory rate; *HR,* heart rate; *d/c,* discharge; *CXR,* chest radiograph; *US,* ultrasound; *POCUS,* point-of-care ultrasound; *EKG,* electrocardiogram; *CBC,* compete blood count; *NLR,* neutrophil to lymphocyte ratio; *ALC,* absolute lymphocyte count; *CMP,* comprehensive metabolic panel; *BUN,* blood urea nitrogen; *CR,* creatinine; *LFT,* liver function test; *CRP,* C-reactive protein; *LDH,* lactate dehydrogenase; *PT/INR,* prothrombin time/international normalized ratio; *CPK,* creatine phosphokinase; *ARDS,* acute respiratory distress syndrome; *PaO_2;* partial pressure of oxygen; *FiO_2;* fraction of inspired oxygen; *DM,* diabetes mellitus; *BMI,* body mass index; *CT,* computed tomography.

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Update on Neurological Manifestations of SARS-CoV-2

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Severe acute respiratory syndrome coronavirus 2, the source of COVID-19, causes numerous clinical findings including respiratory and gastrointestinal findings. Evidence is now growing for increasing neurological symptoms. This is thought to be from direct in-situ effects in the olfactory bulb caused by the virus. Angiotensin-converting enzyme 2 receptors likely serve as a key receptor for cell entry for most coronaviridae as they are present in multiple organ tissues in the body, notably neurons, and in type 2 alveolar cells in the lung. Hematogenous spread to the nervous system has been described, with viral transmission along neuronal synapses in a retrograde fashion. The penetration of the virus to the central nervous system (CNS) allows for the resulting intracranial cytokine storm, which can result in a myriad of CNS complications. There have been reported cases of associated cerebrovascular accidents with large vessel occlusions, cerebral venous sinus thrombosis, posterior reversible encephalopathy syndrome, meningoencephalitis, acute necrotizing encephalopathy, epilepsy, and myasthenia gravis. Peripheral nervous system effects such as hyposmia, hypogeusia, ophthalmoparesis, Guillain-Barré syndrome, and motor peripheral neuropathy have also been reported. In this review, we update the clinical manifestations of COVID-19 concentrating on the neurological associations that have been described, including broad ranges in both central and peripheral nervous systems. [West J Emerg Med. 2020;21(6)45-51.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the source of coronavirus disease 2019 (COVID-19), causes numerous clinical findings including well described respiratory and gastrointestinal findings. While literature on SARS-CoV-2 association with neurological findings was initially sparse, evidence is now rapidly growing for this potentially devastating link. Vigilance is important to recognize all possible sequelae of COVID-19; additionally, early detection and recognition is a mainstay of medicine across any disease.

During the initial outbreak in Wuhan, China, a wide range of clinical presentations was found beyond the typical respiratory symptoms, with close to 50% of patients having gastrointestinal (GI) symptoms, and 7% of patients having no respiratory symptoms.[1] While the US Centers for Disease Control and Prevention (CDC) definition of persons under investigation for COVID-19 has evolved, it generally includes the presence of fever and signs and symptoms of respiratory illness. While this may encompass a large number of cases, it also leaves a big gap in untested patients with minimal to no respiratory symptoms including those with only GI or neurologic symptoms. Earliest reports from Wuhan found that over 36% of patients had some degree of nervous system involvement, the most common being dysfunction of the central nervous system (CNS) with close to 15% of patients having complaints of dizziness or headache.[2] In this article we provide a review of central and peripheral nervous system (PNS) involvement of SARS-CoV-2 (Table 1).

METHODS

We conducted a literature review to obtain data regarding neurologic manifestations of COVID-19. All searches were done in May 2020 using Google searches, Google Scholar, and PubMed using combinations of the following keywords: "COVID," "CNS," "PNS," "neurologic," "coronavirus," "manifestation," "symptoms," and "nervous." Articles were initially selected based on their titles and abstracts for relevance to our review. Table 1 shows the case reports, reviews, and studies that were included in our review. We included articles that described central or peripheral nervous system neurological sequelae in patients with COVID-19. Articles were published between November 2019–May 2020. Exclusion criteria consisted of any articles that did not describe neurologic involvement of COVID-19. In total we included 26 articles in our review, which consisted of case reports and case series, as well as retrospective and prospective observational studies. We excluded 307 articles as not being pertinent to the neurological scope of this study. Also included in our review are articles that discuss potential mechanisms of neurologic involvement of COVID-19 to provide a better understanding of the disease process being described.

Population Health Research Capsule

What do we already know about this issue?
COVID-19 can severely affect many organ systems, including respiratory, gastrointestinal, and nervous.

What was the research question?
What are the current known neurological manifestations of the SARS-CoV-2 virus?

What was the major finding of the study?
Broad and diverse nervous system involvement, including central and peripheral nervous systems, have been identified.

How does this improve population health?
This review provides an increased awareness of the signs, symptoms, and presentations of neurological complications associated with COVID-19.

DISCUSSION

SARS-CoV-1 from the early 2000s was found to have neurologic spread, with evidence of the virus isolated from cerebral spinal fluid (CSF) fluid.[3] The route of entry to the brain appeared to be predominantly through olfactory bulb neurons.[3] The intense systemic inflammatory response associated with viral infection can lead to blood-brain barrier breakdown, allowing cytokines access to the CNS.[4,5,6] The penetration of the virus to the CNS allows for the resulting intracranial cytokine storm, which can result in complications such as acute necrotizing encephalopathy (ANE), CNS disturbances, headache, trouble walking, visual disturbances, weakness, and even stroke.[7,8] This cytokine response can cause a myriad of hematologic issues ranging from thrombosis to a hemophagocytic lymphohistiocytosis.[9]

Transmission of the SARS-CoV-2 virus can occur via droplet and contact transmission as well as through airborne route under specific circumstances.[10,11] SARS-CoV-2 can enter the CNS through the cribriform plate and cause neurologic symptoms.[5,6] Initially, a group from France looked at the utility of using hyposmia and hypogeusia as a screening tool for COVID testing, and found that close to 20% of patients who tested positive for SARS-CoV02 had self-reported hyposmia and hypogeusia.[12] This is thought to be from direct in-situ effects in the olfactory bulb caused by the virus. Due to the reported frequency of hyposmia and hypogeusia, the American Academy of Otolaryngology Head and Neck Surgery and the British Association of Otorhinolaryngology now recommend that these symptoms be added to the list of primary screening symptoms for COVID-19. However, this is not a finding that is unique to SARS-CoV-2, as many respiratory viruses have been associated with hyposmia and hypogeusia in the past.

In addition to the novel SARS-CoV2, other coronaviridae, enteroviridae, rhinoviridae, parainfluenza virus, and Epstein-Barr virus have all been associated with post viral olfactory dysfunction (PVOD).[13] While the percentage of patients with a viral illness who develop olfactory dysfunction is unclear, the phenomenon is well described in the literature. Quint and colleagues looked at a series of 120 patients who had nonconductive olfactory disorders and found upper respiratory infection (URI) to be the most common cause, occurring in 42.5% of the patients.[14] The olfactory dysfunction occurs in the acute symptomatic phase of the virus and then often persists for a prolonged period of time thereafter.[14] The initial dysfunction could be attributed to mucosal edema, but in many cases the olfactory dysfunction persists.

When explored further, varying pathologies were identified. Douek and colleagues identified extensive scarring on biopsy as well as replacement of the olfactory epithelium with respiratory epithelium in patients with PVOD.[15] Additionally, Jafek and colleagues found decreased numbers of olfactory receptors in patients with PVOD.[16] Yamagishi and colleagues also identified decreased numbers of olfactory receptors and nerve bundles in post-URI olfactory loss.[17, 18, 19] Early reports from Wuhan found that approximately 5% of patients had impairment of taste and smell, while later reports from Vaira et al demonstrate a much higher

incidence, upwards of 19% of the 324 patients evaluated.[20] Additionally, the reports out of Wuhan revealed 13% of patients had headaches, and in severe disease they noted acute cerebrovascular accident (CVA) presented in close to 6% of patients in the intensive care unit (ICU).[1] Central and peripheral nervous system involvement has been described through a variety of presentations.

Peripheral Nervous System

Guillain-Barré Syndrome

PNS findings include hyposmia and hypogeusia as discussed above, and there have been cases reported of Guillain-Barré syndrome (GBS). One case report described a confirmed COVID-19 patient who developed progressive bilateral ascending paralysis two weeks after developing respiratory symptoms.[21] This patient had electromyography and neuronal testing that was consistent with GBS and was treated with intravenous immunoglobulin (IVIG) 0.40 grams per kilogram per day; however, the patient refused lumbar puncture for CSF analysis. No outcome post treatment was reported.

A case series of five COVID-19 patients with new diagnosis of GBS in Northern Italy did report post-IVIG outcome measures.[22] All five of the patients were found to have CSF testing that showed less than five white blood cells per cubic millimeter, and negative reverse transcription polymerase chain reaction assay for SARS-CoV-2.[22] All of these patients underwent IVIG treatment, two of whom received a second course of IVIG and a third who received plasma exchange.[22] The outcomes reported that of the two patients who received a second course of IVIG, one remained in the ICU on mechanical ventilation at four weeks post-IVIG, while the other had bulbar symptom improvement although minimal improvement in extremity weakness. The patient who received plasmapheresis remained tetraplegic and ventilator dependent four weeks post treatment. Of the two patients who received only one course of IVIG, one who presented initially with only mild facial and upper extremity weakness had improvement of symptom and discharge; the other patient who presented with moderate to severe upper and lower extremity weakness was still unable to stand and was transferred to a rehabilitation center.

Bell's Palsy

Mehta et al described a case of a 36-year-old patient who presented with complaint of numbness, tingling, and weakness of the right side of his face.[23] This patient had fevers, chills, and myalgias for three days prior to his neurologic complaints. The right side of his forehead had no movement, and he was unable to close his right eye.[23] Computed tomography (CT) angiogram of the head showed no abnormalities. He was diagnosed with Bell's palsy, prescribed prednisone and eye lubrication, and discharged to an isolation shelter as the patient was homeless.[23] His COVID-19 swab came back positive, and the patient was transferred further to a COVID-19 isolation shelter.[23]

Goh et al described a case of a patient with facial nerve palsy that developed in a 27-year-old patient on day 6 of his illness with COVID-19, while having been hospitalized for three days.[24] The patient developed left-sided facial weakness that was preceded by left retroauricular pain and dysgeusia.[24] He was started on prednisone and valacyclovir, as well as lopinavir/ritonavir in an attempt to reduce SARS-CoV-2 viral replication.[24] After one week, the patient had no significant change in his facial nerve palsy symptoms.[24]

Central Nervous System

Cerebrovascular Accidents

From a CNS standpoint, there appears to have been an increase in cases reported of CVA with large vessel occlusion in people younger than 50, with many of these patients testing positive for SARS-CoV2.[25] Oxley et al found five cases of CVA in patients younger than 50 over a two-week period from March 23–April 7, 2020 ,with an average National Institutes of Health Stroke Score (NIHSS) of 17, indicating severe infarction. Researchers extracted data from every two-week period over the precedng 12 months and found the baseline rate of CVA in the mentioned age group was 0.73 patients in 14 days.[25] In another study, Li et al performed a single-center, retrospective observational study, which revealed that of the 219 patients with SARS-CoV-2, 10 (4.6%) developed ischemic stroke. Of the patients who tested positive for SARS-CoV-2, they were more likely to have an increased inflammatory response as reflected by the elevated D-dimer (6.9 [0.3-20] vs 0.5 [0.1-20] milligrams per liter [mg/L], $p<0.001$), and C-reactive protein (51.1 [1.3-127.9] vs 12.1 [0.1-212] mg/L, $p<0.05$) in these patients compared to patients who did not have SARS-CoV-2.[26]

The Mao et al study revealed a similar finding but took this point further. In their retrospective observational case series, they defined the degree of severity of SARS-CoV-2 infection as severe vs non-severe using the American Thoracic Society guidelines for community-acquired pneumonia.[27] Of the 214 patients who tested positive for SARS-Co-2, 88 patients had a severe infection and 126 had non-severe infection. Of those 88 patients, five (5.7%) developed cerebrovascular disease vs only one (0.8%) in those with non-severe infection.[2] This suggests that infection with the virus in isolation is not the sole factor for developing cerebrovascular disease. Rather, the illness severity could be playing a role, and likely corresponds to an increased inflammatory state.[2]

Cerebral Venous Sinus Thrombosis

Hughes et al reported of cerebral venous sinus thrombosis, where the patient had presented with headache that progressed to right-sided weakness, numbness, and expressive aphasia with a NIHSS of 10, which was confirmed on CT venogram to be a sigmoid and transverse sinus thrombosis.[28] This patient improved with low-molecular-weight heparin treatment and outpatient apixaban.

Acute Myelitis

There have been cases of acute myelitis, first reported in Wuhan in a patient who was admitted to medical ward for COVID-19, and subsequently developed acute bilateral lower extremity weakness, loss of sensation, hyporeflexia, and urinary incontinence.[29] This patient was positive for SARS-Cov-2, and serologic testing for a plethora of other potential causative agents was negative. Of note, they did find that this patient also had developed CNS involvement, with basal ganglia and periventricular lacunar infarcts.[29]

Acute Necrotizing Encephalitis

There have been reported cases of ANE associated with SARS-CoV-2, which is caused by breakdown of the blood-brain barrier rather than direct viral invasion, providing another route of CNS sequelae, even when the virus does not invade the neuron.[7,9] Radiographic manifestations for ANE include hemorrhagic rim-enhancing lesions within the bilateral thalami, medial temporal lobes, and subinsular regions on magnetic resonance imaging.[7] These patients present with fever, cough, and profound altered mental status. ANE is not the only cause of altered mental status by COVID-19 as there are a growing number of reports and concerns about severe ICU delirium associated with the disease.

Delirium

Beyond the typical causes of ICU delirium, patients with COVID-19 are at even higher risk due to the extreme isolation from human contact.[30] Early reports from Wuhan reported 7.5% of patients with delirium-like findings, but these were likely under-reported since 75% of cases are missed unless the patient is specifically evaluated for delirium.[2,30]

Parkinson's Disease

Patients with underlying neurologic dysfunction such as those with Parkinson's disease (PD) tend to have associated cardiovascular disease and respiratory dysfunction, which puts them at increased risk for developing severe COVID-19. Other comorbidities such as diabetes mellitus and CVA are often found in PD patients, which also places them at higher risk for developing severe COVID-19, given that PD patients on levodopa already have an independently higher risk of CVA.[31] Dyspnea is found in 39% of PD patients, which is secondary to respiratory dysfunction because of respiratory muscle weakness, poor posture, and inadequate respiration excursions.[32] Furthermore, these patients have impaired mastication and swallowing reflexes, leaving them more likely to develop aspiration pneumonia. The combination of these factors along with the neurodegeneration of the medulla's respiratory center, which also can be attacked by SARS-CoV-2, places the PD patient at higher risk for developing more severe pneumonia and ultimately respiratory failure.[33] Also, Parkinsonian hyperpyrexia syndrome, a movement disorder emergency, has been seen in PD patients with COVID-19 due to the combination of fever and altered dopaminergic medication intake.[34] Although the patients experiencing this phenomenon may recover from COVID-19, some are left with significant disability, while others may not survive.

Other Neurologic Sequelae

The aforementioned pathologies, and those listed in the accompanying table, demonstrate the broad range of neurological sequelae that have been described in the literature. Pathologies that have morbid outcomes, within the setting of potential treatment, were further expanded above. As more is revealed about COVID-19, the table will likely need further expansion of associated complications.

Mechanism

There are numerous theories on the potential causative mechanisms of the neurological sequelae, including the discussed olfactory bulb transmission pathway. Angiotensin-converting enzyme 2 (ACE-2) is a key receptor for cell entry for most coronaviridae, including SARS-CoV-2, and it is present in multiple organ tissues in the body, notably neurons, smooth muscle cells and hepatocytes, with significantly high concentrations in type 2 alveolar cells in the lung.[35] This explains why the virus predominates with respiratory symptoms, especially in the earlier stages. Hematogenous spread to the nervous system has been described, with viral transmission along neuronal synapses in a retrograde fashion.[35] This has been found in other coronaviridae, with viral transmission through the neuron via exocytosis and subsequent binding on ACE-2 receptors, propagating along neuronal channels into the CNS.[35] Neuro-invasion by SARS-CoV-2 is postulated to be at least partially responsible for exacerbating the acute respiratory failure patients with COVID-19 development.[33]

LIMITATIONS

This review has several limitations. Most important is that correlation does not equal causation. As the patients infected with SARS-CoV-2 developed a neurologic complication, the pathophysiology of the virus is unknown. Additionally, the findings described may be attributed to systemic critical illness rather than the etiologic virus specifically. Another limitation is that patients with neurologic symptoms in isolation of cough or fever were not widely tested for SARS-CoV-2 as per CDC guidelines, which have been rapidly evolving. This could in fact lower detection for further cases of neurologic manifestations in the context of a SARS-CoV-2 infection. Lastly, none of the studies reviewed in this article had a control group. There is no evidence in literature yet to identify whether a greater incidence of neurologic manifestations exist with SARS-CoV-2 compared to the inherent risks of developing these neurologic diseases in a native population.

CONCLUSION

While the respiratory manifestations caused by the SARS-CoV-2 virus, including significant progression to acute respiratory distress syndrome, are well described, there is a growing body of evidence describing multiorgan involvement, including neurologic sequelae from the virus. While anosmia and dysgeusia have been well documented as diagnostic symptoms from SARS-CoV-2, other peripheral system manifestations such as Guillain-Barré syndrome and ophthalmoparesis have also been seen. A wide spectrum of central nervous system manifestations has been observed from acute necrotizing encephalitis to transverse myelitis. In this review, we update the clinical manifestations of COVID-19 concentrating on the neurological associations that have been described so far, including broad ranges in both central and peripheral nervous systems.

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Table 1. List of the largest studies and respective study methodology of recently reported neurological pathologies associated with SARS-CoV-2.

Pathology	Level of evidence	Author
Central		
Large Vessel Occlusion - Cerebrovascular Accident	Retrospective observational study Case series (5 patients) Retrospective observational study Case series (10 patients) Prospective observational study	Mao L. et al[2] Oxley T. et al[25] Li Y. et al[26] Berekashvili et al[36] Lodigiani et al[37]
Transverse Myelitis	Case report	Zhao K. et al[29]
Seizure	Retrospective observational study Case series (22 patients) Case report	Somani et al[38] Galanopolou et al[39] Vollono et al[40]
Myasthenia Gravis	Case series (5 patients)	Anand et al[41]
Acute Necrotizing Encephalopathy	Case report	Poyiadji N. et al[7]
Acute Disseminated Encephalomyelitis	Case report	Zhang T. et al[42]
Encephalitis/ Meningoencephalitis	Case report Case report	Moriguchi T. et al[43] Lorenz et al[44]
Corticospinal Tract Signs	Observational series (58 patients)	Helms J. et al[45]
Posterior Reversible Encephalopathy Syndrome	Case report Post mortem study	Kaya et al[46] Coolen et al[47]
Cerebral Venous Sinus Thrombosis	Case report	Hughes et al[28]
Peripheral		
Anosmia and Dysgeusia	Retrospective observational study Cross sectional study Cross sectional study	Mao L. et al[2] Lee et al[48] Yan et al[49]
Motor Peripheral Neuropathy	Case report	Abdelnour et al[50]
Guillain-Barré	Case series (5 patients) Case report Case report	Toscano G. et al[22] Zhao H. et al[29] Virani et al[51]
Ophthalmoparesis	Case Series (2 patients)	Dinkin et al[52]
Bell's Palsy	Case report Case report	Mehta et al.[23] Goh et al.[24]

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CEdRIC: Strategy for Patient Education During COVID-19 Triage

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The current coronavirus disease 2019 (COVID-19) pandemic is forcing healthcare systems around the word to organise care differently than before. Prompt detection and effective triage and isolation of potentially infected and infectious patients are essential to preventing unnecessary community exposure. Since there are as yet no medications to treat or vaccines to prevent COVID-19, prevention focuses on self-management strategies, creating patient education challenges for physicians doing triage and testing. This article describes a five-step process for effectively educating, at discharge, patients who are suspected of being infectious and instructed to self-isolate at home. We are proposing the CEdRIC strategy as a practical, straightforward protocol that meets patient education and health psychology science requirements. The main goal of the CEdRIC process is to give patients self-management strategies aimed at preventing complications and disease transmission. The COVID-19 pandemic is challenging clinicians to rapidly teach their patients self-management strategies while managing the inherent pressures of this emergency situation. The CEdRIC strategy is designed to deliver key information to patients and standardize the discharge process. CEdRIC is currently being tested at triage centres in Belgium. Formal assessment of its implementation is still needed. [West J Emerg Med. 2020;21(6)52-60.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

Countries all over the world are facing a major public health security crisis related to the management of the coronavirus disease 2019 (COVID-19) pandemic. Every country will be affected, and governments around the world need to prepare a strategic response in order to minimize the impact of the disease and its spread on the morbidity and mortality of their populations, as well as the resulting social, economic, and political disruptions. A key ingredient of a healthcare system's response to COVID-19 is the ability to institute prompt detection and effective triage and isolation of potentially infected and infectious patients, with the goal of preventing unnecessary community exposure.[1,2]

The vast majority of suspected COVID-19 patients experience only mild symptoms,[3] and will be instructed to self-isolate at home while awaiting their test results. (This was the case with 77% of the patients who presented at the University Hospital of Liège triage centre from 2 March–4 May 2020.) Patients who test positive are advised to stay at home, provided they are not experiencing complications. Even those who test negative must be warned that they remain at risk of the disease. Hence, sustainability

and preventing healthcare system overload will depend on people's ability to care for themselves at home, while minimizing the risk of infecting their families.

Since there are as yet no medications to treat or vaccines to prevent COVID-19,[4] prevention focuses on self-management strategies: symptom monitoring; appropriate and frequent hand hygiene; cough etiquette; social distancing; and strict self-isolation.[5] Behavioural science must, therefore, be at the heart of the public health response,[6] especially when it comes to patient education. In emergency departments (ED), in particular, recommendations enhance the standard infection prevention and control practices.[7]

In most countries, the screening and triage of COVID-19 suspects are centralised at "triage settings." In Belgium, triage centres have been created specifically to screen patients referred by a physician and suspected of having COVID-19. Triage and screening centres have been set up at primary care facilities: first, near hospitals, to take advantage of their resources and experienced emergency staff; and second, at other, non-primary care facilities. Triage and screening tents (Figure 1) have been erected outside those facilities to reduce the risk to other patients and staff.

These settings serve two essential functions during the pandemic: 1) Triage: examining patients sent by outside doctors and likely to be infected with COVID-19. This prevents these patients from having to go to a general practitioner's waiting room or to a hospital ED, where they might infect others. If appropriate, they are referred to the hospital for admission. 2) Screening: testing to see whether patients are infected or not.

Patient screening and triage is a key opportunity for educating COVID-19 patients to prevent them from transmitting the disease. Effective triage should include patient education at discharge.[8] Despite the constraints (unpredictable workload, in particular), triage and testing settings should be viewed as a good place to improve future patient adherence to recommendations, thereby preventing complications[9] and, in this context, disease transmission. Patient education should also help health professionals (general practitioners in most cases) who receive calls from patients and arrange for remote triage. Unless there is a clinical need for in-person care, patients should be able to get advice and care without visiting the practice. Moreover, informing patients that they have COVID-19 is giving them bad news; delivering that bad news and offering education is challenging in an ED context because the patient is meeting the physician for the first time. Because – as has been previously demonstrated[10] – clinicians lack the skills needed for this, a support tool seems important.

Figure 1. COVID triage centre, University Hospital, Liège (Belgium).

Although patient education is a key component in the fight against COVID-19, health providers have no clear guidance on how to proceed. Here we propose a protocol for providing basic in-person and remote patient education to suspected or confirmed cases in patients who are instructed to self-isolate at home. Patients who are admitted to hospital require special attention and are excluded from the discussion.

The Five-step CEdRIC Strategy

While the need for patients to understand discharge instructions is well established in the literature,[11] in emergency situations – especially mass casualty events – discharge communications may be reduced to a brief exchange,[11] leaving patients uncertain about what to do when they return home; this is especially true for patients with low health literacy. The CEdRIC strategy is a practical, straightforward protocol that meets the requirements for effective discharge patient education adapted to the special conditions made necessary by the current situation. The CEdRIC protocol consists of five steps that clinicians can use to develop a structured approach to discharge instruction (see Table 1 for an overview of the protocol). Each step is supported by references to the education and health psychology literature.

*Step 1 – Ensure that the patient **C**omprehends and accepts the situation.*

The first step after testing and triage involves giving the patient information about his condition, its potential course, and how to self-isolate at home. This information can cause great anxiety when people do not understand why they are being advised to go home while potentially infected with COVID-19. As anxiety impairs patients' ability to take in and process new information,[12] it is important that clinicians listen to and reassure their patients. Clinicians can use open-ended questions to determine how well the patient understands his medical situation.[13]

Jay (1996)[14] showed that methods such as "touch, company and information" are effective in reducing anxiety in seriously injured patients. Information is the only one of these three types of action that is appropriate and applicable in triage settings. Informing patients and raising their awareness of their clinical situation involves two tasks:

Table 1. CEdRIC strategy: a five-step process to improve education of suspected or confirmed COVID-19 patients who are instructed to self-isolate at home.

	Steps	Objective(s)	Features/strategies	Sample sentences to be used with the patient
C	Comprehension of the situation	To inform the patient about their situation To address patient's anxiety	Strike a balance between the seriousness of the situation and reassurance. Inform the patient about strategies for avoiding disease exacerbation and transmission.	"You are showing the symptoms of COVID-19. We can't test you because there are not enough tests available. They are reserved for people requiring hospitalization. Hearing this makes you worried/anxious! Most patients experience mild to moderate flu symptoms (fever > 38°C, cough, headache, etc.), which take time (at least 2 weeks) to diminish or disappear. At that point they have recovered from COVID, but may still be contagious. In all of these cases (and most likely yours), you do not need to be hospitalized. There is no specific treatment for COVID-19. You must take the necessary preventive measures for yourself (to avoid secondary infection) and for others (to avoid infecting them). We can relieve your symptoms, however (antipyretic, antitussive, inhaler, etc.). We will tell you what to do."
Ed	Patient Education about self-management strategies	To instruct the patient on how to take care of themselves and how to protect relatives from infection	Give patients clear instructions about what to do. Reinforce the patient's sense of control, value, and self-efficacy regarding self-management strategies. Use clear verbal communication.	Stay home Monitor your symptoms carefully. Rest and drink lots of fluids. If you have a medical appointment, call the healthcare provider ahead of time and tell him or her that you have, or may have, COVID-19. Cover your cough and sneeze. Wear a face mask whenever you are around any other people. Wash your hands often. Whenever possible, stay in a specific room and away from other people in your home. Do not share your personal items with others. Clean all frequently touched surfaces.
R	References to reliable resources	To point patients to reliable websites and free helplines	Choose evidence-based, easy-to-understand references.	Resources (fill in as appropriate) (Examples from the New York State Department of Health. https://www.albanyny.gov/Government/MayorsOffice/COVID19ResourceGuide.aspx)) www.cdc.gov www.who.int You should call New York State Department of Health at 1-888-364-3065 or Albany County Department of Health at (518) 447-4580 to receive guidance on what to do and how to self-quarantine. Provision of resource materials to patients
I	Explanation about what to do in case of emergency	To bolster patients' ability to monitor and detect symptoms of worsening disease	Inform patients about red flags that should prompt them or other family members to seek medical attention.	"Emergency warning signs include difficulty breathing; new or persistent pain or pressure in the chest; new confusion or inability to wake up; bluish lips or face; discomfort. This list may not describe all possible symptoms. Please consult your healthcare provider for any other serious or worrying symptoms".
C	Checking the patient's comprehension	To assess how well patients understand the instructions To make patients aware about contact tracing	Use the teach-back method Address learning transfer Give patients an opportunity to ask questions.	"We've talked a lot today and I want to make sure I've explained things properly. So let's review what we've been talking about. Can you describe the main instructions on how to prevent complications and the spread of COVID-19?" (If this reveals a misunderstanding, explain again using a different approach). "What are your questions?" (Don't say "Do you have any questions?" since most patients will respond to this by saying "no"). "You will be contacted or invited by authorities shortly to let them know your contacts during the last 7-10 days. Please cooperate actively for contact tracing in order to avoid the spread of the disease."

dealing with their emotional response; and developing a strong rationale. Dealing with a patient's emotional response is difficult. Health professionals must strike a delicate balance between reassuring patients that it is safe to return home and convincing them of the seriousness of the situation, so that they do not minimise the problem.[15]

The large majority of patients who are at low risk should be told that in most people the disease is not as severe as the media reports, and that there are strategies for avoiding transmission to their families (see Step 2). Indeed, recent research suggests that the real-world mortality rate may be lower than previously reported and that the vast majority of suspected COVID-19 cases experience none or only mild symptoms.[3,16,17,18] This could be due to the "iceberg" effect, in which there are many more patients below the surface who act as a reservoir of "spreaders" transmitting the disease to the rest of the population, and include the more vulnerable of those at risk of severe disease. Patients should, however, be warned that this new virus appears to be highly contagious,[19] and requires strict self-isolation.

Step 2 –Educate the patient about self-management strategies.

An important part of this step is making sure that the patient develops "*an accurate mental model of the process of transmission that provides a strong rationale for what they need to do to prevent it*".[15] Rather than just telling people what not to do, the main goal of Step 2 is to give patients clear instructions about what they should do and why. An example (Figure 2) will illustrate the point.

At a minimum, patients should be instructed on how to take care of themselves; in that regard, see the Michie et al (2020)[6] review of advice from the World Health Organisation, US Centers for Disease Control and Prevention, and Public Health England, setting out 13 behaviours important for reducing transmission (see Table 2). As patients' families are usually not allowed in the triage room, patients should also be instructed on how to protect their relatives from transmission.

These recommendations should be described, demonstrated, commented upon, and practiced (at least mentally), so that patients develop a sense of self-efficacy,[21] that is, self-esteem regarding their own capacity to perform these acts at the appropriate time, place, and frequency. This sense of mastery (what Bandura calls "self-efficacy," or the feeling of being competent) is one of the three most important factors explaining involvement and perseverance in tasks (at least in the educational context). The other two factors[22] are perceived value (of the actions, ie, how effective they are, and their ethical value) and perceived control (ie, does the result depend on my efforts; how much control do I have?). The latter is related to the concept of causal attribution, as described by Rotter (1990),[23] while the former distinguishes internal locus of control (results depend upon me) from external locus of control (chance, or other factors beyond my power). Weiner (1985)[24] distinguishes belief in the changeability or immutability of causes. The more a task is perceived as internally controllable and modifiable by the patient himself, the more likely his involvement.

As an example, consider Michie et al[6] behaviour #9 (out of 13) : *"social distancing: if not caring for a symptomatic person, avoid contact and proximity. Maintain distance between yourself and other people, particularly those who are coughing, sneezing, or have a fever."* The caregiver should not just give the patient models of behaviour (see "the long hand" above), but also ensure that the patient is – and feels – able and willing to perform them. Without this, there is a risk that the patient will feel powerlessness, what Seligman (1972)[25] calls "learned helplessness" and even give up on doing those behaviours.

Clear verbal communication strategies (see Table 3) should be used to help patients better understand health information.[26-29]

Figure 2. Social distancing: suggested gestures to replace close contact: "the long hand."[20]

In the context of social distancing, Leclercq (2020)[20] has suggested gestures that could replace close forms of contact such as hugging or kissing to communicate deep sympathy in highly emotional situations like funerals, weddings, anniversaries, and childbirth. The author advises against gestures (such as footshakes, fist-bumps or elbow-bumps) that require approaching the other person. Similarly, he rejects gestures that bear a commonly shared religious connotation (Muslim, Hindu or Christian greetings) or that have connotations of ordering, praying, begging, obeying, etc. To take advantage of the automaticity of "shaking" (in French "serrer la main = to tighten), this author recommends two gestures visible from a distance: on the left, when both hands are free, and on the right (fingers spread apart) when only one hand is free.
In both cases, he recommends reinforcing these gestures by looking the addressee in the eye, uttering (audible or not, but visible) words of sympathy (as brief as possible, such as "I am with you" or the even shorter "With you"), and, finally, a small nod of the head. The signs should be customized according to the context (a sad or a happy one).

These gestures were chosen for their simplicity and sensoriality (pressing hands instead of pressing the other person's body), to avoid any similarity to religious signs or giving the impression of mimicking sign language for the deaf (which differs from country to country).
Since sender and receiver should have the same understanding of such gestures, they should be promoted by mass media and social networks, so that they "go viral" like COVID-19 has. National government media outlets could get this started, after which local and private media outlets could take over and spread the message

Step 3 – Refer the patient to reliable resources

As the conditions for education are suboptimal (crowded facilities and very stressed patients who may be in pain), other forms of education such as written material or videos are a useful accompaniment to verbal instruction. Health professionals should steer patients to reliable websites and free helplines to prevent them from being bombarded with misinformation. All recommended resources should give evidence-based information and be easy to understand. The CDC and COVID-19 Health Literacy Project websites (www.cdc.gov/COVID19 and https://covid19healthliteracyproject.com, respectively) offer an excellent selection of such resources (see Table 4 for patient education resources).

Table 2. Thirteen behaviours to reduce transmission[6] (© 2020 Susan Michie & BMJ Publishing Group Ltd. All rights reserved. Reproduced with permission).

Group of behaviors		Behaviors
Hand hygiene	1.	Wash hands regularly with soap and water for at least 20 seconds.
	2.	Always wash hands: • after coughing and sneezing • after touching nose or mouth • after caring for the sick • before, during, and after food preparation • before eating • after using the toilet • after handling animals or animal waste.
	3.	If soap and water are not available, use an alcohol-based hand sanitiser. This is particularly important after taking public transport.
Surface hygiene	4.	Clean and disinfect frequently touched objects and surfaces in the home and work environment.
Respiratory	5.	Cough or sneeze into crook of elbow or tissue. Stifle sneeze as much as possible.
	6.	Immediately dispose of tissue into closed bin after coughing or sneezing.
Touching	7.	Do not touch mouth, eyes, or nose with unwashed hands.
Self-isolation	8.	If symptomatic or otherwise advised to, stay at home for 14 days.
Social distancing	9.	If not caring for a symptomatic person, avoid contact and proximity. Maintain distance between yourself and other people, particularly those who are coughing, sneezing, or have a fever.
Healthcare	10.	If experiencing a fever, cough, and difficulty breathing seek medical advice early and describe previous travel history to the healthcare professional.
	11.	If recently arrived from specified countries within the last 14 days, call a telephone helpline.
Personal protective equipment	12.	If caring for someone who has been diagnosed, wear facemasks, eye protection, and gloves.
Food safety	13.	Avoid eating raw or undercooked animal products. Handle raw meat, milk, or animal organs in such a way as to avoid cross-contamination with other foods.

Written instructions can be effective, provided they are not used alone and meet some basic requirements such as simplified language, large font, and a user-friendly format.[30] However, studies that have examined the content of written instructions have found that they require an inappropriately high reading level.[31,32] Written text should follow the recommendations by Flesch (1940),[33] namely, to use short sentences and short terms (commonly used words are usually short). There is software that automatically generates Flesch Reading Ease (FRE) scores for readability (the scores range from 0-100 in English; the range varies for other languages). Readability can be tested here: https://readabilityformulas.com/free-readability-formula-tests.php. For instance, the poster named "10 things you can do to manage your covid-19 symptoms at home" (see Appendix) has a FRE score of 64.8, which can be interpreted as "Easily understood by 13–15-year-old students."

Whenever possible, use iconic messages, since as Paivio (1968)[34] has described, when we see a known object (or its image), its name (if known) goes automatically into working memory. He called this mechanism "dual coding." There are various ways to test the understandability of an icon (for instance the 10 icons in the "10 Things" document). One of them consists in presenting the picture (without the text, but mentioning the theme, the title of the poster) to a sample of persons representing the target population. The testees are invited to translate the picture into words. The more the icon is translated in the same way as the (non-visible) text, the more appropriate the icon to "double" the text.

Repeat iconic messages using verbal ones (words). Shannon and Weaver (1949)[35] demonstrated the importance of repetition in ensuring complete transmission of the information contained in a message and compensating for noise that can contradict, hamper, or – even worse – distort the intended meaning. Comment on the pictures using words and arrows. Arrows and/or crosses guide the sense of the reading; the sequence of gestures helps the brain make links, steps, and inferences. Salomon (1972)[36] coined the term "supplantation" to describe the mechanism by which media takes charge of a mental operation rather than letting the learner's brain conduct it itself. Some examples of how this can reduce a learner's mental workload are the camera zooming in and out in a film, or the use of arrows in a figure to guide the reader's gaze, or sound prompts or cues to indicate that it is time to execute an action, or heart rate devices that confirm cardiac arrhythmias that patients could/should detect themselves. Supplantation is a short-term strategy, since the patient does not learn to do these things unaided.

Table 3. Communication strategies to help your patients better understand health information.

- Use plain, non-medical language.
- Speak clearly and at a moderate pace.
- Prioritise what needs to be discussed.
- Limit information to 3-5 key points.
- Repeat them.
- Duplicate verbal information with iconic messages to ensure dual coding.
- Reinforce verbal instructions with a written version, and follow the written version when speaking. (It can serve as a cheat-sheet.)
- Cite online links.
- Suggest where to display the written instructions at home.
- Give the patient the document.

Step 4 – Explain to the patient what to do In case of emergency.

Step 4 aims to enhance patients' ability to monitor and detect symptoms that indicate worsening of their disease. To do that, health professionals tell patients about red flags (for instance, difficulty breathing, new or persistent pain or pressure in the chest, new confusion or inability to wake up, bluish lips or face, discomfort, temperature over 39°C, and headache, etc.) that should prompt them to seek medical attention or advice. Vashi and Rhodes (2011)[37] found that although 76% of patients were given an explanation of their symptoms, only 34% were given instructions on what to do if their symptoms worsened. Therefore, it is important that health professionals prompt their patients to seek medical attention and to consult their healthcare provider for any other serious or worrying symptoms.

Step 5 – Check the patient's comprehension of the information given and explore the patient's questions.

The final step involves assessing how well the patient understands the instructions. Studies in ED settings found that even when they reported high levels of satisfaction with communications, a majority of patients did not understand their diagnosis or instructions for returning.[11] *"The literature suggests asking if patients understand is suboptimal."*[38] Patient discharge could be improved by two simple guidelines: use the teach-back method, and explore the patient's questions. The teach-back method is a communication method that tests whether a patient understands what has been explained. Patients who understand are able to "teach-back" the information accurately using their own words.[39] Systematic reviews have shown that the teach-back method yields better outcomes regarding disease-specific knowledge and better adherence to self-management instructions in chronic disease and emergency settings.[40,41]

Step 5 also is a key time to consider whether the patient is able to transfer what he has learned. Education is successful when the participant applies what he has learned to his behaviour. Transfer should to be assessed by asking the patient how he will apply what he has learned about prevention at home. To make at-home application of recommendations more likely, it could be suggested that visual aids be made permanent in the user's environment (for instance by posting recommendations on the refrigerator).

Finally, a moment should be taken at the end to listen carefully to the patient's main concerns. Healthcare providers should give patients an opportunity to ask questions. Because it is essential that patients understand their instructions, this last step is crucial. It is natural and expected that what the learner knew before being given instructions interacts with the new knowledge, leading to new questions. Healthcare providers should give patients time to absorb the information, ask questions, and react.[42]

DISCUSSION

Clinicians engaged in COVID-19 triage face a major challenge: that of quickly establishing an effective rapport with patients who are instructed to return home, in order to optimise patient self-management after discharge. In this context, the CEdRIC strategy can be viewed as an attempt to achieve essential goals: enabling patients to understand their medical situation; preventing complications; supporting patients; helping patients make effective use of available health services; and managing patients' stress regarding the situation. Those goals are aligned with the core competencies described in the World Health Organisation report on patient education.[43] Due to the acute, infectious nature of this disease, educators have to teach patients new skills such as communicating prevention measures to their families and adhering to strict self-isolation and hygiene measures to avoid transmitting the disease.

The triage context requires a new patient education format adapted to the emergency situation. First, while the recommendations generally advise allowing sufficient time for patient education and listening to what the patient knows and needs, and adapting education activities to the patient's psychological readiness,[44] the pandemic nature of COVID-19 demands a short format appropriate for triage and testing settings. Second, patient education in this context is by necessity less personalised and more focused on public health, with activities focused mainly on the self-isolation and hygiene measures appropriate to each patient's situation. Third, as a consequence of the previous point, the basic steps of patient education no longer apply. In particular, the CEdRIC process bypasses two of those steps: exploring the patient's overall needs (it focuses on knowledge rather than psychosocial needs), and negotiating the educational objectives (since the intervention is not person-dependent). It does, however, allow time for discussion at the end of the process. It takes around 15 minutes to implement CEdRIC strategy. It's important to stick to the five steps and their related contents in order not to drift away from the main objectives of CEdRIC. Table 1 should be used as a checklist in that view.

Table 4. Coronavirus 2019 resources for patients (from the CDC* and the COVID-19 Health Literacy Project).

CDC	COVID-19 Health Literacy Project
• Use plain, non-medical language. • Speak clearly and at a moderate pace. • Prioritise what needs to be discussed. • Limit information to 3-5 key points. • Repeat them. • Duplicate verbal information with iconic messages to ensure dual coding. • Reinforce verbal instructions with a written version, and follow the written version when speaking. (It can serve as a cheat-sheet.) • Cite online links. • Suggest where to display the written instructions at home. • Give the patient the document.	• COVID-19 Prevention: This fact sheet explains how you can help prevent the spread of COVID-19. • About COVID-19: This fact sheet explains what you need to know about COVID-19. • Managing COVID-19: This fact sheet explains what to do if you are sick with COVID-19, or suspect you are infected. • COVID-19 and pregnancy: This fact sheet explains how COVID-19 affects you if you are pregnant, or planning to become pregnant. • COVID-19 for 3-6 year olds: This fact sheet can help 3-6 year olds understand the important information about COVID-19. • COVID-19 for 6-12 year olds: This fact sheet can help 6-12 year olds understand the important information about COVID-19. • COVID-19 for 13-18 year olds: This fact sheet can help 13-18 year olds understand the important information about COVID-19.

**CDC*, US Centers for Disease Prevention and Control; *COVID-19*, coronavirus disease 2019.

Despite these limitations, triage, remote consultations, and discharge offer unique opportunities for teaching patients which strategies they should use to take care of themselves and limit disease transmission. While the literature offers a variety of discharge education approaches, several studies have shown that oral communication and instructional tools are relatively fast and effective techniques, and are appropriate for improving knowledge and comprehension.[30] Effective education should incorporate health literacy concepts.[45] This means that all of the relevant information should be delivered in a format that patients can understand.[11] The CEdRIC strategy borrows a number of tools from the Health Literacy Universal Precautions Toolkit[26]: raising awareness; communicating clearly; using the teach-back method; and encouraging questions.

Even if the pandemic ebbs, vigilance and prevention will be needed for a long time. Health promotion actors should take the CEdRIC strategy beyond the hospital context and into the daily environments of individual citizens.

The CEdRIC strategy is currently being tested in a triage setting at the University Hospital in Liège. Since it is a health innovation, it needs to be adopted and adapted by healthcare providers. The strategy's effectiveness must be documented as well. The COVID-19 pandemic is causing worldwide disruption. We believe that the CEdRIC strategy could be a part of the innovation so necessary to overcoming this crisis.

CONCLUSION

Prompt detection and effective triage and isolation of potentially infected and infectious patients are a cornerstone of the pandemic response.

Discharge from triage is an opportunity to educate patients who are being instructed to return home in self-management strategies, which are the only measures currently recommended for prevention of COVID-19 transmission.

The COVID-19 pandemic requires clinicians to quickly teach their patients self-management strategies while managing the inherent pressures of an emergency situation.

The CEdRIC strategy is a practical, straightforward five-step process for delivering effective triage discharge instructions to suspected COVID-19 patients told to stay home.

The main goals of the CEdRIC approach are to provide self-management strategies for preventing complications and disease transmission.

Further study is needed to assess the CEdRIC strategy's effectiveness.

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Telemedicine to Decrease Personal Protective Equipment Use and Protect Healthcare Workers

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TO THE EDITOR:

Infectious disease outbreaks, such as coronavirus disease 2019 (COVID-19), place tremendous strain on availability of personal protective equipment (PPE) and frontline healthcare providers. Readily available PPE can substantially reduce the rate of infection in healthcare workers and the spread of the illness.[1,2] The lack of adequate PPE places providers at increased risk of infection, increases healthcare worker stress, and decreases staffing as providers fall ill. We know that inadequate PPE and risk of becoming infected are primary concerns of healthcare providers during pandemics, serving as key drivers in their willingness to work.[3,4] Therefore, it is imperative that efforts are undertaken to minimize the threat facing them and their families.[5] Here, we describe an emergency department (ED) effort to safely limit PPE use and decrease the risk of illness to providers by implementing telemedicine to care for patients already within our department walls.

LEVERAGING IN-ROOM TELEMEDICINE FOR INFLUENZA-LIKE ILLNESS PATIENTS

Patients approaching our ED are screened outside by a nurse in full PPE for influenza-like illness symptoms. For those who screen positive, a tele-registration protocol is initiated. Using a secure device, a patient's photo identification and phone number are forwarded to registration staff, who then complete the registration process remotely by phone. Those with mild symptoms are directed to a drive-through, where a telemedicine cart facilitates an encounter with a physician who determines the need for a swab. A nurse in PPE moves from vehicle to vehicle performing swabs and providing standardized discharge instructions.

Patients with severe symptoms are redirected to an alternate ED entrance, which leads into an anteroom that immediately separates potentially positive patients from the general ED population. ED rooms are outfitted with a wall-mounted television and wide-angle camera with directional speaker system. After trialing this system, we found that it was more efficient and effective to use iPads (Apple Inc, Cupertino, CA) on rolling stands because they worked more reliably, were easier for physicians to use, and required fewer room entries for configuration. Following a successful pilot, each ED room and clinician work area was outfitted with an iPad and stand for a total of 100 units across both our adult and pediatric EDs.

This system has the additional benefit of being relatively cost efficient, with each iPad and stand costing $1099.40 per unit. This means for an average ED with approximately 30 beds and four physician/nurse work areas it would cost $37,379.60 for a similar telemedicine system. Optimal utilization of this system requires synchronized team communication. For most encounters, the number of providers required to enter the patient room can be reduced to one. The rest of the care team (including trainees, nurses, consultants, and interpreters) can observe and engage via telemedicine. In addition, critical care physicians can provide input remotely during high exposure-risk resuscitations.

SUMMARY

Telemedicine saves at least one to two interactions per patient that would otherwise require PPE. While this strategy minimizes unnecessary exposures for our healthcare workers, they are not restricted from physically assessing patients when deemed necessary. The risks and benefits of physical interaction requiring PPE are left to provider discretion, although we found that most COVID-19 patients under investigation at our ED can be managed through telemedicine.

Research has shown that telemedicine is safe and effective, and that the degree of illness severity can be assessed without direct interaction.[6] While direct auscultation of the chest cannot be performed remotely, the value of this exam for these patients is debatable. Auscultation alone has poor interobserver agreement and

can miss 50% of pneumonias, which are better predicted by oxygen saturation less than 95%, fever, and tachycardia, with the gold standard being chest radiograph (CXR).[7–10] Respiratory status can be assessed reliably by talking with the patient, evaluating his or her history, and observing for objective signs of respiratory compromise, with the addition of a CXR when indicated.

Our ED had a sophisticated telemedicine system built into every ED room prior to COVID, yet we found that a low-cost iPad-based system was more effective and could potentially be quickly deployed in other settings to conserve valuable PPE and prioritize healthcare worker safety. During the COVID-19 pandemic, healthcare systems and providers must rapidly innovate and disseminate practices that strengthen our crisis management capabilities.

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Preparedness, Adaptation, and Innovation: Approach to the COVID-19 Pandemic at a Decentralized, Quaternary Care Department of Emergency Medicine

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The COVID-19 pandemic has required healthcare systems to be creative and adaptable in response to an unprecedented crisis. Below we describe how we prepared for and adapted to this pandemic at our decentralized, quaternary-care department of emergency medicine, with specific recommendations from our experience. We discuss our longstanding history of institutional preparedness, as well as adaptations in triage, staffing, workflow, and communications. We also discuss innovation through working with industry on solutions in personal protective equipment, as well as telemedicine and methods for improving morale. These preparedness and response solutions and recommendations may be useful moving forward as we transition between response and recovery in this pandemic as well as future pandemics. [West J Emerg Med. 2020;21(6)63-70.]

BACKGROUND

The COVID-19 pandemic has led to over one million infections in the United States (US), making the US the leader in both total number of infections and deaths due to SARS-CoV-2. Variation in public health response around the world is one of the many reasons that resulted in some countries being affected more heavily by the pandemic than others. Countries such as Vietnam and South Korea, which had early case counts[1] but aggressive countermeasures such as shelter-in-place orders and widely available testing had success against the virus. Efficacy of a response is partially related to preparedness.

The most serious recent pandemic the US experienced was H1N1 influenza in 1918.[2] Several pandemics since then, including H1N1 influenza in 2009, were impactful and led to preparedness plans at institutional, state, and national levels.[3] The Ebola virus disease (EVD) outbreak in West Africa in 2014-2015 led to additional preparedness ventures in the US.[4] This included standing up the National Ebola Training and Education Center (NETEC), recently rebranded as the National Emerging Special Pathogen Training and Education Center, to assist with frontline and facility-level preparedness focused on pathogens like Ebola transmitted through body fluid exposure.[5] Conversely, some countries in Asia have had prior experience with respiratory pathogens through outbreaks of severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome and have a robust response plan.[6-8] We know this preparedness is important, as swift response by countries such as South Korea led to disproportionately fewer deaths due to COVID-19 than others affected at the same time.[1]

As of this writing (August 18, 2020), the State of Georgia ranked fourth in the US in numbers of confirmed COVID cases (238,861),[9] and has experienced 4727 deaths.[10] The

Emory University Healthcare system is a large, decentralized, quaternary care system with multiple hospitals and many levels of medical and nursing leadership. The Emory Department of Emergency Medicine covers the entire system within a single leadership structure representing over 500,000 annual patient visits across seven emergency departments (ED). Our experience with COVID-19 has been within this context, and in our initial wave we saw over 1500 COVID-19 positive patients in our EDs (March 14 - April 27, 2020). Although we have not experienced the incredible surges seen in New York, our case burden necessitated a robust response, and we have had many successes as well as opportunities to improve our care and processes. For example, testing shortages statewide initially reduced our ability to test. In response, our institution worked to stand up our own proprietary testing, only to be later plagued by swab shortages. We believe that an assessment of our pandemic response, preparedness, and implementation provides an opportunity to reflect and share our experiences with others in the medical community**.** Below we detail the main take-aways and recommendations from our experience.

PREPAREDNESS DURING PRE-PANDEMIC TIMES IS IMPERATIVE

Because of our institution's pre-existing relationship with national public health leadership including faculty who hold joint appointments with the CDC, we were fortunate to have a robust, serious, communicable disease program in a steady state of preparedness. This state of preparedness was born out of a mission to provide assistance to employees of the CDC, physically located beside our campus in Atlanta, and bolstered by the EVD outbreak in 2014-15 in which the program successfully and safely cared for multiple patients with EVD. This program includes both nurses and providers trained and ready to care for patients with serious communicable diseases in our biocontainment unit. Regular training and drills involve personal protective equipment (PPE) donning and doffing sessions for powered air-purifying respirators (PAPR) level and high-level (face mask or N95, eye protection, contact gown, and gloves) PPE, a group of nursing "super users" who practice delivering care in their PPE quarterly, and real-time exercises in the ED alongside our Serious Communicable Diseases Unit (SCDU) team.

A real asset has been our ED's close association with nurses and faculty members embedded within the SCDU team, the benefit of which became readily apparent when the ED was included early in planning as COVID-19 became a reality in the US. These pre-existing skills were helpful as we had established practices converting our ED to care for a serious communicable disease, and had been early adopters of a universal travel screen to isolate patients with infectious symptoms away from our large population of immunocompromised patients. We also had high-level PPE trainers ready to mobilize as it became necessary to partner with ancillary staff, such as radiology and environmental services. At one ED, we trained 218 nurses and providers to safely don and doff high-level PPE in one week using the scalable, pre-trained "super user" approach. Although other institutions may not have the same relationship with the CDC, there are still many ways that an institutional state of preparedness can be maintained.

Preparedness Recommendations

1. Maintain a cadre of healthcare workers trained as PAPR and high-level PPE super users, including nurses and providers, with quarterly recertification and donning and doffing drills in PPE.
2. Maintain a standard operating procedure (SOP) for care for patients with serious communicable disease, with which department administration is familiar and can be rapidly deployed and scaled as necessary.
3. Use a universal travel screen at patient entry points to screen and isolate patients with infectious symptoms.[11]

ADAPTABILITY – IN TRIAGE, WORKFLOW, STAFFING, AND COMMUNICATION

Our department was able to adapt to the rapidly evolving information regarding the science, availability of resources, and system responses in addressing the changing needs of our patients, as well as to hone early, less-than-ideal processes. Some of this stems from the baseline adaptive outlook of emergency medicine (EM) operations, where the constant state of changing workflow truly is our steady state.[12] Below we detail specific adaptations in *one of our EDs*, including our triage, workflow, and staffing algorithms (Figure 1). These adaptations, protocols and practices were widely adapted across our EM service line.

Triage

We started to screen patients with recent travel to China with fever or cough in January 2020, guided by early recommendations from our Infection Prevention (IP) team. Patients were triaged to one of two negative pressure rooms and IP was contacted for co-management of each patient. Patients pending triage waited in a small, enclosed, negative-airflow waiting room, which was ultimately found not to be ideal as patients with fever and respiratory complaints were sitting in close proximity for hours; thus, early on we adapted triage procedures to manage the increase in volume of persons under investigation (PUI) for COVID-19, specifically through a split-flow operational model. Because of our immunocompromised patient population and small physical space, we split our triage and ED flow into infectious/respiratory complaints and non-respiratory complaints before the patients entered the treatment space. We initially used a symptom screen to identify infectious/respiratory complaints that included fever, cough, and shortness of breath, and then expanded this screen when additional characteristic COVID-19 symptoms were recognized. This split triage

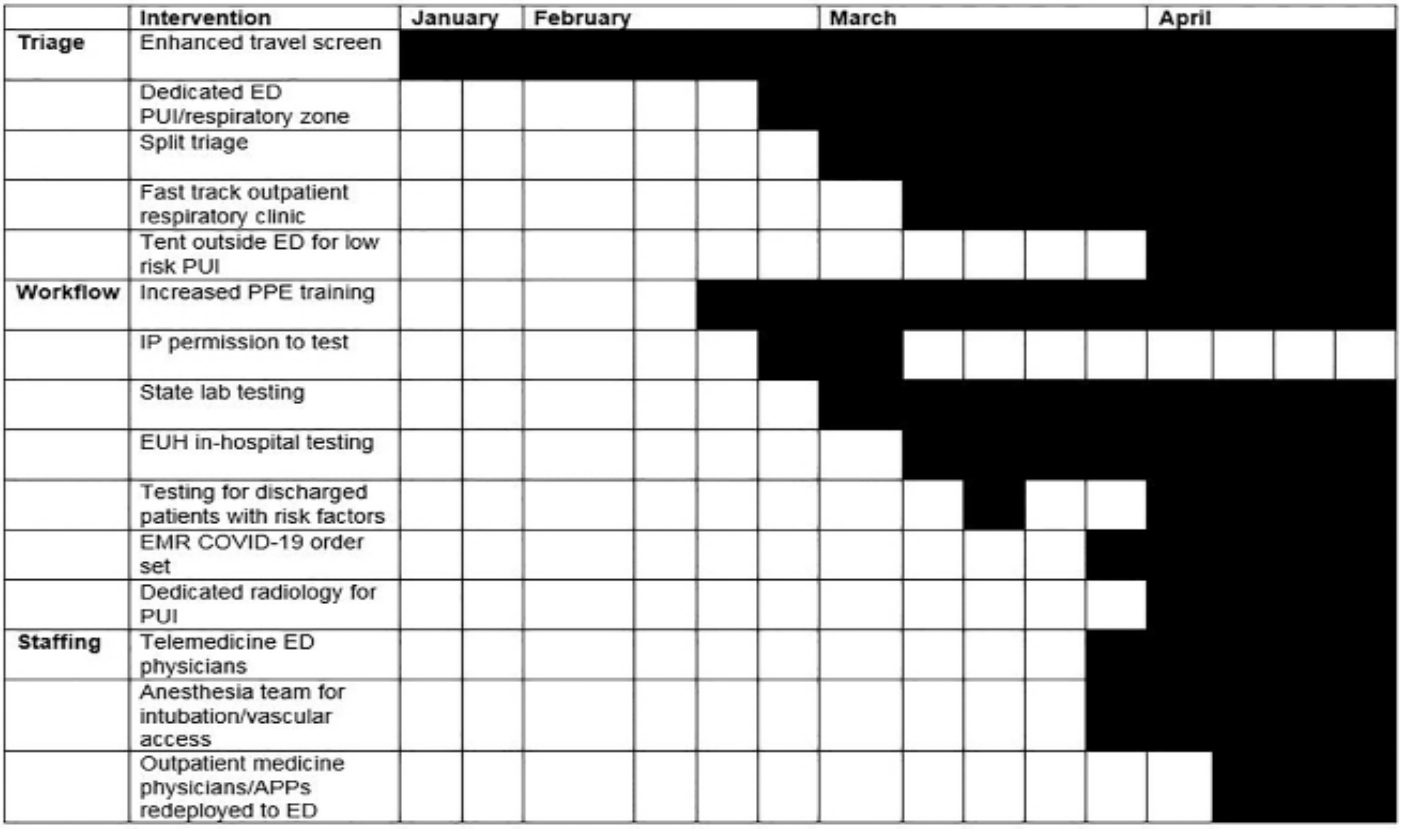

Figure 1. Timeline of key interventions in the Emergency Department (ED) at Emory University Hospital (EUH) during the COVID-19 response (January 13, 2020 – April 27, 2020).
PUI, person under investigation; *IP,* infection prevention; *EMR,* electronic medical record.

model enabled flexibility and kept infectious respiratory patients physically apart from the rest of our patient population, including immunocompromised patients without infectious complaints.

The tiered triage model was based on risk assessment through a revision of the 2009 H1N1 SORT criteria,[13] revised to the known presenting signs, symptoms, and risk factors for patients with COVID-19 from literature out of China and the US.[14-17] Triage now occurs physically outside the ED by a triage nurse, behind a screen and in PPE, based on medical history, symptoms, heart rate, and oxygen saturation. Low-risk PUIs are directed to a rapid discharge area (initially a physically separate, fast-track area, and subsequently transitioned to a tent outside the ED) with COVID-specific discharge and home-isolation instructions and goal arrival-to-discharge time of 30 minutes. This protocol became the standard applied across our system's EDs. We created minimalist protocolized work-ups including chest radiograph (CXR) and nasopharyngeal swab, managed by advanced practice providers (APP). A room was dedicated for chest CXRs for patients likely to be discharged. Intermediate-risk patients identified based on comorbidities and social situation (chronic lung, heart or kidney disease; immunocompromised; diabetes; communal housing) waited in the respiratory-patient waiting room later to be triaged by APP/telemedicine doctors into the rapid discharge area or into the main respiratory zone. High-risk patients based on clinical signs were brought immediately back into the respiratory zone for physician evaluation.

Initial challenges with this process included the physical layout of the ED, which required modification with temporary walls and markings delineating warm zones to prevent crossover of infectious vs noninfectious patients. Other challenges included adapting and flexing the model based on upticks in patient volumes and acuity. All cardiac arrest and stroke patients were triaged as PUI into a resuscitation bay, with all staff wearing high-level PPE (N95 respirator, face shield or eye protection, gown, and gloves). Our physical space was also modified to adapt to this changing triage and flow, including addition of high-efficiency particulate air filtration and temporary walls to delineate the respiratory zone.

Triage Recommendations

1. Institute a split triage and flow model to separate infectious/respiratory vs noninfectious complaints, using a tiered triage approach based on comorbidities, clinical condition, and infectious symptoms.
2. Modify physical space as needed to maintain discrete infectious and non-infectious zones.

Workflow

During the first three months of the developing COVID-19 pandemic, our diagnostic testing ability changed due to testing modifications and fluctuating availability of supplies. We had a unified testing strategy across institution and agreed upon at the administration level, which was adapted as needed in conjunction with IP. Initially, we used state health department tests and called IP for permission to test. Subsequently, we began to use an Emory-developed RT-PCR test, which reduced turn-around time to <24 hrs (Figure 1). At a system-level, a fast-track outpatient respiratory clinic was developed to redirect flow of low-risk patients from the ED. When the supply chain for swabs was interrupted, we preserved testing for those patients being admitted, and eventually were able to test all admitted patients for cohorting and infection control while in hospital. As our availability of swabs increased, we expanded testing for patients being discharged with moderate to severe risk factors as well as healthcare workers. We also began to deploy the Cepheid rapid test in cases where early knowledge of the results could aid with disposition, such as clearing patients to return to communal living (nursing homes, shelters, or other close quarters). We also used the rapid test to send respiratory patients with negative test results and alternative diagnosis to the clinical decision unit, and prior to providing positive pressure ventilation and respiratory treatments in the ED. Use of the rapid test decreased our ED boarding pending test results for these certain special populations, and otherwise admitted patients were usually not held in the ED for results.

Within our practice, we made significant changes in workflow. We implemented protocols to reduce spread of the virus and for patient and staff safety, including temporarily stopping the use of noninvasive positive pressure ventilation and nebulizers in the ED. We also intubated using video-assisted laryngoscopy in conjunction with plastic drapes or shields. We collaborated with ancillary departments to create more efficient workflow protocols with radiology, laboratory, and environmental services to conserve PPE, expedite PUI exams, and provide more timely diagnostic results. Our CT scanner decontamination protocol was streamlined to require that hospital-grade sanitizer be used to wipe it clean after masked patients.

Many of our colleagues from various specialties assisted in offloading non-PUI patient volume from the ED, such as dental pain and orthopedic injuries, which were quickly rerouted after an appropriate medical screening exam to be seen by oral surgery and orthopedic surgery off-site. With encouragement from hospital administration via incident command working groups, subspecialties were able to shift their practice to ensure rapid access to care for their patients to offset the need for ED referral for evaluation, and our psychiatry program created a mechanism to streamline psychiatric patient boarding and placement. An anesthesia team was put together to perform intubations as well as arterial and central line placement to free emergency physicians to care for other critically ill patients while conserving PPE. We also modified the electronic health record for COVID-19 orders to facilitate ordering of labs, imaging, and isolation precautions.

Workflow Recommendations

1. Unify and streamline testing strategy across institution, to prioritize limited testing capacity for those patients for whom the test result would have the greatest impact on their care or disposition.
2. Consider implementation of personnel-protective safeguards, particularly during aerosol-generating procedures, such as use of evidence-based shields, video laryngoscopy, and avoidance of positive pressure ventilation and nebulization.
3. Use other services to streamline and offset workload for emergency providers, including alternate areas for patient care, rapid clinic follow-up, and proceduralists to assist as needed in the ED.

Staffing

This flexible triage and patient care model led to modifications to our ED staffing. In the pre-pandemic steady state, we had already implemented a seasonal, influenza-surge staffing model to include an overnight on-call emergency physician to care for patients admitted to the intensive care unit but boarding in the ED. We quickly adapted this existing surge staffing for increased respiratory patient volume. When the volume ebbed, presumably due to stay-at-home precautions, we flexed providers off the schedule while maintaining pay to increase wellness, morale, and prepare for future anticipated surges. Additionally, when providers needed to come off the schedule for illness, our process enabled us to preserve the on-call system by flexing in providers from the surge schedule to fill available shifts. Daily needs assessments of staffing occurred, enabling this flexible model to activate providers onto the schedule as needed. The development of telemedicine, discussed further below, enabled us to be more flexible with rounding in our observation units to enable the ED providers on shift to focus on higher acuity care. At the system level, 22 outpatient internal and family medicine attending physician and APP volunteers were trained in ED operations and PPE early on in the pandemic. These colleagues were deployed to the ED to cover lower-acuity patients in the non-respiratory zone and for aftercare responsibilities, freeing emergency physicians for higher acuity cases.

Staffing Recommendations

1. Implement a surge staffing schedule to enable as needed flexing physicians and APPs on and off the schedule to address ED surge as well as fill in for providers who need to come off the schedule for illness.

2. Consider credentialing family and internal medicine physicians and APPs, to offload lower-acuity workload from emergency providers as needed.

Communication - in one place, among all stakeholders

As the pandemic impacts our healthcare system, email traffic has increased, including communications from many sources such as the healthcare system, department leads, and individual hospital sites. Providers and staff reported information overload from the sheer volume of emails as well as the quickly changing guidelines and operating procedures in response to new information on the pandemic as well as supply chain challenges. We surveyed our providers about how they felt about communications and found that of the 71 respondents out of 240 physicians and APPs surveyed, 42% felt they were receiving the right amount of information from the institution, while 46% felt they were receiving too much information from the institution. Sixty-four percent of physicians and 68% of APPs surveyed felt that they were receiving the right amount of information from our ED and the medical directors of their sites.

The main areas of concern regarding communication and clinical work included provider safety and frequently changing protocols. In response to this feedback, we moved toward developing a living, web-based, SOP document, which was updated frequently and served as a central source of up-to-date information. This allowed us to avoid minor email updates and enable providers and staff to have one central repository of information for protocols and safety. The SOP also included a built-in feedback form that provided feedback directly to the creator. Between March 29 - April 22, 2020, the SOP underwent nine iterations. Institutionally, we moved toward one daily update email. Additionally, the ED medical directors began holding weekly meetings on a virtual platform, which served to update the clinical group regarding operation changes, brainstorming for solutions, and as formal processing group sessions for debriefing of personal and professional stressors related to the pandemic. Finally, for situational awareness, the chair of EM provided a weekly podcast to keep faculty, staff, and residents up-to-date on the latest changes and ongoing system-level initiatives.

Early in our response to the pandemic, it was recognized that physician and nursing communications were occurring in a siloed fashion, thus resulting in ineffective process implementation as well as frustrations across both disciplines. These communications were then coordinated and centralized to occur within the incident command center (ICC) structure outlined below as well as with pre-shift huddles between charge nurse and hand-off physicians to determine real-time plans for the day. This informed the rapid coordination of workflows and modification of clinical protocols within the ED by including all key stakeholders in a daily meeting where tasks were assigned and coordinated through project managers. Ultimately, this coordination enabled us to push forward many of our initiatives.

We also began to improve coordination as a system with an ICC structure. ED operations was identified as a workgroup within the ICC structure. This workgroup managed ED operations with daily meetings between all medical directors across hospitals as well as separate ICC meetings. These changes enabled us to be unified as a system and communicate as one voice at the system level. As our department covers a number of hospitals with different leadership structures and policies, these daily meetings across hospitals were important to ensure that our SOPs functioned appropriately across each site and that best practices were shared and quickly disseminated across our EDs.

Communication Recommendations

1. Streamline and standardize multiple levels of communication between department and institution via an incident command structure with EM represented in the ICC structure.
2. Coordinate communication between physician and nursing leadership.
3. Create a SOP document that is readily accessible and updated regularly for providers and staff to access centralized information.

INNOVATION

Working with Industry

Faced with the potential healthcare surge of COVID-19 patients as well as potential for PPE shortages and sick providers, we worked toward innovative solutions to mitigate these risks. Our close relationships between other academic institutions and industries helped with creative solutions to PPE supply issues, including development of 3-D printed faceshields and novel intubation plexiglass shields[18] in coordination with the Georgia Institute of Technology. Other PPE solutions included investigation and trialing of respirator sterilization and reuse strategies, such as ultraviolet (UV) sterilization. Finally, many solutions were primarily technology-based, including a mobile, web-based application, C19check.com, to provide the general public a source of information to assess their risk of severe COVID-19 disease and what to do next to help mitigate a hospital surge.[19] This application, translated into multiple languages to maximize impact, assisted our general patient population with decision-making as to when to come to the ED, and was developed out of an established relationship between industry and our institution. The application was promoted through university channels online as well as to the public through university media relations in order to raise awareness of the checker and facilitate guidance to the public. The application also has the capability to expedite ED triage process by providing an option for patients to self-triage with the application. Patients can then show the triage provider their output, as a provider-hands-free option, to help sort the patients into their triage risk category, thus theoretically facilitating social distancing even within the ED.

Industry Recommendations

1. Identify outstanding needs (eg, PPE) and institutional partners with skillsets to fill these needs.
2. Consider leveraging novel or existing web-based technology to inform the general public and facilitate healthcare utilization.

Telemedicine

We also developed an EM telemedicine initiative, which was identified as a tool that could be deployed to help with challenges such as access to care, resource optimization, physician safety, and a mechanism to allow quarantined but asymptomatic providers to contribute clinically. We obtained tablets mounted on rolling stands, which could facilitate easy transition between patients, for a telemedicine physician located in a central office location outside the ED. This system included a telemedicine stethoscope so the physician could virtually examine the patient as needed. Initially, we sought to deploy the telemedicine physician as a way to evaluate and treat low-risk respiratory patients in our tent external to the ED; however, we quickly learned the physical layout, acoustics, and visual limitations of the tent made telemedicine use in this way unfeasible. Our telemedicine program has since been successfully deployed at multiple different stages along the patient care continuum, thereby expanding its utility. From a prehospital perspective, patients who do not require emergent care are seen by clinic physicians using telemedicine. This has improved the patient care experience while mitigating ED resource use and staff exposure. In ED triage, the telemedicine emergency physician is connected with a triage nurse to provide rapid medical evaluation and input initial orders. For low-acuity patients, the nurse in the room assists the telemedicine emergency physician with a full evaluation, including facilitating telemedicine stethoscope use, and can complete the entire work-up and discharge plan.

The telemedicine physician has been used to staff APPs when needed in the ED, and to round remotely in each hospital's ED observation unit. One physician has been able to simultaneously care for low-acuity patients in observation units as well as respiratory patient triage areas in two hospitals at once, thus optimizing workflows, improving patient flow, and reducing PPE consumption. Finally, telemedicine has been used for patient follow-up, including COVID-19 test results sent during an ED visit or high-risk patients not tested during their index visit. All patients have follow-up using an algorithm that involves escalation as indicated from a nurse call, to a physician or APP call, to a telemedicine visit or to a COVID-19 clinic visit, or finally to return to the ED. Moving forward, additional opportunities for telemedicine include pre-emergency medical services for evaluation by providers to determine need for transport or for saturated departments as a way to continue management of stabilized patients.

Telemedicine Recommendations

1. Consider implementation of a telemedicine program for ease of prehospital triage, to streamline low-acuity emergency patient care, or for patient follow-up.

Morale

Our department has a strong institutional focus on wellness during steady state including wellness initiatives and a funding stream.[20-22] This baseline has easily translated into initiatives during the COVID-19 pandemic including a focus on health, safety, and wellness of faculty and staff. In terms of health and safety, before known local community transmission of SARS-CoV-2, we fast-tracked staff testing through a systemwide COVID-19 hotline. We had early clarification of the process of caring for our own, enabling return to work, and developed strategies to maintain salaries. We also prioritized learner safety, removing medical students and off-service rotating residents from the ED early on in the pandemic, and encouraged EM residents to see only non-PUI patients initially until our safety procedures solidified. Scribes were also placed centrally within the department and did not enter PUI rooms. Masking was mandated for all patients as well as staff in the ED, and masks were provided for those who did not have one. We also focused on PPE solutions, such as use of PAPR for staff comfort. While we had to employ PPE conservation strategies such as N95 mask reuse with UV sterilization between uses, the attention to correct PPE use allowed our staff to remain safe. (As of April 15, 2020, only three of 218 MD/APP/registered nurses tested positive for COVID-19 at one site.)

In terms of personal wellness, our department was instrumental in facilitating childcare for providers by partnering with volunteer medical students given interruptions in their educational schedule, and with professional childcare agencies after schools closed. Our department of EM also funded on-shift food for the EDs for two weeks at the beginning of increased COVID-19 PUI volume, and then transitioned to fundraising at an institutional level to continue to provide food for all ED staff on shift. Faculty also started collating personal locations to volunteer space (such as unused garage rooms or carriage houses) for those in need of quarantine or isolation outside their own homes, in addition to the hotel housing offered by our institution. Great attention was paid to the emotional state of providers and staff, with ongoing discussions normalizing and validating the range of emotions experienced and offering emotional processing groups at the end of weekly operations through virtual sessions led by department leadership. Counseling services were offered by phone or virtual platform by Emory's Faculty and Staff Assistance Program and Emory Psychiatry. Yoga and meditation classes were offered on a virtual platform so employees could continue to participate while practicing social distancing.

Morale Recommendations

1. Implement PPE strategies that address both supply chain and staff morale, including universal masking to protect both patients and staff, offering alternative PPE solutions such as PAPR for staff comfort, and maintaining a strong PPE supply chain so that fear of lack of available PPE is reduced.
2. Support staff wellness through programming to address acute needs, such as childcare, quarantine housing, on-shift food, and emotional stress.

CONCLUSION

These are just some of the interventions that we found to be helpful as our department learned to navigate this crisis. We are continuing to prepare, adapt, and innovate as we are faced with the changing realities of the COVID-19 pandemic each day and prepare for the transition between response and recovery, and back again. As with many healthcare systems around the US, we noticed an overall decline in ED volumes as well as an increase in influenza-like illness cases (Figures 2a, 2b) through March–April 2020. As our percentage of laboratory-confirmed influenza cases steadily decreased to zero, our laboratory confirmed COVID-19 cases peaked at 25.1% of those tested having a positive result during our initial surge (March 23–29, 2020). Our test positivity rate began steadily rising again in June–July 2020, greatly exceeding our initial surge. We are still struggling with adaptation to shifting guidelines and the unknowns of what is to come as individual governors allow stay-at-home orders to expire and with discordance in public masking recommendations.

While we initially disassembled our tents given reduced volumes, they remained on site and have been reconstructed given our new surge in COVID-19 patient volume. We are now experiencing increased ED boarding as inpatient beds are full with COVID-19 patients as well as postoperative patients after restarting elective surgery at our institution. The preparedness and processes put in place during the initial surge facilitated our team in adeptly managing patient care and ED flow as cases drastically increased. Without question, we will continue to use these lessons and recommendations on preparedness, adaptability, and innovation in this second surge of COVID-19 and in the future for inevitable additional waves, as well as for whatever emerging public health emergency comes next.

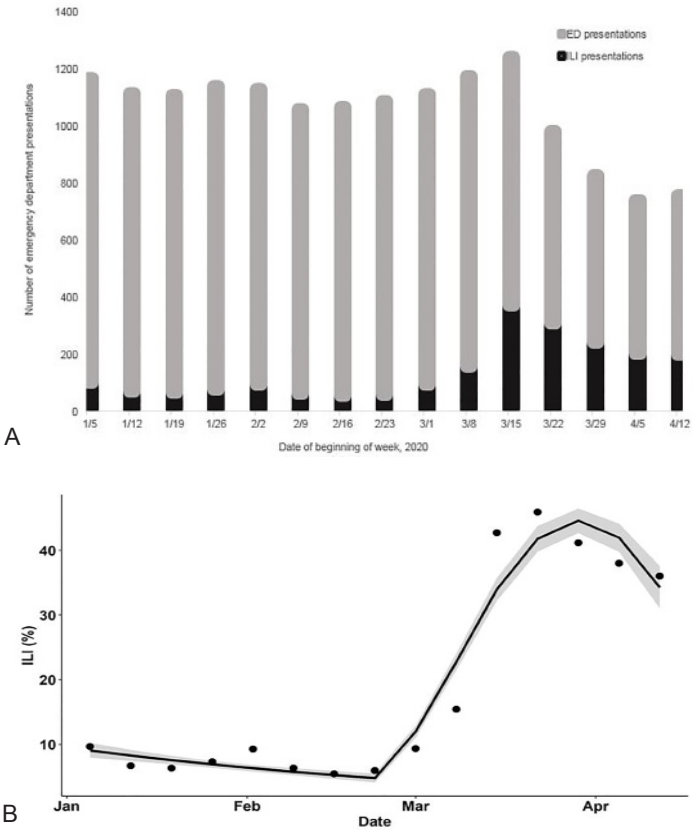

Figure 2. A) Weekly number of presentations, and presentations for Influenza-like illness (ILI) to the Emergency Department at Emory University Hospital during the COVID-19 pandemic in 2020. B) Broken-stick quadratic regression (95% CI) of weekly proportion of visits that were ILI with breakpoint set at the week beginning February 23 2020 (week of first announced death due to COVID-19 in the state of Washington) OR = 0.90, 95% CI: 0.88 - 0.91, p < .001.

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CODE BLUE-19: Proposal to Mitigate COVID-19 Transmission in the Emergency Department for Out-of-hospital Cardiac Arrest

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Resuscitation of cardiac arrest in coronavirus disease 2019 (COVID-19) patients places the healthcare staff at higher risk of exposure to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Unfortunately, COVID-19 status is unknown in most patients presenting to the emergency department (ED), and therefore special attention must be given to protect the healthcare staff along with the other patients. This is particularly true for out-of-hospital cardiac arrest patients who are transported to the ED. Based on the current data available on transmissibility of SARS-CoV-2, we have proposed a protocolized approach to out-of-hospital cardiac arrests to limit risk of transmission. [West J Emerg Med. 2020;21(6)71-77.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

BACKGROUND

It has been recognized that cardiopulmonary resuscitation (CPR) is an aerosol-generating procedure (AGP).[1] In fact, there is evidence of transmission of severe acute respiratory syndrome coronavirus and Middle East respiratory syndrome to healthcare workers involved in CPR despite wearing proper airborne personal protective equipment (PPE).[2,3] Considering the growing number of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections in the United States and around the world, many healthcare workers will provide direct care to patients suffering cardiac arrest who are suspected of having coronavirus disease 2019 (COVID-19). Careful planning and thorough preparation are required to deliver quality resuscitation while protecting staff and other patients from potential exposure to the virus. In addition, mindful deployment of available resources must be weighed against resuscitative efforts and patient outcomes.[4]

Given that the overall survival to discharge of out-of-hospital cardiac arrest (OHCA) is approximately 8.8%, the benefits of resuscitation now must be weighed against transmission risk to providers.[5] The emergency physician should assess the likelihood of neurologically intact survival in each OHCA and decide whether to continue resuscitation prior to the patient entering the emergency department (ED).[6] Placement of an ultrasound machine in the ambulance bay prior to patient arrival to quickly

visualize cardiac activity may assist with decision-making.[7] With this in mind, the following is a proposed integrative protocol for OHCA during the COVID-19 pandemic.

TRANSMISSION

With the emergence of the SARS-CoV-2 and its related disease process (COVID-19), the world faces a pandemic that has drawn comparison to that of the Spanish influenza outbreak of 1918.[8] At the time of this writing, over 13.3 million cases have been confirmed and over 580,300 deaths have been associated with COVID-19. Of these confirmed cases, over 3.4 million were identified in the United States.[9]

Viral transmission has been identified by both respiratory droplet and surface contact. Mitigation of transmission has become a key strategy. Across the world, measures such as stay-at-home orders, school closures, travel bans, self-quarantine, and the implementation of physical distancing have been recommended.[10] The workforce has made rapid, large-scale adaptations to reduce disease transmission, including a major shift to working from home and conducting business remotely with online applications.

In contrast, for first responders and front-line healthcare workers, contact with confirmed and suspected COVID-19 patients cannot be avoided, and the risk must instead be managed and mitigated. Moreover, many of these personnel will be involved in or exposed to AGPs. Examples of these interventions include endotracheal intubation, open suctioning, manual ventilation before intubation, and CPR.[11] All of these procedures may be involved in the resuscitation of a patient in cardiac arrest. Noting that cardiac injury and cardiac arrest are among observed complications of COVID-19, it is critical to reconsider pre-pandemic approaches to cardiac arrest patients.[12] Our institution, in partnership with the region's emergency medical services (EMS) agencies, has developed a protocolized approach to managing the EMS-to-ED care transition for OHCA.

Several key assumptions guide this strategy. First, under pandemic conditions, it is important to devise protocols that assume risk of COVID-19 infection in all OHCA. Furthermore, if the cause of cardiac arrest is due to COVID-19 infection, then the patient is likely to exhibit persistent oropharyngeal viral shedding.[13] This shedding creates a high-risk environment for resuscitation. Planning and preparation for these patient encounters and acknowledging available resources is vital to optimizing care while protecting healthcare workers and other patients from transmission.

PROTOCOLIZED APPROACH TO SUSPECTED COVID-19

This protocol was developed at a tertiary, academic hospital within a large metropolitan area served by multiple EMS agencies, each with different capabilities, equipment, and protocols. The intent was to minimize dispersion of aerosolized viral particles throughout the ED, while maintaining optimal personnel, equipment, medications, and communication to facilitate high-quality resuscitation throughout care transfer. To achieve these goals, the following are required:

a) Ensure that necessary staff have donned appropriate personal protective equipment (PPE) before they assume care of the patient

b) Reduce the number of providers in the room to the fewest possible while still allowing optimal resuscitation

c) Encourage use of negative pressure rooms, or identify resuscitation rooms with portable, high efficiency particulate air (HEPA) filter units

d) Reduce the time during which the patient is receiving CPR in the ED but outside the negative pressure environment by minimizing travel distance from the ambulance bay to the negative pressure room.

e) Minimize staff ingress and egress from the resuscitation room

f) Reduce likelihood of an "open" airway (ie, an airway without a viral filter in place on an endotracheal tube or supraglottic device) during chest compressions inside the ED

g) Mitigate the risk of aerosolized viral particle dispersion outside the negative pressure room.

To achieve these goals, the protocol recommends specific physical placement of equipment and personnel both prior to and during a resuscitation. The code team for this protocol includes an attending physician, a senior emergency medicine resident physician, three nurses including the code narrator (code nurse), a respiratory therapist (RT), an ED tech (code tech), and an ED pharmacist. To minimize infection risk, the code team consists of two teams: one team inside the room, and the second team outside (Figure 1). Use of an automated compression device to replace the code tech, if available, further reduces the number of the in-room team members.

PPE is pre-staged outside of designated negative pressure rooms to facilitate use and availability. Medications most commonly used in cardiac arrest resuscitation and a defibrillator are pre-positioned by the code team on a sheet (referred to as the dump sheet, Figure 2) while the code cart stays with the out-of-room team to minimize contamination, ingress, and egress. To further minimize ingress and egress, multiple modes of communication are brought into the room, including portable two-way radios, pre-printed cards with common terminology, and dry-erase white boards and markers. Moreover, to reduce the likelihood of an open airway and mitigate viral particle dispersion, a pre-staged cardiac arrest aerosol mitigation bag is positioned on the route to the ambulance bay, containing a bag-valve-mask (BVM), a supraglottic airway device (SGA), a viral filter, lubricating jelly, and a clear plastic drape (Figures 3-4). In the event that an SGA has not been placed in the OHCA by EMS personnel, the attending physician places the SGA while in the ambulance bay. The use of a viral filter on the SGA and drape placement over the patient's entire body serve to mitigate aerosolized viral particle dispersion while outside of the resuscitation rooms. This protocol reflects the availability of certain resources and personnel, such as negative pressure rooms,

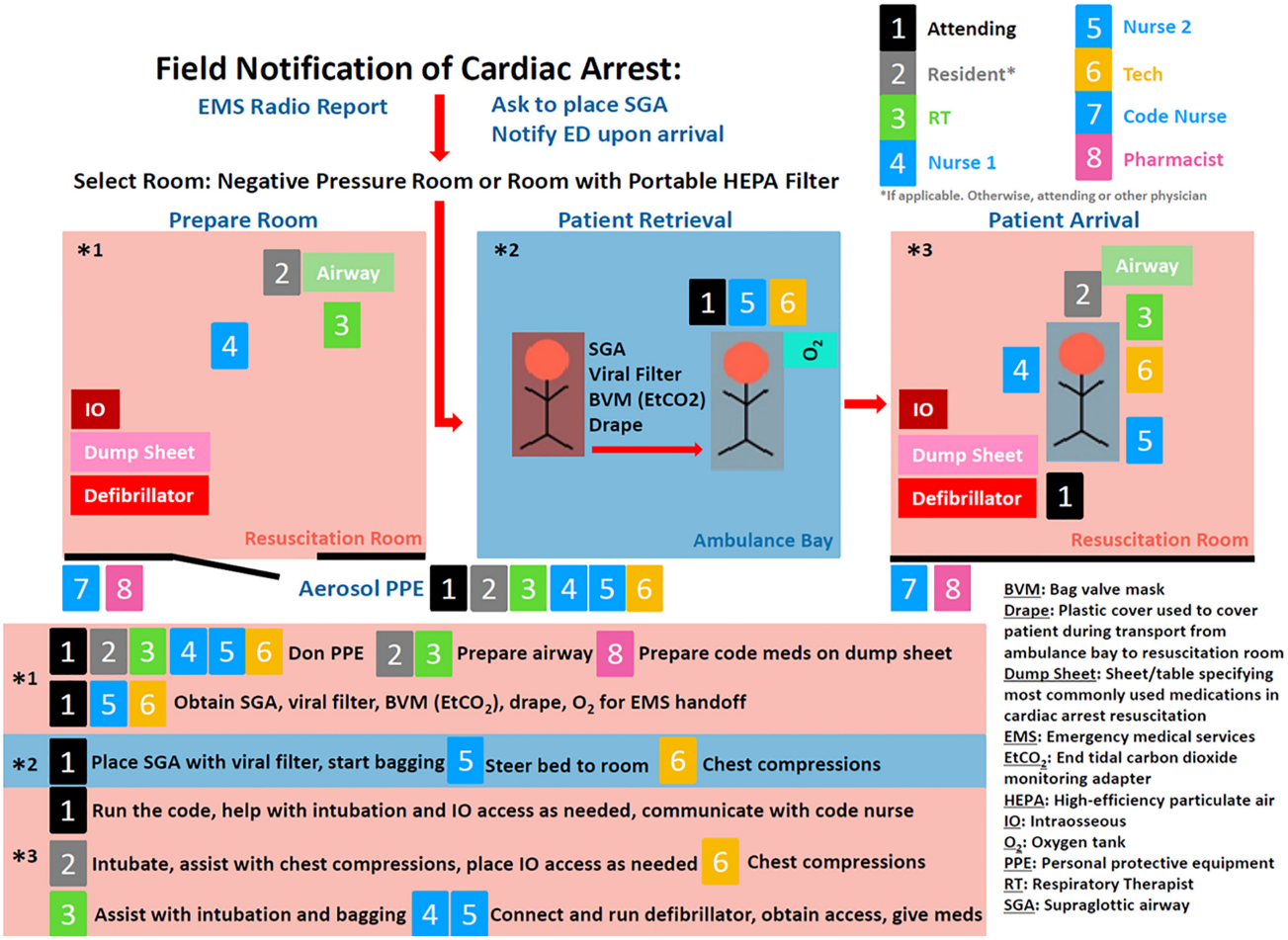

Figure 1. Illustrative diagram of code team and responsibilities to mitigate COVID-19 transmission.

portable HEPA filter units, and resident physician providers. This protocol can be modified based on available resources.

EXAMPLE PROTOCOL

EMS report:

- EMS contacts ED to report cardiac arrest with ongoing CPR.
- If airway is not already secured by advanced airway such as endotracheal tube or SGA, ED personnel requests EMS personnel to place an SGA and meet the ED team in the ambulance bay for patient handoff.

CODE Team and PPE

- Nursing supervisor identifies and notifies both the in-room team (an attending physician, a senior emergency medicine resident physician, two in-room nurses, an RT, and a code tech) and the out-of-room support team (a code nurse and an ED pharmacist) at the time of EMS call-in.
- Members of the in-room team don airborne PPE prior to patient arrival and remain inside the resuscitation room while the code nurse and the ED pharmacist remain outside of the room for the entire duration of the code. Communication between the attending physician who remains inside the room wearing airborne PPE and the code nurse outside of the room is through multiple means, including a hand-held, portable two-way radio, dry-erase white boards and markers, and pre-printed cards with common terminology. For example, the attending physician holds the in-room radio and speaks directly to the code nurse who is holding the out-of-room radio.

Prior to Arrival

- The in-room team has two separate objectives prior to patient arrival. A handoff sub-unit consisting of the attending physician, the code tech, and one of the in-room nurses dons airborne PPE upon EMS report, obtains the cardiac arrest aerosol mitigation bag (Figure 2) and a portable radio, and pre-stages the resuscitation room stretcher equipped with an oxygen tank in the ambulance bay to meet EMS.

Figure 2. "Dump sheet" for cardiac arrest COVID-19 response. Medications most commonly used in cardiac arrest resuscitation and a defibrillator are pre-positioned by the code team on a sheet. Its purpose is to avoid contaminating the crash cart.

- Other personnel of the in-room team, the resident physician and RT, don airborne PPE and prepare for airway management, including preparing the video laryngoscope, ensuring the supplies needed to intubate are present, and confirming that the ventilator is optimally configured for viral filtration.
- Secondary in-room nurse works with the ED pharmacist to prepare code medications and ensure defibrillator and intraosseous availability. The code cart remains outside of the room while commonly administered resuscitation medication for a typical code duration is placed inside the resuscitation room (Figure 1).
- The code nurse remains outside of the room and communicates with the attending physician through a portable two-way radio.

On Arrival to the Ambulance Bay

- The patient is transferred from the EMS stretcher to the ED stretcher. The attending physician places an SGA (if not already in place) and connects the viral filter between the SGA and BVM. EMS report is given during this transition.
- The attending physician provides ventilation by bagging the patient and the ED tech provides compressions. The nurse pushes the stretcher to the resuscitation room. Ideally the plastic drape is on the patient during transport from ambulance bay to the room (Figure 3).

Patient in Room

- As the patient enters the room, the door closes to activate the negative airflow. The attending gives a short report over the radio to the code nurse outside of the room regarding the events prior to arrival including downtime, rhythm, and shocks and medications that have been delivered as reported by EMS. The code nurse assumes timekeeping of code events.
- The code tech continues compressions until the first rhythm and pulse check.
- Meanwhile, the primary nurse attaches the patient to the monitor and defibrillator.
- The resident physician intubates the patient during first pulse check*. If a resident physician is not available, then the attending physician performs the intubation.
- The secondary nurse establishes intravenous (IV) access if not already established by EMS and administers medications or draws blood as needed.
- The attending physician leads the code and communicates all events in the room to the code nurse outside. The attending places an IO if required.
- After intubation, the resident physician participates in providing chest compressions and rotates with the ED tech and nurse for the duration of the code.

*Ordinarily, an SGA is sufficient for ventilation during CPR. However, under current pandemic conditions, the assumption is that a cuffed tube in the trachea is preferred to decrease expiratory leak and further mitigate contamination.[14]

Outside the Room

- The code nurse radios to the team when it is time for rhythm checks, pulse checks, and medication administration.
- The ED pharmacist outside the room assists in making suggestions for medication and fluid administration related to cardiac arrest resuscitation guidelines and assists the code nurse in documenting events. Furthermore, the pharmacist procures and prepares other necessary medications that are not in the room.

Achieving Return of Spontaneous Circulation (ROSC)

- The attending physician gives orders for an electrocardiogram, additional labs, arterial line placement, continuous IV fluids and medications, etc. through the radio. The out-of-room team prepares and delivers these items.
- The team in the room stays in airborne precautions PPE for 30 minutes post-AGP procedure (intubation) if providing care inside the room.[15]

Patient Death

- The attending physician announces time of death to both teams; the out-of-room nurse documents this finding in the chart.
- The patient remains in the negative pressure room for 30 minutes post-AGP to reduce any aerosols. The patient is then double-bagged, with "contaminated" and "biohazard" stickers placed on the outside of the bag.

Figure 3. Cardiac arrest aerosol mitigation bag for cardiac arrest COVID-19 response.
This bag includes a supraglottic airway device, bag valve mask, viral filter, end tidal carbon dioxide monitoring adapter, and a plastic drape used to cover patient.

Figure 4. Plastic drape for cardiac arrest COVID-19 response. Used to cover patient during transport from ambulance bay to the resuscitation room. The drape has two vertical slits on top allowing the operator to access the airway and one horizontal slit below allowing for chest compressions or for further access as needed without having to remove the drape.

CHALLENGES

This protocol is intended to minimize risk of healthcare exposure to SARS-CoV-2 while delivering quality resuscitation for cardiac arrest. To date, there is limited evidence to estimate COVID-19 transmission during care for cardiac arrest. Development of practice protocols requires a balanced approach: weighing an unknown transmission risk against known risk to the patient from treatment delays.[16]

Several Additional Notes:

The protocol reflects certain institutional-dependent aspects that may require modification to generalize. For example, certain team members such as resident physicians and pharmacists may not be available to fulfill these roles at other institutions.

Regarding airway management, available resources and provider experience should guide intervention. For example, in a setting where the clinician is inexperienced in airway management and a video laryngoscope is not available, an SGA may be preferred.

The protocol aims to minimize the number of individuals involved with the resuscitation. Given this recommendation, there is great utility in an automated compression device, acknowledging the financial resources required for such a device.

Additionally, early iterations of this protocol used white boards and preprinted code-communication sheets for communication. These efforts were subsequently deemphasized in favor of radio or phone communication, which proved to be audible despite the background noise and allowed for an easier conversation between the in-room and out-of-room teams. However, these options remain available as an alternative and backup form of communication. As an example, laminated cards with events such as rhythm check, items such as medications, and common questions were deployed in the negative pressure rooms.

Another limitation of this protocol is who is using the communication devices. Designed for an academic institution, the protocol designates the attending hold the radio in room, whereas in non-academic settings the physician may or may not have the capacity to act as the communications liaison and may have to delegate that role to another individual. All communication devices should be disinfected with EPA-approved, low-level disinfection (LLD) between each patient encounter, in accordance with local institutional biomedical equipment cleaning guidelines.[17]

Observations during arrests suggest the plastic drape has potential to interfere with resuscitation and may need to be removed after arrival into the resuscitation room. The design of the drape consists of two vertical slits on top for airway access and a large horizontal slit on the bottom for direct chest

compressions. Despite this unique design, the drape may be associated with technical difficulties, including difficulty in manipulating airway equipment, and drape movement during compressions.

Point-of-care ultrasound (POCUS) can provide valuable information during cardiac arrest, including identification of interventions outside of the standard Advanced Cardiac Life Support algorithm. Importantly, it has been demonstrated that patients in asystole with no cardiac activity on POCUS have low chance of survival to hospital discharge. In such scenarios, prolonging CPR is likely unavailing, and under the current pandemic may further expose the healthcare worker to SARS-CoV-2. Potentially, an ultrasound check in the ambulance bay could allow calling the code in appropriate circumstances prior to bringing patient into the ED. If POCUS is used, a designated location for the ultrasound machine in the ambulance bay could reinforce its use. The ultrasound machine should be disinfected with LLD after every use, in accordance with local institutional biomedical equipment cleaning guidelines.[18]

Lastly, advanced discussions with EMS agencies regarding expectations are vital to implementing this protocol. A challenge to these discussions is the multitude of EMS agencies that may respond to a facility, and the potential need to coordinate with each one independently. Even in jurisdictions with minimal out-of-hospital practice variation due to statewide EMS protocols, coordination with EMS agencies is still necessary in order to anticipate and adjust for specific scenarios such as severe weather conditions for hospitals without ambulance bays.

CONCLUSION

Cardiac arrest management is always challenging. Cardiac arrest management during an evolving pandemic poses additional challenges. These recommendations are intended to assist our local, regional, national, and global medical colleagues in the care of cardiac arrest during the pandemic. This protocol is specific to our institution but may be modified to meet the needs of others. All efforts aim to safeguard providers while maintaining high quality of care for our patients.

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Effect of an Aerosol Box on Intubation in Simulated Emergency Department Airways: A Randomized Crossover Study

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Introduction: The use of transparent plastic aerosol boxes as protective barriers during endotracheal intubation has been advocated during the severe acute respiratory syndrome coronavirus 2 pandemic. There is evidence of worldwide distribution of such devices, but some experts have warned of possible negative impacts of their use. The objective of this study was to measure the effect of an aerosol box on intubation performance across a variety of simulated difficult airway scenarios in the emergency department.

Methods: This was a randomized, crossover design study. Participants were randomized to intubate one of five airway scenarios with and without an aerosol box in place, with randomization of intubation sequence. The primary outcome was time to intubation. Secondary outcomes included number of intubation attempts, Cormack-Lehane view, percent of glottic opening, and resident physician perception of intubation difficulty.

Results: Forty-eight residents performed 96 intubations. Time to intubation was significantly longer with box use than without (mean 17 seconds [range 6-68 seconds] vs mean 10 seconds [range 5-40 seconds], p <0.001). Participants perceived intubation as being significantly more difficult with the aerosol box. There were no significant differences in the number of attempts or quality of view obtained.

Conclusion: Use of an aerosol box during difficult endotracheal intubation increases the time to intubation and perceived difficulty across a range of simulated ED patients. [West J Emerg Med. 2020;21(6)78-82.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

There have been numerous recommendations for enhanced personal protective equipment (PPE) during endotracheal intubation during the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic.[1-3] Transparent "aerosol boxes" have been promoted as additional

barriers to prevent droplet spread during endotracheal intubation.[4-6] Decreased spread of simulated droplet particles has been demonstrated with the use of such a box during a cough simulation.[4] Although aerosol boxes have received extensive attention on social media and there is evidence of worldwide distribution of such devices,[7] some have cautioned against widespread implementation without further research into potential negative effects.[8]

Initial proponents have since noted restricted movement with aerosol boxes.[4,6] Begley et al conducted a simulation study in which they demonstrated an increased time to intubation with boxes.[7] To date, most of the studies regarding these extended protection measures have been conducted in simulated operating room or intensive care unit settings and have focused on conventional airways. The need for reliable protection for physicians is particularly urgent in the chaotic frontline of the emergency department (ED), where the frequency of difficult intubations and the undifferentiated patients could amplify both the downsides and benefits of aerosol boxes. The objective of this study was to measure the effect of an aerosol box on intubation performance across a variety of simulated difficult airway scenarios in the ED.

Population Health Research Capsule

What do we already know about this issue?
Aerosol boxes may decrease droplet spread of coronavirus but may increase intubation time in controlled settings. Effects in emergency airways are unknown.

What was the research question?
Does use of an aerosol box interfere with emergency endotracheal intubation in simulated undifferentiated difficult airways?

What was the major finding of the study?
Aerosol box usage increased perceived difficulty and time to intubation for simulated difficult emergency intubations.

How does this improve population health?
Quantifying the increased difficulty of emergency intubation with intubation boxes will inform development of airway protocols for infection control during pandemics.

METHODS

Study Design and Population

This was a randomized, crossover design study conducted at a large, university-affiliated simulation center. Study participants included resident physicians from all years of a three-year emergency medicine (EM) program (with the additional inclusion of participants from a five-year combined EM-pediatrics program). Each participant signed an informed consent statement. The study was deemed exempt by the university's institutional review board.

Study Protocol and Materials

Faculty instructors from our department's Division of Simulation developed five patient case scenarios using Laerdal SimMan 3G (Laerdal Medical, Stavanger, Norway) to simulate one normal airway and four difficult airways based on real-life patients seen during the SARS-CoV-2 pandemic. These included the following: 1) an angioedema patient simulated using the large tongue function on the mannequin; 2) a morbidly obese patient simulated by adding pillows, ACE wrap, and skin-colored padding to the torso and neck of the mannequin (which partially limited neck mobility and also caused the mannequin's neck to be slightly flexed while in the supine position); 3) a trauma patient simulated with the mannequin on a backboard and wearing a cervical collar; and 4) an upper gastrointestinal (GI) bleed patient using a modified Laerdal SimMan that has been previously described.[9]

Participating residents were divided into 21 small groups of 2-4 residents based on assignments for a concurrent procedure lab that was part of their standard curriculum. Each study group was randomized by an electronic number generator to one of the five patient types. Each resident performed two intubations on their patient type, with sequence of control vs intervention randomized by an electronic number generator. Intubation with the aerosol box in place served as the intervention; intubation without a box was the control. Our aerosol box was a 20" x 20" x 16" Plexiglass structure with 4"-diameter arm holes, approximately nine kilograms, manufactured at our institution and based on the original design from Taiwan[10] that was studied by Canelli et al.[4]

A concurrent media access control (C-MAC) video laryngoscope was used for all intubations (Karl Storz SE & Co., Tuttlingen, Germany) since this is the standard practice for all potential SARS-CoV-2 intubations at our institution. Size 3 and size 4 standard curved blades and a hyper-angulated blade were available. Endotracheal tubes (ETT) with both flexible and rigid stylets were provided. A gum-elastic bougie was available to all upper level residents; interns were not provided this device given their lack of previous training with it. To increase resident familiarity with the box, participants practiced intubating a normal 3G mannequin through the aerosol box with both a normal curved blade and a hyper-angulated blade for five minutes. For subsequent data collection, participants intubated their randomly assigned patient type in video-recorded attempts both with and without the box and using any of the available equipment.

Data Collection and Outcomes

The primary outcome was time to intubation. For all recorded attempts, a faculty investigator timed the intubation on site, from the time the resident picked up the blade until the ETT passed through the vocal cords per a previously published protocol.[11] Faculty recorded this time in seconds as well as number of attempts (defined as number of times the blade was placed into the patient's mouth). Residents recorded Cormack-Lehane (CL) view, percent of glottic opening (POGO) score, and their perceived difficulty of intubation on a 10-point Likert scale. They also provided open-ended comments about the intubation immediately after the attempt. See Appendix A for the complete data-collection instrument.

Time to intubation, CL view, and POGO score were independently reviewed by one of the faculty investigators not involved in initial data collection, using recorded video of the C-MAC screen. Discrepancies from the original recorded data were reviewed and discussed by the entire study group until consensus was obtained.

Statistical Analysis

We summarized frequencies and percentages by group for categorical variables. Continuous variables were summarized by group using median and range. We used chi-square test, Fisher's exact test, and Wilcoxon test to test for differences between groups. We performed all statistical analysis using SAS Version 9.4 (SAS Institute, Cary, NC).

RESULTS

Forty-eight residents performed 96 intubations (Table 1). Time to intubation was significantly longer with the aerosol box in the full cohort of patients, as well as with the trauma, obese, and angioedema patient subgroups (Table 2). The point estimate for time to intubation was also longer with the box in the normal patient and GI bleed patients but did not reach statistical significance. Only two intubations required multiple attempts, both with box use. Participants rated intubation with the box as being significantly more difficult. There was no statistically significant difference between groups for number of attempts, CL view, or POGO score.

Participants volunteered comments on 58 intubations (40 intubations with the box, 18 without). One of the study investigators (JT) categorized comments according to themes. Major themes with representative example comments are displayed in Table 3. The most common comments involved restricted movement or difficulty with equipment when using the box. Thirteen responses mentioned decreased space or maneuverability in the box, while seven additional comments specifically noted equipment issues when using the box (such as cord tangle or ETT contact with the box). Three comments indicated that using the box was easier than the participant anticipated. There were no comments pertaining to the view obtained.

Table 1. Study characteristics (N = 96) of residents and the simulated intubations they performed with and without a transparent aerosol box.

	No box used	Box used	P-value*
Postgraduate year			1.00
1	21 (43.7)	21 (43.7)	
2	5 (10.4)	5 (10.4)	
3-5	22 (45.8)	22 (45.8)	
Blade used			0.6820
Normal	23 (47.9)	21 (43.7)	
Hyper-angulated	25 (52.1)	27 (56.2)	
Patient type			1.00
Normal	11 (22.9)	11(22.9)	
Trauma/cervical collar	10 (20.8)	10 (20.8)	
Obese	10 (20.8)	10 (20.8)	
Angioedema	10 (20.8)	10 (20.8)	
Gastrointestinal bleed	7 (14.6)	7 (14.6)	
Bougie			0.6170
No	47 (97.9)	45 (93.7)	
Yes	1 (2.1)	3 (6.2)	

*Estimated using chi-square or Fisher's exact test.

Table 2. Time to intubation results, median (minimum-maximum).

	No box used	Box used	P-value
Time (in seconds)	10 (5.0-40.0)	17.0 (6.0-68.0)	<.0001
Normal	10.0 (6.0-23.0)	12.0 (9.0-68.0)	0.0746
Trauma/cervical collar	7.0 (5.0-40.0)	11.0 (7.0-23.0)	0.0272
Obese	10.0 (7.0-29.0)	18.5 (12.0-29.0)	0.0079
Angioedema	9.5 (7.0-18.0)	21.5 (6.0-66.0)	0.0113
Gastrointestinal bleed	15.0 (12.0-21.0)	18.0 (14.0-25.0)	0.1391
Number attempts	1.0 (1.0-1.0)	1.0 (1.0-2.0)	0.1595
Difficulty	3.0 (1.0-7.0)	4.0 (1.0-9.0)	0.0008
Cormack-Lehane view	1.0 (1.0-2.0)	1.0 (1.0-2.0)	0.4154
Percent of glottic opening	100.0 (50.0-100.00)	95.0 (20.0-100.0)	0.1576

*Estimated using Wilcoxon test.

Table 3. Open-ended comments regarding use of transparent aerosol box during intubations.

Theme	Decreased space/maneuverability	Equipment issues	Easier than anticipated
Representative comments	"Hand motions more difficult and limited due to box"	"Got cord tangled once blade was in box; had to remove blade and restart"	"Somewhat limiting but easy to navigate with a few practice attempts"
	"Box was difficult to maneuver in"	"Cord length with C-MAC is a problem depending on which box hole you thread blade through"	"Still relatively easy"

DISCUSSION

Time to intubation was longer with aerosol box use in our simulated difficult airway scenarios. We chose time to intubation as our primary endpoint because rates of hypoxia are high during intubation of patients with SARS-CoV-2,[12] increasing the importance of limiting apneic time in this patient population. Similar to Begley et al,[7] our study demonstrated a significantly increased time to intubation with the use of an aerosol box.

We sought to test aerosol boxes across a variety of airway types commonly encountered in the ED. It is possible that the magnitude of disadvantage from box use is greater in some patient types than others, altering the risk-benefit assessment. Accordingly, we randomized the type of patient that participants would intubate. Participants also had equipment that replicated current use in our ED, to include a video laryngoscope with normal and hyper-angulated blades. These elements more realistically simulated the variability of ED practice than previous aerosol-box studies.

Protecting physicians during intubations is critical in the time of the SARS-CoV-2 pandemic. Aerosol boxes may offer some protection by reducing pathogen spread.[4] Initiatives to quickly develop protective equipment, aided by social media and 3-D printing technology, have delivered multiple versions of aerosol boxes to hospitals across the country. However, the advantages of box use must be balanced against their negative impacts. In addition to longer intubation times, participants in our study rated intubation as more difficult with the box. The increased perceived difficulty correlated with the main concern voiced by participants, that of difficulty maneuvering equipment within the box. This is consistent with reports from other studies.[4,6] Our study was not powered to detect difference in first-pass success, but both intubations that required multiple attempts in our study involved box use. This is also consistent with the findings of Begley et al.[7]

It is possible that these issues could be mitigated by improved box design or additional practice. Several participants in our study noted that intubation with the box became easier with practice. Future studies could better define the amount of training required with aerosol boxes to develop provider proficiency. Until that time, consistent with the recommendation of other investigators,[7,8] we caution against widespread adoption of these devices.

LIMITATIONS

This study was conducted at a single institution with EM residents trained at a single residency program. While participants had a broad range of airway experience from relatively novice interns to upper-level residents with more than 100 intubations, it is not ear whether clinicians with additional experience, including attending physicians, would be similarly affected by use of the box. Although there was a significant difference in the primary outcome even in our most experienced intubators, the magnitude of this difference was smaller than with our less experienced participants (Appendix B). Additionally, only one brand of video laryngoscope was used in the assessment, and intubations were in a simulated setting. These factors may also limit generalizability. We used an older box design, and it is possible that newer designs may result in better performance than the older design.[7,13,14]

To limit confounding variables, residents did not have to move the box on and off the bed in our study, which could affect time to the intubation. In addition, we used a custom perception-of-difficulty scale that has not been validated in external studies. It was not possible to blind the residents to the intervention and data collection, so resident preconceived biases may have affected their performance. Finally, as with all simulation airway studies, the movement used to intubate mannequins does not exactly replicate the movement used in human patients. It is, therefore, possible that the effects of the box would be different in the emergency department compared to the simulation laboratory.

CONCLUSION

Use of an aerosol box during difficult endotracheal intubation increases the time to intubation across a range of simulated ED patients.

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Physician Wellness During a Pandemic

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Introduction: We are currently in the midst of the coronavirus disease 2019 (COVID-19) pandemic. Research into previous infectious disease outbreaks has shown that healthcare workers are at increased risk for burnout during these dire times, with those on the front lines at greatest risk. The purpose of this prospective study was to determine the effect that the COVID-19 pandemic has had on the wellness of emergency physicians (EP).

Methods: A survey was sent to 137 EPs in a multi-hospital network in eastern Pennsylvania. We compared 10 primary and two supplemental questions based on how the physicians had been feeling in the prior 2-3 weeks (COVID-19 period) to the same questions based on how they were feeling in the prior 4-6 months (pre-COVID-19 period).

Results: We received 55 responses to the survey (40.1% response rate). The study found that during the pandemic, EPs felt less in control (p-value = 0.001); felt decreased happiness while at work (p-value 0.001); had more trouble falling asleep (p-value = 0.001); had an increased sense of dread when thinking of work needing to be done (p-value = 0.04); felt more stress on days not at work (p-value <0.0001); and were more concerned about their own health (p-value <0.0001) and the health of their families and loved ones (p-value <0.0001).

Conclusion: This study showed a statistically significant decrease in EP wellness during the COVID-19 pandemic when compared to the pre-pandemic period. We need to be aware of evidence-based recommendations to help mitigate the risks and prevent physician burnout. [West J Emerg Med. 2020;21(6)83-87.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a novel coronavirus that appeared in Wuhan, China, in late 2019, was named a public health emergency of international concern by the World Health Organization (WHO) on January 30, 2020.[1] Less than two months later, on March 11, 2020, the WHO declared it a global pandemic.[1] SARS-CoV-2 and the disease it causes, coronavirus disease 2019 (COVID-19), have now infected millions worldwide, and the related death toll currently numbers in the hundreds of thousands.[2] The pandemic continues to infect tens of thousands daily as physicians in emergency departments (ED) relentlessly battle the virus on the front lines.[2]

From the very initial stages of the outbreak, the United States' response has been rightfully focused on the availability

of personal protective equipment (PPE), ventilators, and other medical supplies as evidenced by the US government invoking the Defense Production Act.[3,4] However, this battle, as outbreaks from the past have shown, comes at a great cost to physician wellness, and if not given the attention it appropriately deserves, can subsequently lead to burnout.[5-7] Physician wellness includes physical, mental, and social well-being balanced between personal and work-life domains.[8] It has been well established that physician wellness and burnout have a direct impact on patients in terms of quality of care and patient safety as well as on the medical providers themselves.[9] Burnout is more common in physicians than with other US workers, and emergency physicians (EP) are among those at greatest risk.[10]

Research into previous outbreaks of influenza, H1N1, SARS, and MERS, has shown that burnout is commonly experienced by healthcare workers.[5-7] Multiple factors are at play including fear and anxiety over an unknown number of infected, excessive workload, lack of resources, insomnia, and isolation.[5-7] The effect of working in this constantly changing environment has been shown to be particularly stressful, and those working in high-risk units experienced greater levels of distress.[7] Lin et al found that ED staff faced more demanding work conditions as well as more physical and psychological stress than staff in other units.[6]

The purpose of this prospective study was to determine the effect that the COVID-19 pandemic has had on the wellness of EPs. Our primary objective was to compare physician wellness during the pandemic to physician wellness pre-pandemic. Our secondary objective was to compare the time spent using social media and consuming news during the pandemic to the time spent pre-pandemic.

METHODS

This was a prospective survey study administered to EPs in an 11-hospital network located in eastern Pennsylvania, about 80 miles from New York City. The survey was sent to 137 physicians via a secure hospital email. Fifty-five physicians responded via e-mail to the research assistant who then assigned participant numbers to each physician to provide anonymity. The survey (Figure) was partially derived from previously validated surveys.[11] The survey asked 10 primary questions and two supplemental questions regarding physician wellness, and participants were asked to answer questions based on how they have been feeling over the prior 2-3 weeks (March 27–April 17, 2020), which correlated to the beginning of the Covid-19 pandemic in our area.

The subjects were asked to answer questions using a scale for the primary questions ranging from not at all (1) to completely true (5), and for the supplemental questions ranging from 0 to 1 hours (1) to greater than 5 hours (4). To serve as a baseline for comparison, the physicians were then asked to answer the same primary and supplemental questions based on how they thought they felt 4-6 months before the start of the pandemic. Due to the skewed and ordinal nature of our survey questions, we conducted separate Wilcoxon signed-rank tests. We analyzed our data using SPSS version 25 (IBM Corporation, Armonk, NY) and reported medians and ranges for all survey outcomes, with $p < .05$ denoting statistical significance and no adjustment for the multiple comparisons.

RESULTS

A total of 55 subjects (40.15% response rate), 39 male and 16 female, completed the survey. Of the 39 male subjects, 17 were resident physicians and 22 were attending physicians. The 16 female subjects included six resident physicians and 10 attending physicians. We collected age data in ranges by decade with a median age range of 30-40 years.

Wilcoxon signed-rank test analysis showed a statistically significant difference between the five-point scale score distributions of the pre-COVID-19 period and the COVID-19 period in seven out of the 10 primary questions. There was no statistically significant difference in three out of the 10 primary questions (Table) Likewise, there was no statistically significant difference in either of the two supplemental questions (Table).

The data showed that during the pandemic, EPs felt less in control (p-value = 0.001) and felt decreased happiness while at work (p-value = 0.001). Additionally, during the pandemic, they had more trouble falling asleep (p-value = 0.001) and had an increased sense of dread when thinking of work needing to be done (p-value = 0.04). Furthermore, the data revealed that during the pandemic, EPs felt more stress on days not at work (p-value <0.0001) and were more concerned about their own health (p-value <0.0001) as well as the health of their families and loved ones (p-value <0.0001).

DISCUSSION

The COVID-19 pandemic has forced many healthcare workers to confront challenges that they have never experienced before. This unprecedented time is fraught with fear and anxiety especially for frontline workers providing direct patient care. A crucial yet often overlooked aspect of the public health response to the pandemic is physician wellness. This prospective survey study conducted at an early stage in the COVID-19 pandemic provides important insight into this marginalized aspect of the global response.

Our study revealed that there was an overall decrease in EP wellness during the COVID-19 pandemic when compared to the pre-pandemic period. The data showed a statistically significant difference in seven out of the 10 primary wellness survey questions. The difference indicated a decrease in wellness during the pandemic for all seven of the questions that showed statistical significance. These findings are in line with findings regarding physician wellness from previous infectious disease outbreaks.[5-7] Research into past outbreaks also showed that physician concern for their own health (p-value <0.0001) and concern

Age:
___20-30 ___30-40 ___40-50 ___50-60 ___60+

Gender: ___male ___female

Are you a resident? ___Yes ___No

Do you ___live alone ___live with significant other ___live with significant other and kids

OPTIONAL QUESTION: HOW MANY CLINICAL HOURS DO YOU WORK IN AN AVERAGE MONTH?
___<60 hours ___65-80 ___80-100 ___100-120 ___120-130 ___130-145 ___>145

Answer these questions about how you have felt **over the past 2-3 weeks**

	Not at all true	Somewhat true	Moderately true	Very true	Completely true
I feel happy at work					
I feel in control when dealing with difficult problems at work (unknown disease, PPE, etc)					
I feel a sense of dread when I think about work I have to do					
I have trouble falling asleep					
I have trouble staying asleep					
I am concerned about my own health					
I am concerned about the health of my family and loved ones					
I am concerned about my financial situation					
I feel stress at work					
I feel stress on days that I am not working					

How much time do you spend on social media (Facebook, Twitter, etc.) in an average day?
___0-1 hour ___1-3 hours ___3-5 hours ___5+ hours

How much time do you spend watching news (local news, CNN, etc.)?
___0-1 hour ___1-3 hours ___3-5 hours ___5+ hours

Answer these questions about how you felt **4-6 months ago**?

	Not at all true	Somewhat true	Moderately true	Very true	Completely true
I feel happy at work					
I feel in control when dealing with difficult problems at work (unknown disease, PPE, etc)					
I feel a sense of dread when I think about work I have to do					
I have trouble falling asleep					
I have trouble staying asleep					
I am concerned about my own health					
I am concerned about the health of my family and loved ones					
I am concerned about my financial situation					
I feel stress at work					
I feel stress on days that I am not working					

How much time do you spend on social media (Facebook, Twitter, etc.) in an average day?
___0-1 hour ___1-3 hours ___3-5 hours ___5+ hours

How much time do you spend watching news (local news, CNN, etc.)?
___0-1 hour ___1-3 hours ___3-5 hours ___5+ hours

Figure. Wellness survey of emergency physicians during the COVID-19 pandemic.

for family and loved ones (p-value <0.0001) was common, which was echoed in this study.[5-7]

Additionally, the study showed that there was no difference during the pandemic compared to the pre-pandemic period in physicians staying asleep, concern about their financial situation, and, interestingly, feelings of stress at work. However, feeling stress on days not at work did significantly increase during the pandemic (p-value <0.0001). This difference is likely multifactorial but may partially be explained by inadequate social support due to increased isolation as well as mandated school closures affecting work-life balance. Another intriguing finding of our study was

Table. Statistical analysis of primary and supplemental survey questions.

Primary Survey Questions (n = 55)	Pre-COVID-19 (median, range)	COVID-19 (median, range)	P-value
I feel happy at work.	4 (1-5)	3 (1-5)	0.001
I feel in control when dealing with difficult problems at work (unknown disease, PPE, etc.).	4 (1-5)	3 (1-5)	0.001
I feel a sense of dread when I think about work I have to do.	1 (1-4)	2 (1-5)	0.04
I have trouble falling asleep.	1 (1-5)	2 (1-5)	0.001
I have trouble staying asleep	1 (1-5)	1 (1-5)	N/A
I am concerned about my own health.	1 (1-5)	2 (1-5)	<.0001
I am concerned about the health of my family and loved ones.	2 (1-5)	4 (1-5)	<.0001
I am concerned about my financial situation.	2 (1-5)	2 (1-5)	N/A
I feel stress at work	2 (1-5)	2 (1-5)	N/A
I feel stress on days that I am not working.	1 (1-4)	2 (1-5)	<.0001
Supplemental Survey Questions (n = 55)			
Social media (hours/day)	1 (1-3)	1 (1-3)	N/A
Watching news (hours/day)	1 (1-3)	1 (1-2)	0.06

COVID-19, coronavirus 2019; *PPE,* personal protective equipment.

that, despite the constant media coverage, subjects did not significantly increase the amount of time spent viewing news or using social media. The decreased physician wellness scores during the pandemic were therefore independent of these activities.

There is a need for larger studies on physician wellness during the COVID-19 pandemic, but the findings of this study could inform medical administration about the need for protective measures, not only in the form of masks and gowns but also in the form of developing programs to address physician wellness and burnout. Initial evidence-based recommendations are emerging to address these concerns at the organizational, team, and individual levels.[12-16] If we do not take these recommendations seriously and implement the needed safeguards, we could soon be dealing with another outbreak – physician burnout.

LIMITATIONS

This study has several limitations. The sample size (n = 55) was relatively small. Our study group originated from a single hospital network, was a convenience sample, and was limited by non-response bias. Survey questions were derived from a previously validated study, but the specific question that subjects answered might not have covered the broad range of physician wellness. The survey used physician self-report of feelings up to six months earlier, which introduced the potential for recall bias, as well as social-desirability bias. Even though statistical significance was found in several of the questions, there may not be a clinical significance given how similar the medians and/or general distribution of scores were in some cases. Future studies will attempt to conduct multivariable modeling to tease out independent predictors of survey responses, such as gender or level of training of the physician, provided sample size is sufficient.

CONCLUSION

In keeping with data from past outbreaks, this prospective survey study showed that there was an overall decrease in emergency physician wellness during the COVID-19 pandemic when compared to the pre-pandemic period. Evidence-based recommendations to address this often-overlooked issue are starting to emerge, and it is crucial that individual physicians, as well as hospital administrators, be aware of these safeguards in order to prevent unnecessary physician burnout.

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A Video-based Debriefing Program to Support Emergency Medicine Clinician Well-being During the COVID-19 Pandemic

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Introduction: Emergency clinicians on the frontline of the coronavirus pandemic experience a range of emotions including anxiety, fear, and grief. Debriefing can help clinicians process these emotions, but the coronavirus pandemic makes it difficult to create a physically and psychologically safe space in the emergency department (ED) to perform this intervention. In response, we piloted a video-based debriefing program to support emergency clinician well-being. We report the details of our program and results of our evaluation of its acceptability and perceived value to emergency clinicians during the pandemic.

Methods: ED attending physicians, resident physicians, and non-physician practitioners (NPP) at our quaternary-care academic medical center were invited to participate in role-based, weekly one-hour facilitated debriefings using Zoom. ED attendings with experience in debriefing led each session and used an explorative approach that focused on empathy and normalizing reactions. At the end of the pilot, we distributed to participants an anonymous 10-point survey that included multiple-answer questions and visual analogue scales.

Results: We completed 18 debriefings with 68 unique participants (29 attending physicians, 6 resident physicians, and 33 NPPs. A total of 76% of participants responded to our survey and 77% of respondents participated in at least two debriefings. Emergency clinicians reported that the most common reasons to participate in the debriefings were "to enhance my sense of community and connection" (81%) followed by "to support colleagues" (75%). Debriefing with members of the same role group (92%) and the Zoom platform (81%) were considered to be helpful aspects of the debriefing structure. Although emergency clinicians found these sessions to be useful (78.8 +/- 17.6) interquartile range: 73-89), NPPs were less comfortable speaking up (58.5 +/- 23.6) than attending physicians (77.8 +/- 25.0) ($p = < 0.008$).

Conclusion: Emergency clinicians participating in a video-based debriefing program during the coronavirus pandemic found it to be an acceptable and useful approach to support emotional well-being. Our program provided participants with a platform to support each other and maintain a sense of community and connection. Other EDs should consider implementing a debriefing program to safeguard the emotional well-being of their emergency clinician workforce. [West J Emerg Med. 2020;21(6)88-92.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

The 2019 coronavirus pandemic poses unique systems and psychological challenges to clinicians in the emergency department (ED). Clinicians involved in managing public health crises are prone to experiencing a range of emotions including anxiety, fear, and grief that can lead to disaster-related distress.[1-3] This has become increasingly evident as the pandemic continues, and these reactions impact the resilience and retention of the ED workforce.[4,5]

Critical incident stress debriefing (CISD) is a recommended practice for processing clinician reactions and may reduce the incidence of disaster-related distress.[6,7] It is likely most effective when performed as soon as possible in time and place to an event.[7,8] However, the coronavirus pandemic demands that emergency clinicians balance a variety of stressors while on shift including high acuity, patient surge, and risks to personal physical safety. In response, we designed and implemented a video-based ED debriefing program to support the well-being of our emergency clinicians. Our program had the following objectives: 1) to facilitate discussion regarding emotional reactions to coronavirus disease 2019 (COVID-19); 2) to provide peer-to-peer support in an era of social distancing; and (3) to identify resources to improve self-care and build resilience. The objective of this paper was to describe the details of our program and report the results of our evaluation of its acceptability and initial impact on emergency clinicians providing care during the coronavirus pandemic.

METHODS

Design and Participants

Our program was offered to emergency clinicians at our quaternary-care academic medical center that sees over 110,000 ED annual visits. The staff includes 119 physicians (attendings and residents) and 50 non-physician practitioners (NPP) (physician assistants and nurse practitioners). An invitation was sent to ED attending physicians, resident physicians, and NPPs by email to participate in voluntary debriefings on well-being and emotional reactions to COVID-19. To increase psychological safety, the email stated that each session would be for a single clinician role group (eg, attending physicians only) and identified the facilitators (DLM and JKT, both present for all sessions).[9] The email provided a link to the secure, password-protected Zoom meeting. Our hospital's institutional review board (IRB) approved evaluation of this program.

Facilitator Experience

The same two ED faculty (DLM and JKT) with experience in clinical debriefing, simulation, and clinician wellness co-facilitated each session. In the year preceding this debriefing program (2018-2019), these two facilitators completed >150 hours of debriefings with ED staff in individual or team-based medical simulations. Both facilitators have received formal training in group debriefing at the Center for Medical Simulation (Boston, MA) and through Master of Science coursework. Finally, JKT has 15 years of experience in residency leadership (2003-2018), during which time he focused on resident wellness, mentorship, and professional development. These experiences informed study design and debriefing structure.

Debriefing Structure

Two ED attendings with experience in clinical debriefing, simulation, and clinician wellness co-facilitated each session. We selected a co-facilitator approach so that facilitators could support each other in their own emotional reactions to the debrief and model normalizing statements for participants. We also employed a "follow the leader" co-debriefing strategy.[10] An advantage of this strategy is that one attending can primarily lead the debriefing while the other observes participants for reactions, non-verbal cues, and communicates with the lead via Zoom's chat function.[10] The facilitators huddled before each session to identify any particular topics that the group might benefit from debriefing (eg, a recent surge in patient volume).

Participants were asked to log in from a non-clinical environment, use video and headphones, and attest to confidentiality of participation at the start of each session, which were divided into three phases (Appendix A):

1. Opening (5 minutes): The facilitators outline the objectives, describe a confidentiality contract, and discuss a plan for maintaining a psychologically safe environment. We informed participants that we would not record the audio or video of these sessions, and would not provide a list of participants to departmental leadership. We reiterated that solving clinical systems or operational problems is outside the scope of the debriefing, but with participant permission, we would submit concerns that came up during the debriefing to departmental leadership in a de-identified manner. Finally, we informed participants that Zoom has a "lobby" function, or private virtual space, in which one can take a break from the call if distressed without leaving the session altogether.
2. Discussion (45 minutes): The facilitators prompt reflection on emotional reactions to recent events in the ED or at home, steering the discussion toward empathic validation, normalizing reactions instead of problem solving. Facilitators often modeled these statements at the start of this phase as an "ice-breaker," and communicated with participants using the chat function in addition to the video.
3. Closing (5 minutes): The participants have an opportunity to share any final burning issues; the group develops 1-2 major

take-aways from the session; and facilitators share a link to a list of well-being resources provided by the hospital.

After each session, facilitators debriefed each other on their own reactions to the session and summarized any specific systems-based or operational concerns approved by the participants to be shared with departmental leadership.

Survey Design and Analysis

An anonymous and voluntary 10-point survey was distributed electronically to all participants at the end of the pilot (Appendix B). To create this survey, study team members (DLM, JKT) reviewed previous evaluations of debriefing and peer-support programs related to well-being in healthcare, including survey-based studies.[11-13] Based on these results, study team members (DLM, JKT) created questions that focused on debriefing participants' experience with the program. For multiple-answer questions (3, 5, and 8), we pre-defined a significant result to be a choice that >70% of respondents included in their answer. We selected these answer choices based on the results of previous evaluations of debriefing programs and our program objectives.[11-13] Questions 4, 6, and 7 asked participants to rate the relative utility of these sessions and comfort speaking up during a debriefing using a visual analogue score (VAS).[14] Finally, we solicited feedback from remaining study authors and incorporated recommendations into the final survey.

The mean and interquartile range (IQR) were determined for each role group. Remaining questions were single option or open-ended. We used SurveyMonkey Inc. (San Mateo, California) to compile survey data and performed our analysis using Microsoft Excel (Microsoft Corporation, Redmond, WA).

RESULTS

We completed 18 debriefing sessions between March-April 2020 with 68 emergency clinicians (29 attending physicians, 6 resident physicians, and 33 NPPs). The mean number of participants in each session was 8.5 (IQR 6-10) for attendings, 4 (IQR 3.5-4.5) for residents, and 19 (IQR 14-26) for NPPs. We received a 76% response rate (52/68) (79% of attendings, 50% of residents, and 79% of NPPs) and 77% of respondents participated in at least two debriefings.

Emergency clinicians were primarily motivated to participate in these sessions to enhance their sense of community and connection (81%), support colleagues (75%), and better understand the emotional reactions of peers (71%). No other choices met our predefined threshold of >70% to be a significant factor and only 4% of emergency clinicians reported participating in order to process a specific clinical encounter. The clinicians reported four aspects specific to the debriefing process to be helpful: facilitators created a safe environment (98%); debriefing with members of the same role group (92%); facilitators were trusted colleagues (87%); and the Zoom platform was easy to use (81%). Among the surveyed programmatic aspects that respondents may have found unhelpful, none met our predefined threshold.

The average perceived value of these sessions for emergency clinicians was 78.8 +/- 17.6 (IQR 73-89). There was no statistical difference in mean rating between attending physicians (81.9 +/- 15.7) and NPPs (74.8 +/- 19.5) (p = 0.16) (Figure 1).

Emergency clinicians rated their comfort with speaking up during these debriefings to be 69.1 +/- 25.9 (IQR 52-93), and there was a statistical difference between attending physicians (77.8 +/- 25.0) and NPPs (58.5 +/- 23.6) (p = < 0.008) (Figure 2). Finally, emergency clinicians reported that debriefings contributed to a sense of connection with colleagues with an average 80.8 +/- 19.5 (IQR 69-96).

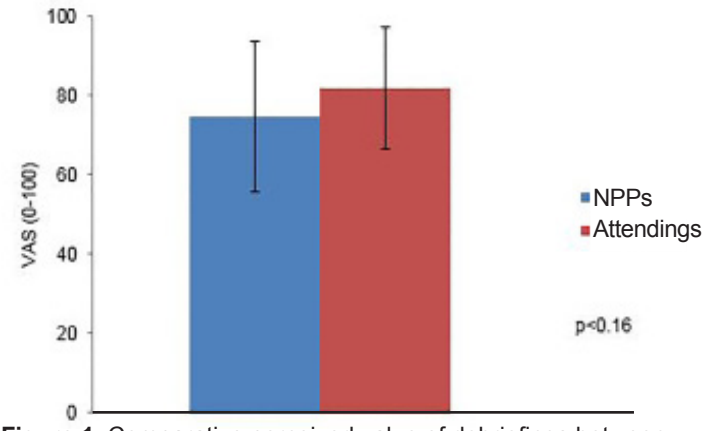

Figure 1. Comparative perceived value of debriefings between non-physician providers and attending physicians.
NPP, non-physician provider; *VAS,* visual analogue scale.

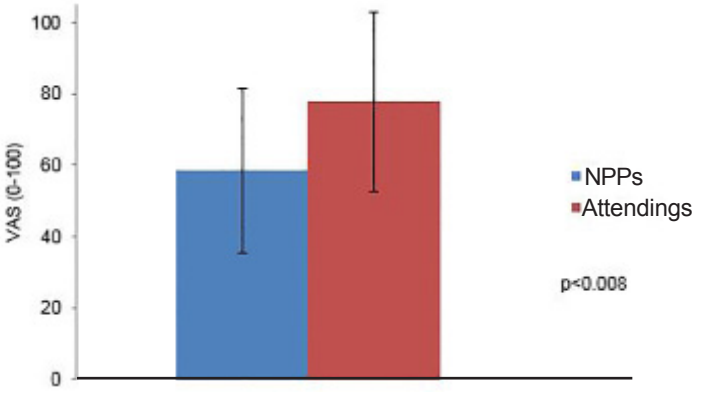

Figure 2. Comparative comfort speaking up during debriefings between non-physician providers and attending physicians.
NPP, non-physician provider; *VAS,* visual analogue scale.

DISCUSSION

We present a program to support the well-being of emergency clinicians during the coronavirus pandemic through video-based, emotion-oriented debriefings. Our

results suggest that emergency clinicians are most interested in participating in this type of program to enhance their sense of community and connection with colleagues and understand emotional reactions of their peers, in comparison to less commonly identified reasons such as processing grief or a specific clinical encounter. Emergency clinicians sought opportunities to understand their peers' emotional reactions to COVID-19 and support the range of emotional responses to the uncertainties and risks pervading both work and home environments. Debriefing also provided emergency clinicians with a platform to discuss unmet needs to improve self-care and build resilience.

Unlike critical-event debriefing and debriefing in simulation, there is less of a consensus around the best approach to debriefing clinicians on the emotional impact of a long-term public health crisis and occupational risk.[6,15-17] We therefore employed an explorative approach to debriefing, focusing on empathy, compassion, and normalizing reactions. However, as the pandemic continues, debriefing specific emotions such as anxiety, guilt, isolation, and grief may become increasingly important at different phases of the crisis.[2,3]

Seventy-seven percent of respondents participated in two or more sessions. However, the voluntary nature of these debriefings may predispose our population to represent a subgroup of emergency clinicians who are more comfortable with sharing their emotional reactions with peers and showing vulnerability. This may influence our survey results and suggests that debriefing with peers may be a strategy to safeguard well-being for some but not all emergency clinicians. Recognizing this variability, we recommend that EDs interested in implementing a peer-based debriefing program incorporate it into a comprehensive approach to clinician wellness.

Finally, our finding that NPPs reported less comfort speaking up in a debriefing than attending physicians was unexpected. It is possible that low staff turnover of our attending group contributes to increased comfort with vulnerability. There may be less heterogeneity in professional experience for attendings than NPPs, influencing their perceived comfort with speaking up in these sessions. Hierarchy in clinical experience may also contribute to this finding. The attending leadership role may make speaking up easier, whereas NPPs are a clinically supervised group. Finally, the mean number of participants per session was higher for NPPs than attending physicians; this may also have contributed to the psychological safety of the debriefing environment. Further investigation is warranted as we grow the program to include other frontline emergency providers (eg, nurses and pharmacists). In the meantime, we plan to mitigate this potential factor by using Zoom's breakout- room function.

LIMITATIONS

Because it was a single-center study, the results of this intervention may have limited external validity. The process itself may have been influenced, either positively or negatively, by the facilitators' relationship with the participants and previous interpersonal experiences, leading to a halo or millstone effect. Our survey did not account for external factors such as the level of ED preparedness and other wellness interventions by our administration that predate the pandemic. These may influence the way emergency clinicians experienced our debriefings. Further, our survey did not define "speaking up," and this term may have been understood differently by participants, limiting interpretation of the results of this specific question.

Finally, our methodology did not allow us to investigate why few resident physicians volunteered to participate in our debriefings. Interventions implemented by the residency before the pandemic to support resident well-being, such as dedicated resident-only debriefing sessions during residency conference and a peer mentorship program, may have been effective and residents therefore did not elect to participate in our intervention.

CONCLUSION

Emergency clinicians at our hospital reported that a video-based debriefing program was an acceptable and valuable intervention for supporting their emotional well-being during the initial phase of the coronavirus pandemic. The program provided participants with a platform to support each other and maintain a sense of community and connection despite social distancing. EDs should consider implementing a similar program to safeguard the emotional well-being of its clinician workforce as we move into subsequent phases of the pandemic.

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Method to Reduce Aerosolized Contaminant Concentration Exposure to Healthcare Workers During the COVID-19 Pandemic when Temporary Isolation Systems Are Required

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The COVID-19 pandemic has strained the healthcare system. It has led to the use of temporary isolation systems and less-then-optimum patient placement configurations because of inadequate number of isolation rooms, both of which can compromise provider safety. Three key elements require special attention to reduce the maximum and average aerosolized contaminant concentration exposure to a healthcare worker in any isolation system: flow rate; air changes per hour; and patient placement. This is important because concentration exposures of aerosolized contaminants to healthcare workers in hospitals using temporary isolation systems can reach levels 21-30 times greater than a properly engineered negative pressure isolation room. A working knowledge of these three elements can help create a safer environment for healthcare workers when isolation rooms are not available. [West J Emerg Med. 2020;21(6)93-98.]

BACKGROUND

Controlling both the droplet component and the aerosol component of an infectious process is critical to stopping the spread of an infection. Droplets can generally be controlled by a barrier be it gloves, masks, gowns, goggles and splash shields, tents, or isolation (intubation) boxes. The interior of some common barrier devices can create unsafe, contaminated air 21-30 times higher than inside a standard negative pressure isolation room (NPIR) when an aerosol is present. For example, the isolation box presented in Canelli et al[1] presents an effective method for reducing the droplet component of an infection. If an aerosol component is present, it can be determined that the air contaminant concentration level inside this device will reach 21 times that of a standard NPIR in six minutes and its steady state value of 30 times that of a standard NPIR in 23 minutes.

Healthcare providers need to be aware of two potentially dangerous situations when using temporary isolation devices by considering not only the role of the droplet component but also the role the aerosol component plays in the potential to spread infections. First, consider if prior to intubation, a provider needed to attend to a patient inside a portable isolation box to access their central line for example. Assuming the provider is not wearing a powered air purifying respirator (PAPR), if their face is near or inside the opening of the isolation device their N-95 mask now has to filter air 21-30 times more contaminated then when wearing the N-95 mask in a standard NPIR. Therefore, the inhaled contaminants are 21-30 times greater than when the patient is in a NPIR without an isolation box. Second, when the isolation box is removed after intubation there is a release of air 21-30 times more contaminated than that of a patient in a NPIR without an isolation box into the local environment exposing nearby healthcare providers to these higher contamination levels.[2] Furthermore, the use of an isolation box in a hallway could expose this highly contaminated air to other patients or visitors in the hallway.

Understanding the information and analysis presented in this paper will give healthcare providers the basic knowledge required to calculate the maximum exposure of an isolation system compared to a standard NPIR. It will also give the necessary skills to determine configuration options for patients that will minimize a healthcare worker's average exposure to contaminants from overflow patients waiting for placement into an appropriate NPIR. This should be shared with your building engineers to determine how to minimize the concentration of contaminated air outside of the standard NPIR. This analysis only applies to an aerosolized component

of contamination and does not include the effect of the droplet component, which can be reduced by local barriers.

ANALYSIS

A reference volume, V_{ref}, could refer to a room, isolation box, or even a protective hood. The ratio of the contaminant concentration in any reference volume compared to the contaminant concentration of a source, i.e., patient's exhaled breath, is the contaminant concentration ratio (CCR).

$$(1)\quad CCR(t) = \frac{[C(t)_{V\,ref}]}{[C_{breath}]} = \left(\frac{n * q_{breath}}{Q_{out}}\right) * (1 - e^{-ACH * t})$$

The appendix shows the derivation of this equation and other equations presented. The definition of terms is in Table 1. Equation (1) holds true if the contaminated source were placed in a negative, positive or equal pressure room because each type of pressure differential room can create the same Q_{out} (Q = flow rate) and air changes per hour (ACH) values. We know it makes sense to place a contaminated source patient in a NPIR because it helps keep those outside of this room safe.

The basic assumption is that the contaminant is fully aerosolized and mixes evenly throughout the reference volume, V_{ref}. The volume flow rate leaving the reference volume, Q_{out}, is typically controlled by a high-efficiency particulate air filtration system to create the desired ACH. The volume flow rate of a single (n = 1) patient's contaminated breath is determined from the patient's tidal volume and respiratory rate.

$$(2)\quad q_{breath} = TV * RR\ (m^3/hour)$$

Because the exponential portion of Equation (1) approaches zero as time (t) progresses, the CCR approaches a steady state value given by Equation (3) and is shown in Figure 1.

$$(3)\quad CCR(\infty) = \frac{[C(\infty)_{V\,ref}]}{[C_{breath}]} = \left(\frac{n * q_{breath}}{Q_{out}}\right)$$

Table 1. Definitions of terms used to measure air contamination caused by aerosolized components.

ACH – Air changes/hour
[C] – Concentration of contaminant (particles/m^3)
CCR – Contaminant concentration ratio
O_2 – Oxygen supply to patient
n – number of patients in V_{ref}
P – # Contaminant particles
Q, q – Flow rate (m^3/hour)
Q_{out}= ACH * V_{ref}
RR – Respiratory rate (1/hour)
t – time (hours)
TV – Tidal volume (m^3)
V_{ref} – Reference volume (m^3) (e.g., isolation box or room)

The time to reach 99% of this steady state value ($T_{99\%}$) can also be determined from Equation (1). This result can be written as Equation (4) and is shown in Figure 2.

$$(4)\quad T_{99\%} = -\frac{1}{ACH}\ln(1 - 0.99)\ (hours)$$

It is vital to understand that Equation (3) tells us that the final, steady state CCR value depends on the main controllable variable Q_{out}. Therefore, any two isolation systems with similar-source patients will have identical CCRs only if Q_{out} is identical in both systems. This is true even when the volumes are different. Equation (4) shows that any two different isolation systems regardless of their volumes will reach their individual steady state CCR values at the same time only if their ACH values are identical. So, Q_{out} determines the steady state CCR value and ACH determines the time to reach this steady state value.

DISCUSSION

One goal of an isolation system is to achieve the lowest steady state CCR possible to create a safer environment for healthcare workers and other patients nearby. Equation (3) shows this is achieved by having the highest flow rate, Q_{out}, possible. The CCR will be identical for any given number, n, of patients in any two isolation systems as long as Q_{out} is identical in each system. For this reason, Q_{out} is a key element to pay attention to when assessing an isolation system. Equation (4) shows the role of ACH in determining the time it takes to reach $T_{99\%}$. A larger ACH shortens this time.

A 12 ACH NPIR with a V_{ref} of 30 m^3 has a Q_{out} of 360 m^3/hour. Single patients are assumed to have a tidal volume (TV)

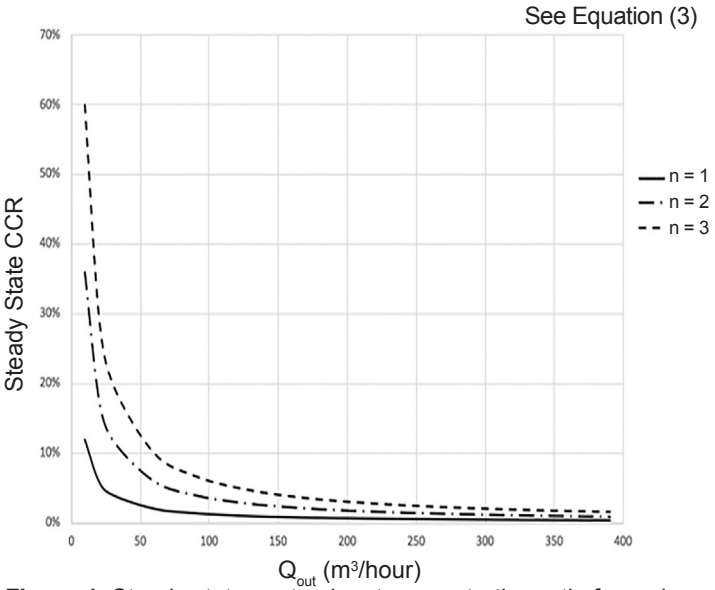

Figure 1. Steady state contaminant concentration ratio for various number of contaminated patients (n) for any reference volume where q breath = 1.2 m^3/hour.
CCR, contaminant concentration ratio.

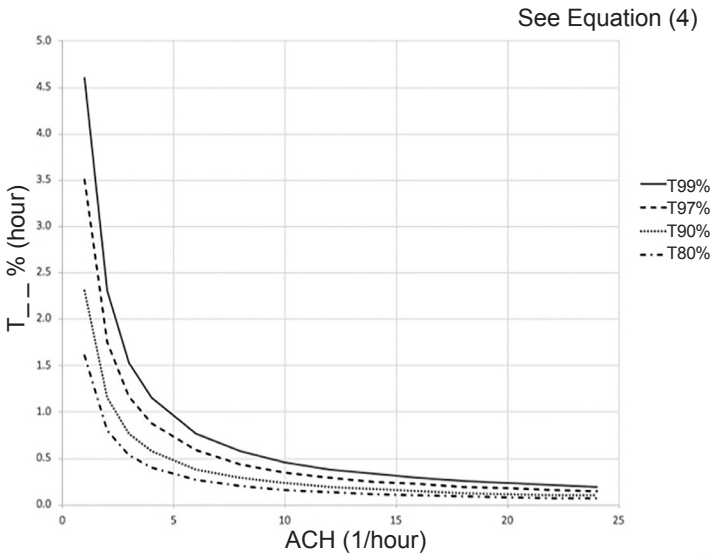

Figure 2. Time to reach T_ _ % of the steady state contamination concentration ratio for any reference volume.
ACH, air change per hour.

of 0.5 liter and respiratory rate (RR) of 40/minute or a q_{breath} of 1.2 m^3/hour. Therefore, this standard NPIR will reach 99% of its steady state aerosolized CCR of 0.33% in 0.4 hours (24 minutes). Simply put, the final room contaminant concentration will be 0.33% of the single patient-source contaminant concentration. The source contaminant concentration could be the patient's exhaled breath directly, the breath exhaled after passing through a mask, or even nebulized contaminants. As previously stated, standard NPIRs require an ACH =12. For comparison ACHs for operating rooms (OR), general medicine rooms, and hospital hallways are 15, 6 and 2, respectively. An OR is kept at positive pressure while rooms and hallways are kept at equal pressure with respect to the surrounding areas.[3]

The maximum and average CCR exposures for steady state conditions, assuming equal exposure time and identical patients, are given for three configurations of an overwhelmed healthcare environment without an adequate number of NPIRs (shown in Figures 3, 4, and 5). The appendix shows the average CCR at steady state for equal time with equal patients is the

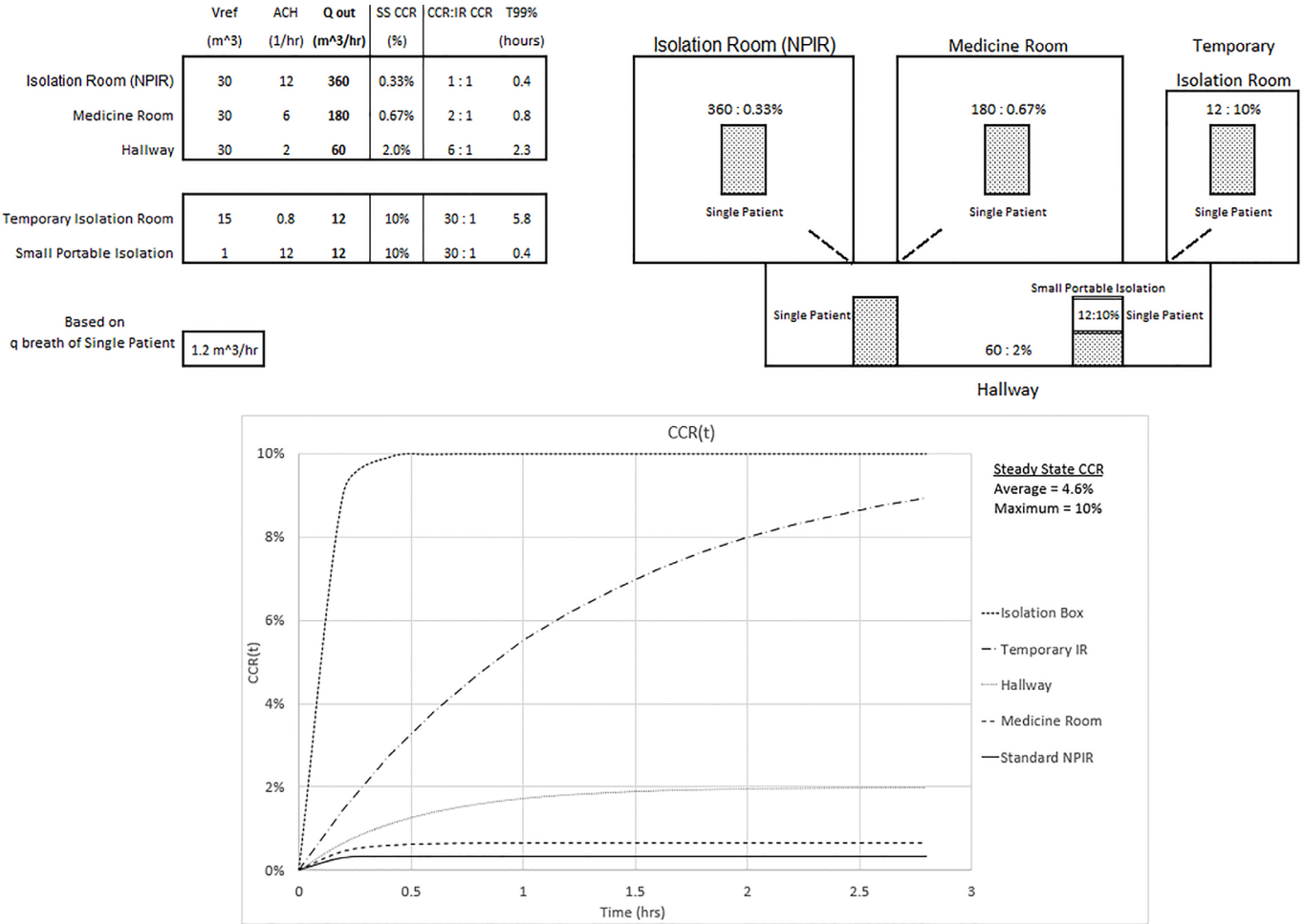

Figure 3. Configuration and CCR(t) of steady state average and maximum CCR exposures of 4.6% and 10% for equal time with all patients (average is 14 times the exposure of a standard isolation room CCR of 0.33%).
NPIR, negative pressure isolation room; *SS,* steady state; *CCR,* contaminant concentration ratio.

average of the individual CCRs at steady state. The techniques described in this paper are for emergency situations only. They are not intended to be used for an aerosolized infectious disease environment when there are a sufficient number of properly engineered NPIRs available to meet patient demand.

Figure 3 shows an overwhelmed system without a sufficient number of NPIRs where all five patients require isolation. Note the inverse relationship between the Q_{out} values and the corresponding steady state CCR. Looking at the temporary isolation room (IR) and small portable isolation devices, for example, this same relationship does not hold for the ACH values. ACH does have an inverse relationship with the $T_{99\%}$ values. The small portable system in the hallway could represent a tent or isolation box and is assumed to have a passive air exchange of 12 ACH in this setting. Realize that 360 ACH would be required to achieve a standard NPIR Q_{out} of 360 m^3/hour. This won't directly affect the hallway until the 10% CCR small portable container, which is not actively ventilated, is opened when a provider needs access to the patient or is removed after the patient is intubated. The temporary IR is capable of 0.8 ACH, and the CCR will also reach a 10% CCR. Twenty-four ACH would be required to achieve a standard NPIR Q_{out} of 360 m^3/hour. The maximum CCR exposure of 10% to the healthcare worker occurs in the portable and temporary isolation systems and is 30 times the standard NPIR level. The average CCR exposure to the healthcare worker who spends equal time with each patient would be (0.33% + 0.67% + 2% + 10% + 10%)/5 = 4.6%, or 14 times the standard NPIR. These results assume each compartment's ventilation is separate from the others. The graph of CCR(t) in the figure is obtained from Equation (1).

In Figure 4 we assume improvements were made to the ventilation system of the temporary IR that led to an improved ACH of 6 and the portable isolation system in the hallway is removed. Accounting for n = 2 in the hallway, Q_{out} still determines the CCR and ACH determines $T_{99\%}$. The maximum CCR exposure of 4% to the healthcare worker occurs in the hallway and is now 12 times the standard NPIR. The average CCR exposure to the healthcare worker who spends equal time with equal patients would be reduced to 0.33% + 0.67% + 1.33% + 2*4%)/5 = 2.1%, or six times the standard NPIR.

In Figure 5 one hallway patient is then moved into the NPIR. The maximum CCR exposure of 2% to a healthcare worker still occurs in the hallway but is only six times the NPIR standard. The average CCR exposure for equal time with equal patients is

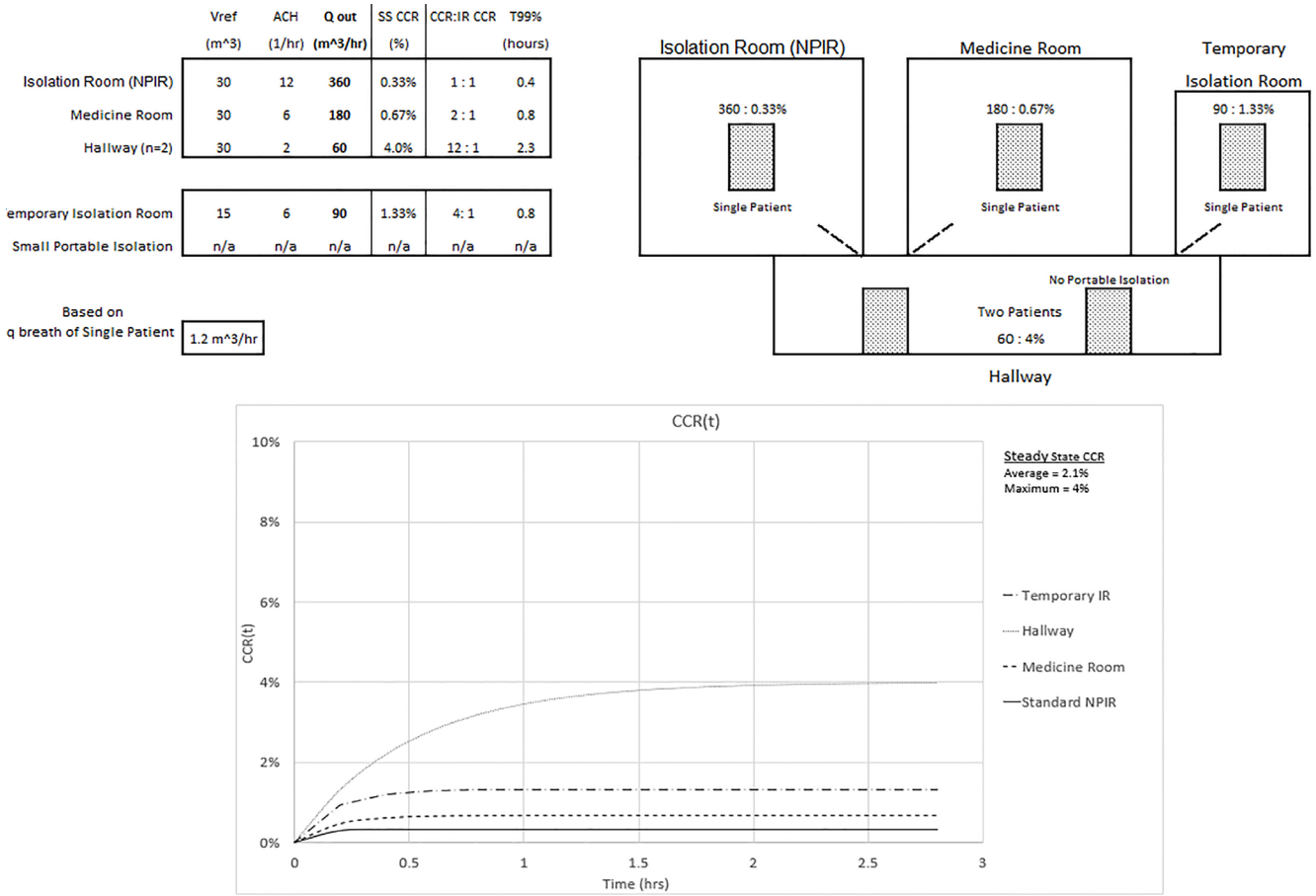

Figure 4. Configuration and CCR(t) of steady state average and maximum CCR exposures of 2.1% and 4% for equal time with all patients (average is 6 times the exposure of a standard isolation room CCR of 0.33%).
NPIR, negative pressure isolation room; *SS,* steady state; *CCR,* contaminant concentration ratio.

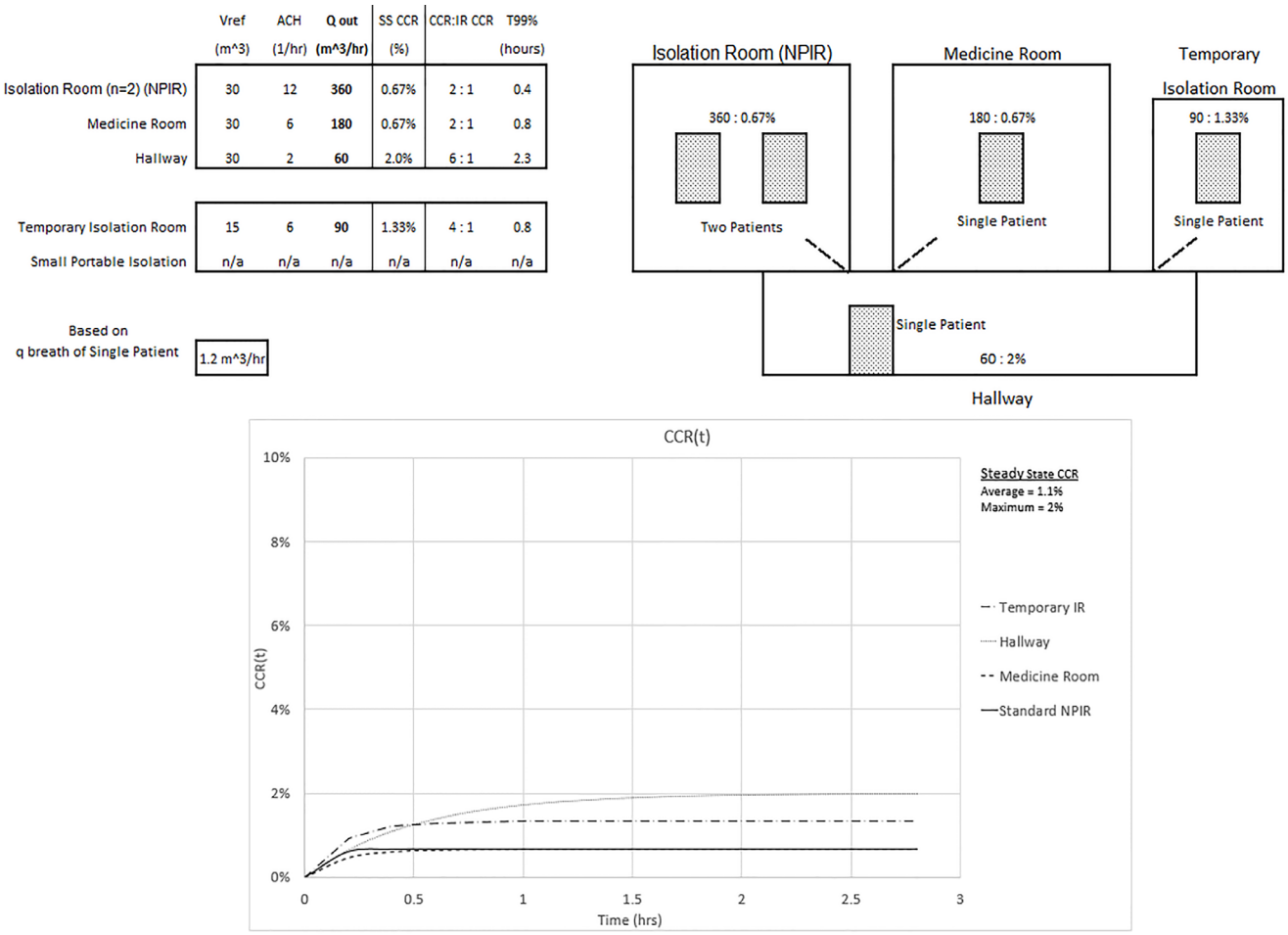

Figure 5. Configuration and CCR(t) of steady state average and maximum CCR exposures of 1.1% and 2% for equal time with all patients (average is three times the exposure of a standard isolation room CCR of 0.33%).
NPIR, negative pressure isolation room; *SS,* steady state; *CCR,* contaminant concentration ratio.

further reduced to (2*0.67% + 0.67% + 1.33% + 2%)/5 = 1.1%, or three times the standard NPIR. The tradeoff is that in the NPIR, the CCR is 0.67%, or double the "allowable" level.

Each of these three configurations offers advantages and disadvantages depending on patient diagnosis, gender, and the availability of space, equipment, and staff. These considerations are all important when deciding how to optimize patient care and healthcare safety. The patient configurations presented here demonstrate how an overwhelmed hospital environment might lead to a 3-, 6-, or even 14-fold increase in average contamination exposure to healthcare workers. Configurations different than those presented would require a separate analysis.

SUMMARY

There are three key physical elements to understand when working with isolation systems. They are flow rate (Q_{out}), air changes per hour (ACH), and patient placement, which affects the maximum and average contaminant concentration ratio exposure. Q_{out} determines the magnitude of the CCR. A larger Q_{out} will result in a smaller CCR.[4] Matching the flow rate of any two isolation systems, regardless of their size, will give equal CCRs when the source contaminant concentrations are identical. The magnitude of the ACH determines the time the isolation system will reach 99% of its steady state value ($T_{99\%}$). A larger ACH will result in a smaller $T_{99\%}$. Matching the ACH of any two isolation systems, regardless of their size, will ensure the $T_{99\%}$ are equal in both systems. Understanding these different effects of Q_{out} and ACH are important to avoid maximum CCR exposures that can reach 21-30 times that of a standard NPIR as was shown with the small volume portable isolation box. The third key element (patient placement) becomes important when a hospital system is overwhelmed and it is not possible to place a patient requiring isolation into a standard NPIR. It then becomes important to realize that patient placement can be varied to reduce the maximum and average CCR a healthcare worker is exposed to. Based on criteria set in a specific example, it was demonstrated that optimum patient placement reduced the average CCR exposure from 14 to only 3

times that of a standard NPIR.

It is beyond the scope of this article to discuss details of other purposes for using these equations. It may not be obvious to the reader at this point, but these equations could be used as first order calculations to determine basic thresholds of ventilation required to maintain a specified safe level of contaminant concentration of aerosols in hospitals, schools, places of worship, theaters, government buildings and the like. This article should be shared with your engineering department to improve collaboration and maximize their task of optimizing ventilation to minimize exposure to infectious particles in the care of COVID-19 patients.

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In-situ Simulation Use for Rapid Implementation and Process Improvement of COVID-19 Airway Management

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Introduction: The coronavirus disease 2019 (COVID-19) pandemic presents unique challenges to frontline healthcare workers. In order to safely care for patients new processes, such as a plan for the airway management of a patient with COVID-19, must be implemented and disseminated in a rapid fashion. The use of *in-situ* simulation has been used to assist in latent problem identification as part of a Plan-Do-Study-Act cycle. Additionally, simulation is an effective means for training teams to perform high-risk procedures before engaging in the actual procedure. This educational advance seeks to use and study *in-situ* simulation as a means to rapidly implement a process for airway management in patients with COVID-19.

Methods: Using an airway algorithm developed by the authors, we designed an *in-situ* simulation scenario to train physicians, nurses, and respiratory therapists in best practices for airway management of patients with COVID-19. Physician participants were surveyed using a five-point Likert scale with regard to their comfort level with various aspects of the airway algorithm both before and after the simulation in a retrospective fashion. Additionally, we obtained feedback from all participants and used it to refine the airway algorithm.

Results: Over a two-week period, 93 physicians participated in the simulation. We received 81 responses to the survey (87%), which showed that the average level of comfort with personal protective equipment procedures increased significantly from 2.94 (95% confidence interval, 2.71-3.17) to 4.36 (4.24-4.48), a difference of 1.42 (1.20-1.63, $p < 0.001$). There was a significant increase in average comfort level in understanding the physician role with scores increasing from 3.51 (3.26-3.77) to 4.55 (2.71-3.17), a difference of 1.04 (0.82-1.25, $p < 0.001$). There was also increased comfort in performing procedural tasks such as intubation, from 3.08 (2.80-3.35) to 4.38 (4.23-4.52) after the simulation, a difference of 1.30 points (1.06-1.54, $p < 0.001$). Feedback from the participants also led to refinement of the airway algorithm.

Conclusion: We successfully implemented a new airway management guideline for patients with suspected COVID-19. *In-situ* simulation is an essential tool for both dissemination and onboarding, as well as process improvement, in the context of an epidemic or pandemic. [West J Emerg Med. 2020;21(6)99-106.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

Epidemics and pandemics present numerous challenges to frontline healthcare workers. These providers must not only take care of patients during a period of uncertainty but must also ensure they protect themselves from exposure. The coronavirus disease 2019 (COVID-19) pandemic has led to the need for new management protocols to be created and implemented rapidly, including clinical guidelines related to the safety of healthcare workers.[1] In the emergency department (ED), aerosol-generating procedures (AGP), such as endotracheal intubation of patients with presumed/confirmed COVID-19, represent the highest risk to healthcare providers due to the aerosolization of viral particles.[2,3] These new guidelines must be quickly tested and disseminated in order to provide safe care.

The process of implementing a new management guideline can take significant time and buy-in from key stakeholders. New protocols typically develop through an iterative process, often in the form of a rapid Plan-Do-Study-Act (PDSA) cycle.[4,5] Through a PDSA process, an educational, operational, or other need is identified and a process designed to fix it. After this initial implementation, feedback is obtained and studied. The initial process is then refined, restarting the cycle. In-situ simulation has previously been shown to be a powerful tool for identifying and correcting latent safety threats as well as process improvements in new hospital units and protocols.[6-8] By using simulation within the space where that process occurs, new guidelines can be tested by those most affected, and comments can be fed back to revise the current workflow.[9]

Simulation is useful not only for process improvement but also to prepare teams for critical events. Prior work has shown that care teams have a better understanding of job responsibilities and improved communication during trauma activations after participating in an in-situ simulation.[10] Surgeons use "simulation-based clinical rehearsals" to practice high-risk procedures prior to performing them on actual patients.[11,12] Similarly, the use of "just-in-time" simulation training, which refers to the opportunity to practice a skill immediately prior to use in the clinical environment, has been shown to be effective in teaching skills and providing refreshers to avoid skill decay.[13-15]

The COVID-19 pandemic provides unique circumstances surrounding the implementation of new management guidelines and methods for teaching a large cohort of providers the skills necessary to deliver care in a safe manner. Due to state and federal executive orders prohibiting large gatherings, effectively leading to the cessation of typical in-person learning opportunities for providers, alternative methods for teaching are required.[16,17] This brief innovation details our model for implementing an algorithm for managing the high-risk AGP in patients with presumed COVID-19 diagnosis and highlights our method for both rapidly refining our algorithm through a PDSA process and onboarding our providers to this new management protocol while following social distancing guidelines.

METHODS

Simulation Scenario

Our airway algorithm was developed by this authorship group (BSB and CHH) in coordination with hospital leadership and the Department of Anesthesiology (Supplemental File).[18] To facilitate rapid PDSA cycling of this protocol and to onboard attending and resident physicians to new airway management guidelines, we developed an in-situ simulation scenario featuring a decompensating patient with COVID-19 requiring definitive airway management with intubation. The scenario was designed to fulfill the following primary objectives: 1) demonstrate and adhere to donning and doffing of personal protective equipment (PPE) for high-risk AGPs in suspected COVID-19 patients; 2) perform an AGP while maintaining precautions, including pre-brief, intubation, and post-intubation management; and 3) demonstrate closed-loop communication with an interprofessional team with PPE in place and ongoing infection control procedures. The scenario design process as well as the case itself are further detailed and available for use through the Association of American Medical Colleges iCollaborative.[19] We developed and reviewed the scenario prior to implementation by educational leadership within the physician, nursing, and respiratory therapy groups.

In anticipation of a surge in critically ill patients requiring AGP, we conducted in-situ simulation sessions three times daily, prior to the start of clinical shifts. After one week, sessions were reduced to twice daily. These sessions occurred at the Michigan Medicine Adult Emergency Department, using a resuscitation room that was similar to rooms where patients would be intubated. Exact room was determined at the time of the session, based on room availabilities. Through announcements via email as well as during virtual departmental meetings, we invited all physicians, nurses, and respiratory therapists to participate in order to delineate roles and promote team communication. To comply with guidelines to minimize large gatherings, sessions were limited to the providers who were going to be working in the resuscitation area during the oncoming shift. Simulations were limited to six participants in their typical roles, reflecting the number of providers caring for a patient who requires an AGP in our protocol (two physician providers, two nurses inside the room, one respiratory therapist, and one additional nurse outside

the room). If additional providers working that day showed up to the session, they were allowed to observe, following recommended social distancing guidelines.
Initial sessions were taught by two authors (BWM and CHH). Additional faculty and residents were subsequently recruited on a volunteer basis to teach these sessions and were provided instruction on teaching methods and observed for a session, following a train-the-trainers framework. To minimize additional infectious risk, teachers were encouraged to sign up to teach sessions that were to occur immediately prior to their own shifts.

Prior to deployment of the simulation sessions, the airway management algorithm was provided to all providers through a link in an online repository Box (Redwood City, CA), although it was not mandatory for providers to review prior to attending the session.[20] Simulation sessions focused on introduction of the concepts of appropriate donning of PPE; preparation and planning for intubation; the intubation procedure; post-intubation management; and appropriate doffing of PPE. Following a pre-brief that reviewed the airway management algorithm and demonstration of key elements, the participants engaged in the simulation scenario as a team, using a deliberate practice framework to correct errors in real time, noted by a critical action checklist. Due to national shortages of PPE, simulated equipment, such as Styrofoam masks replicating N95s, were used to practice donning and doffing techniques. Following the session, participants underwent debriefing that reinforced the critical actions.

Airway Algorithm Refinement

The simulation sessions also informed the change process for the airway algorithm, following a PDSA cycle (Figure 1). After the initial implementation of the simulation, we sought feedback on the airway algorithm from participants and any observers present in real time regarding what worked well and how the algorithm could be improved. Additionally, providers were encouraged to email us with any additional feedback based upon their experiences in the clinical environment. This feedback was shared with the entire authorship group, who reviewed the information and used it to inform subsequent iterations of the airway algorithm. As new knowledge regarding best practices became available, this was also incorporated into new versions of the algorithm. We provided updated guidelines in Box for learners to review and refer to as needed.

Following participation in the simulation, the physician participants were asked to complete a retrospective pre/post survey using a five-point Likert scale (1 being extremely uncomfortable, 3 being neither comfortable nor uncomfortable, and 5 being extremely comfortable) regarding their comfort with aspects of the management of AGPs in COVID-19 patients before and after the simulation. Questions included physician level of comfort both before and after

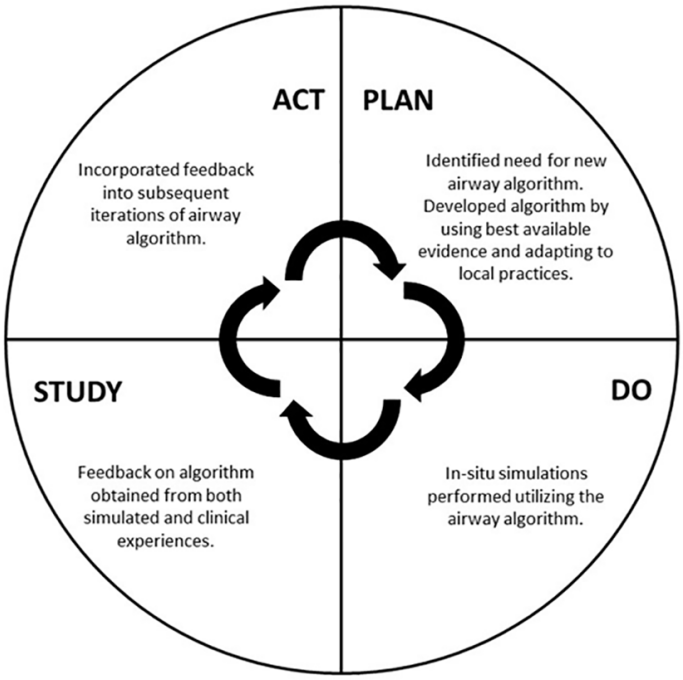

Figure 1. Plan Do Study Act cycle for refinement of the institutional airway algorithm for patients with suspected COVID-19.

the simulation in the following domains: 1) PPE donning and doffing procedures; 2) understanding their role in AGPs; and 3) performing aerosol-generating procedural tasks such as intubation. We determined the mean and 95% confidence intervals (CI) of the survey results, and evaluated the pre- and post-simulation results using two-sided paired t-tests. All statistical computations were performed in SAS v9.2 (SAS Institute; Cary, NC). P value < 0.05 was considered statistically significant. We measured onboarding and reach through attendance at sessions by ED residents and faculty compared to those currently working in the department. Residents who were on off-service rotations and faculty who did not work shifts during the months of March and April were excluded. This study was exempted from institutional review board review by the University of Michigan Medical School Office of Research.

RESULTS

Between March 16–April 1, 2020, 93 physicians completed the simulation training through a total of 37 simulation sessions. Of these physicians, 91.4% (85) were emergency physicians, while 8.6% (eight) were intensivists or anesthesiologists who attended sessions for the purpose of training their own departments in this algorithm. Of the ED providers, 45.9% (39) were residents or fellows and 54.1% (46) were attending physicians. This represented 86.7% (39 of 45) residents and 83.6% (46 of 55) of faculty who worked shifts in the ED during this time.

We received 81 responses from the 93 participants (87%

response rate). Thirty (37%) of the providers had participated in an AGP on a suspected or confirmed COVID-19 patient prior to participating in the simulation. The average level of comfort with PPE procedures increased significantly from 2.94 (95% CI, 2.71-3.17) to 4.36 (4.24-4.48), a difference of 1.42 (1.20-1.63, $p < 0.001$). The providers again showed a significant increase in average comfort level in understanding their role with scores increasing from 3.51 (3.26-3.77) to 4.55 (2.71-3.17), a difference of 1.04 (0.82-1.25, $p < 0.001$). In addition, providers showed significantly increased comfort in performing procedural tasks such as intubation. Their comfort level increased from 3.08 (2.80-3.35) before to 4.38 (4.23-4.52) after the simulation, a difference of 1.30 points (1.06-1.54, $p < 0.001$) (Table 1). There was no significant difference in the above scores between the providers who had participated in AGPs in suspected or confirmed COVID-19 patients, and those who had not (p-values 0.33, 0.41, and 0.45, respectively) (Table 2).

During the study period, we created a total of 12 versions of the COVID-19 airway algorithm. Changes occurred in response to several avenues of feedback, as described in the methods. Ever-changing consensus recommendations related to airway management in a new disease required maximal flexibility and adaptability. New knowledge regarding best practices were adapted as they became available. Additionally, all participants were offered the opportunity to provide suggestions for change after participating in the simulation. The airway algorithm was also used by many participants on clinical shift immediately following completion of simulation, leading to the discovery of areas needing refinement. To track modifications to the algorithm we created a descriptive "Change Log," which is represented in Table 3.

Table 1. Survey questions and results with means and pre/post intervention differences.

Question	Pre-Intervention Mean (95% CI)	Post-intervention Mean (95% CI)	Difference (95% CI)	P-value
How comfortable did you feel in appropriately donning and doffing PPE in an AGP in a suspected COVID-19 patient?	2.94 (2.71 - 3.17)	4.36 (4.24 - 4.48)	1.42 (1.20-1.63)	<0.001
How comfortable did you feel in knowing your role in the management of an AGP in a suspected COVID-19 patient?	3.51 (3.26 - 3.77)	4.55 (4.42 - 4.68)	1.04 (0.82-1.25)	<0.001
How comfortable did you feel in performing your responsibilities (intubating, giving medications, transitioning patient to vent, etc) without violating PPE precautions during the management of an AGP in a suspected COVID-19 patient?	3.08 (2.80 - 3.35)	4.38 (4.23 - 4.52)	1.3 (1.06-1.54)	<0.001

AGP, aerosol-generating procedure; *PPE,* personal protective equipment; *CI,* confidence interval.

Table 2. Provider comfort with the following after simulation based on whether had performed procedure in patient.

	Donning and doffing PPE mean (95% CI)	Difference (95% CI)	P-value
Had performed procedure prior (n = 30)	4.43 (4.25 - 4.62)	0.12 (-0.16 - 0.44)	0.33
Had not performed procedure prior (n = 51)	4.31 (4.15 - 4.48)		
	Knowing role in management of AGP mean (95% CI)	Difference (95% CI)	P-value
Had performed procedure prior (n = 30)	4.62 (4.41 - 4.83)	0.11 (-0.13 - 0.40)	0.42
Had not performed procedure prior (n = 51)	4.51 (4.34 - 4.68)		
	Performing AGP and maintaining PPE mean (95% CI)	Difference (95% CI)	P-value
Had performed procedure prior (n = 30)	4.45 (4.21 - 4.69)	0.12 (-0.12 - 0.37)	0.45
Had not performed procedure prior (n = 51)	4.33 (4.14 - 4.53)		

AGP, aerosol-generating procedure; *PPE,* personal protective equipment; *CI,* confidence interval.

Table 3. COVID-19 airway algorithm change log.

	Preparation	Pre-brief	Procedure	Post-procedure	Equipment
1	• Move patient to negative pressure room • Identify the team: 2 airway operators, 2 nurses, 1 respiratory tech, 1 runner, 1 PPE monitor • Check equipment in airway bag • Don PPE	• Discuss plan, including pre-oxygenation, RSI medications and post-intubation sedation plan	• Avoid providing BVM oxygenation unless life threatening hypoxemia • Intubate with RSI and VL • Use an iGel with a viral filter if need for re-oxygenation • Avoid ventilation until ETT cuff inflation	• Confirm ETT placement with $ETCO^2$ • Transfer to ventilator by clamping ETT to connect to circuit • Discard equipment and wipe down Glidescope • Doff PPE with the assistance of the PPE monitor	• Glidescope • BVM with $ETCO^2$ adapter and viral filter for preoxygenation and rescue breathing • Airway bag containing airway equipment, nursing supplies, and respiratory therapist supplies
2	• Updated PPE guidelines to remove shoe covers due to concern for self-contamination and to include goggles • Identified specific Glidescope for AGP	• Expanded RSI medications and clarified recommended doses		• Clarified doffing procedure to specify hand hygiene between each step	• Added two way communication device between team in room and outside • Changed airway bag to preset airway table
3	• Clarified that post-sedation medications should be primed prior to entering room		• Specified that heated high flow nasal cannula should be turned off prior to intubation • Emphasized that cuff should be inflated prior to positive pressure ventilation	• Clarified appropriate doffing order	
4					• Updated airway table to include labels for ease of use and restocking • Updated ventilator circuit to remove extraneous viral filter
5	• Clarified order of donning PPE			• Updated guidelines to wipe down unopened equipment for reuse	
6	• Updated order of donning PPE				
7					• Changed tube clamps to plastic due to metal clamps cracking ETT
8			• Adjusted pre-oxygenation method with BVM to accommodate lack of bidirectional flow of oxygen.		• Removed disposable stethoscope from airway table • Added cover to table to signify that it was ready for use • Added sterile cover to two way communication device for ease of cleaning
9			• Clarified the process for attaching the BVM to the ETT	• Added clarification on process for cleaning equipment and order for doffing PPE	

Table 3. Continued.

10	• Face shield added to donning procedure	• Expanded recommendations for post-intubation sedation	• Changed pre-oxygenation option from 6L nasal cannula to 15L green nasal cannula • Clarified order and speed of RSI medications	• Changed airway table to modular airway packs
11	• Clarified role responsibilities in obtaining airway packs • Removed role stickers from bags • Added additional changing of gloves during donning of PPE to accommodate reuse of N95 mask	• Added code starter pack for medications		
12		• Clarified medication plan for hemodynamic optimization	• Clarified procedure for cleaning equipment in and out of room as well as restocking of airway packs	• Added rescue cart available outside of room

AGP, aerosol-generating procedure; *BVM,* bag valve mask; *ETCO*^{2}*,* end tidal carbon dioxide; *ETT,* endotracheal tube; *PPE,* personal protective equipment; *RSI,* rapid sequence intubation; *VL,* video laryngoscopy.

DISCUSSION

The COVID-19 pandemic presents a unique scenario in which new management guidelines must be implemented in a rapid manner to provide healthcare workers the tools necessary to safely perform patient care. The use of *in-situ* simulation allowed for the simultaneous training and refinement of our airway algorithm. Provider comfort in multiple domains improved significantly following the simulation, independent of whether the providers had participated in an AGP in a suspected or confirmed COVID-19 patient prior to participating in the simulation training. These domains included PPE donning and doffing; knowing one's role in AGPs; and performing AGPs such as intubations.

During this time, multiple changes took place to the airway algorithm and several themes were noted throughout the revision process. The importance of proper PPE donning/doffing was recognized during initial algorithm development; however, defining the order and type of PPE were continually assessed and modified. Communication barriers were uncovered including need for two-way communication devices. Layout of airway equipment was redesigned from an initial airway bag to a preset airway table and, finally, to separate, modular airway packs.

This study highlights the importance of *in-situ* simulation training, particularly its impact on provider confidence with high-risk AGPs such as intubation, as well as team roles and PPE donning and doffing. Additionally, it shows that an airway algorithm can be developed and refined in real time based on user feedback and rapidly disseminated to ED providers. Future work will look at the impact of the training on provider outcomes such as adherence to PPE donning and doffing standards, as well as patient outcomes such as success of airway interventions. Additionally, further analysis of data will look at any differences between the original trainers and the secondary teachers to evaluate the quality and consistency of the sessions.

LIMITATIONS

The need to follow social distancing guidelines presented a significant limitation in the number of providers we were able to train at one time. In the setting of a pandemic, access to supplies and equipment was unpredictable. One limitation was the need to adapt to what was available and in stock. Although other hospitals may not be able to reproduce exactly our airway algorithm, the process for implementation is generalizable. Additionally, the recommendations we provided to our learners were best practice recommendations as there was limited evidence supporting a definitive management algorithm in the context of the COVID-19 pandemic.

We did not ask the participants to review the airway algorithm prior to attending the session, although some may have done so. Given that we did not collect data on whether or not participants were familiar with the algorithm

prior to the simulation, our results may underestimate the utility of the simulation training. Additionally, as this was a retrospective survey, there is the possibility of recall bias as it relates to participant comfort with the procedure. Although future work will assess whether or not different instructors were more effective teachers, it was not a part of this study and therefore is a potential limitation in understanding the dissemination of content.

CONCLUSION

We successfully implemented a new airway management guideline for patients with suspected COVID-19. The use of *in-situ* simulation helped providers learn these new guidelines and become familiar with new equipment and protocols over a short time period. Additionally, the feedback obtained through the simulation was useful in refining our algorithm. In-situ simulation is an essential tool for both rapid dissemination and onboarding, as well as process improvement in the context of an epidemic or pandemic.

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Responding to a Pandemic: The Role of EM-CCM on ICU Boarders in an Urban Emergency Department

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Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the novel coronavirus that was first detected in China, was declared a public health emergency of international concern on January 30, 2020. By March 11, 2020, the World Health Organization (WHO) characterized it as a global pandemic. The United States reported its first cases of coronavirus disease 2019 (COVID-19), the illness caused by SARS-CoV-2, on January 20, 2020. As of September 2, 2020, there have been over 6.26 million confirmed cases of COVID-19 in the United States with over 13,000 confirmed cases in the city of Detroit, Michigan.[1] SARS-CoV-2 is a highly transmissible virus. The disease it causes, COVID-19, is a predominantly respiratory illness with varying symptom severity contributing to the potential for significant critical illness.

The Setting

Henry Ford Hospital (HFH) is an urban, academic, quaternary referral center in Detroit. The hospital houses five distinct intensive care units (ICU) with 156 ICU beds; up to 68 of these beds can be used for medical intensive care unit (MICU) needs. In August 2016, the HFH emergency department (ED) established a Division of Emergency Medicine-Critical Care Medicine (EM-CCM) comprised of five specialty physicians with board certification in both EM and critical care medicine. The division has seen steady growth and faculty accrual each year. As the COVID-19 pandemic began in Detroit, the division of EM-CCM consisted of eight faculty who divide their clinical and non-clinical duties between the ED and the ICU. Additionally, these physicians form the early intervention team (EIT), working as critical care consultants in the ED and assisting with the delivery of focused management for critically ill patients. This includes post-resuscitative care, advanced ventilator management, adherence to ICU-bundled care, and selection and titration of vasoactive medications. As Michigan identified its first cases on March 10, 2020, the EM-CCM group at HFH found itself at the center of this overwhelming pandemic response.

The Surge Response

Identifying the ED-ICU Needs

HFH ED includes a category 1 area: a hybrid ED-ICU zone that includes 16 beds and two resuscitation bays with the ability to care for and adapt to the management of incoming patients as well as ICU boarders. In early March, we learnt of the Italian experience with the surge of critical illness during COVID-19. It became clear that we would need to prepare to deliver early and prolonged critical care. Additionally, there was the consideration of isolation and protection of both patients and healthcare workers (HCW) from the transmission of SARS-CoV-2.[2-4] This meant working with our ED and nursing leadership to adapt an area of category 1 into a COVID-19 ED-ICU where our ED nurses transitioned to essentially serve as both ED and ICU nurses.

Adapting our Setting

The number of cases presenting from the community rose rapidly in Detroit, requiring a shift in practice to

presume that every patient with respiratory distress had COVID-19. This also meant a transition in ED workflow as we assumed many of our critical resuscitations would require aerosol-generating procedures (AGP) and performing AGPs in our positive-pressure airflow resuscitation bays would contribute to unnecessary HCW exposure. Thus, all resuscitations and AGPs were moved to negative pressure rooms and all resuscitation team members used personal protective equipment (PPE) for every resuscitation, including N95 masks. Moving resuscitation bays to negative pressure bays was disruptive; the transition required immense collaborative efforts between leadership, trauma services, nursing, ED technicians, and our ED pharmacists. Closed loop communication was essential as team members in PPE had to communicate needs to those outside the rooms. Fortunately, our hospital engineering facility team was able to convert the original resuscitation bays to negative air-flow spaces.

Expanding Early Intervention Team Coverage

Recognizing the potential for a surge of critically ill patients, the EIT identified the need for expanded coverage from five days a week (2 PM–10 PM), to seven days a week (2 PM–10 PM) and 24-hour on call availability. EIT performed "virtual rounds" and daily morning communications with the primary ED team. We also evaluated all ICU boarders for daily ICU rounding needs such as medication review, ventilator adjustments, and preventative care bundles. These virtual rounds allowed for enhanced communication with in-house ICU triage teams, prioritizing throughput based on severity of illness.

Guidelines and Procedures Evolving to Accommodate COVID-19

Developing guidelines during any pandemic response requires adaptability and rapid adjustment to changing standards of care. Responding to this particular pandemic, caused by a respiratory virus that had already resulted in a significant amount of critical illness and ventilator dependence worldwide, required prioritization in the protection of HCWs from accidental exposure and guidelines for decision-making when multiple, critically ill hypoxic patients arrive to the ED in tandem. As such, the EIT was critical in the development of ED-based guidelines that outlined and highlighted many of the necessary steps for protecting HCWs. Guidelines for patients undergoing AGPs stratified the risk of individual AGPs such as intubation, noninvasive positive-pressure ventilation (NIPPV), nebulizer treatments, and high-flow oxygen therapy, and recommended cohorting any patients suspected of having COVID-19 and undergoing an AGP into negative pressure rooms, followed by closed door rooms.

Ultimately, as the number of patients requiring AGPs grew, the ED heating, ventilation and air conditioning systems were re-engineered to support negative flow in larger areas allowing for safer cohorting of large groups of patients. Intubation guidelines focused on protection of HCWs by minimizing the use of bag valve mask (BVM) unless necessary, and the use of high efficiency particulate air (HEPA) filters if BVMs were needed. HEPA filters were also recommended for use on all NIPPV machines and ventilators. Cardiac arrest guidelines discussed details such as new positions for pharmacists outside resuscitations rooms to minimize exposure and use of PPE, the utilization of "runners" who acted as intermediaries between donned, code team members and the external ED team, communication recommendations using two-way radios, and avoiding patient disconnection from the vent during arrests to minimize aerosolization and HCW exposure.[5] Lastly, EM-CCM physicians recognized that with rising numbers, community spread, and increasingly severe hypoxic presentations, resource limitations were inevitable.[6] Thus, EIT advocated for management principles that would preserve access to invasive ventilation. This included the optimization of noninvasive oxygenation devices in appropriately ventilated rooms and, in some cases, participation in goals of care conversations with patients and their families while in the ED.

The novel nature of the virus meant that many of these guidelines relied heavily on experiences of healthcare systems in Europe and on the West Coast of the US, as well as prior experiences with severe acute respiratory syndrome and Middle East respiratory syndrome outbreaks; thus, the guidelines were updated and redistributed frequently. These ED guidelines, although originating for the ED from the Division of EM-CCM, were often translated hospital-wide via collaborative relationships of EM-CCM physicians with hospital committees and leadership.

Reflections on the Pandemic Response

EM-CCM is a growing specialty with a unique perspective in the management of critically ill patients from the doors of the ED through the duration of their ICU stay. This perspective creates predictive insight into bottlenecks for admissions and discharges from ICUs, as well as a unique understanding of the adaptability and limitations of EDs during surges.

During the peak of the COVID-19 pandemic, HFH expanded its ICU capacities to eight ICUs primarily caring for COVID-19 patients. Despite this expansion, ED hold times were as long as 45 hours with daily averages between 6-12 hours. Prior to the pandemic, ICU boarding was not uncommon, but COVID-19 patients proved to be an additional challenge as they often required more advanced ventilator management strategies, higher doses of sedative medications, utilization of paralytics, and increased nursing monitoring and interaction. EIT physicians spent most of their time in full PPE moving from bedside to bedside, adjusting ventilator settings and reviewing medications to improve ventilator synchrony and oxygenation.

As the number of patients continued to rise, internal regulations for ICU requirements were adjusted to allow

patients with high oxygen requirements, but not yet requiring high-flow nasal cannula or NIPPV, to be placed in general patient units (GPU). This conserved ICU beds, but meant more patients were being boarded in the lower acuity area of the ED while awaiting a GPU bed. As a result, EIT, already expanded in hours, expanded further into lower acuity areas of the ED to assess and monitor patients at risk for decompensation and ensure AGP and intubation guidelines were followed. The hybrid ED-CCM model at HFH proved ideal for this kind of adjustment, as the EIT physicians were able to expand beyond the physical ED-ICU space and assist in the wide spectrum of care of COVID-19 patients.

EM-CCM physicians leveraged their roles in surge committees and resuscitation councils to highlight the toll of COVID-ICU type care on the ED environment. Administrative leadership responded by halting all incoming transfers from outside hospitals and encouraging residents and fellows from other specialties to pick up ED shifts and to assist with screening and nasal swabs in a temporary tent facility. Critical care fellows were re-assigned from traditional electives to the EIT service in the ED to assist with critical care consultations and management. EIT physicians were involved in the development of a multidisciplinary proning team that was used both in the ED and the inpatient hospital setting to assist with the logistics of early proning. Finally, EIT used their relationship with anesthesia critical care physicians to set up an anesthesia procedure team to assist with ED intubations and procedures as we quickly realized that simultaneously managing the abundance of procedures while assessing newly arriving critically ill was an insurmountable task.

Outside of the ED, EIT's presence in the ED and involvement in the care of nearly all patients who traveled through our ED into our ICUs, allowed the ICU to focus entirely on the patients within their units. This reduced the strain on ICU physicians for staffing, allowing more rest between COVID-19 ICU rotations. EIT physicians' dual roles within the ED and the ICUs maintained clear lines of communication regarding ED and ICU needs during daily departmental town halls, allowing for early identification of resource scarcities within the hospital, and focused, bed-management discussions.

The HFH Division of EM-CCM continues to be included in the hospital ICU collaborative responses. The guidelines that were written initially for internal use were shared both systemwide and then with external ED leaders who reached out for assistance. During the COVID-19 pandemic response emergency physicians across the world stepped up to develop safe guidelines and protocols for the care of COVID-19 patients. At HFH, EM-CCM is a growing division that leveraged its position in both the EM and CCM worlds to help plan, prepare for, and support the surge of critically ill COVID-19 ICU boarders.

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How the COVID-19 Epidemic Affected Prehospital Emergency Medical Services in Tehran, Iran

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Introduction: Coronavirus disease 2019 (COVID-19) has substantially impacted the healthcare delivery system in Tehran, Iran. The country's first confirmed positive test for severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was on February 18, 2020. Since then, the number of cases has steadily increased in Iran and worldwide. Emergency medical services (EMS) quickly adapted its operations to accommodate a greater number of patients, and it worked to decrease the risk of COVID-19 spread among EMS personnel, given the disease's high transmissibility.

Methods: We evaluated the chief complaint as well as the pattern and number of EMS calls and dispatches during the 28-day intervals before and after the February 18, 2020, COVID-19 outbreak in Iran.

Results: EMS calls increased from 355,241 in the pre-outbreak period to 1,589,346 in the post-outbreak period, a 347% increase ($p<0.001$). EMS dispatches rose more modestly from 82,282 to 99,926, a 21% increase ($p<0.001$). The average time on telephone hold decreased from 10.6 ± 12.7 seconds pre-outbreak to 9.8 ± 11.8 seconds post-outbreak, a 7% decrease ($p<0.001$). The average length of call also decreased from 1.32 ± 1.42 minutes pre-outbreak to 1.06 ± 1.28 minutes post-outbreak, a 20% decrease ($p<0.001$). The highest number of daily dispatches occurred during the second and third weeks of the four-week post-outbreak period, peaking at 4557 dispatches/day. After the first reported case of SARS-CoV-2, there were significant increases in chief complaints of fever (211% increase, $p<0.001$) and respiratory symptoms (245% increase, $p<0.001$).

Conclusion: The number of EMS calls and dispatches in Tehran increased 347% and 20%, respectively, after the outbreak of COVID-19. Despite this, the time on hold for EMS response decreased. The Tehran EMS system accomplished this by increasing personnel hours, expanding call-center resources, and implementing COVID-19-specific training. [West J Emerg Med. 2020;21(6)110-116.]

Disclaimer: Due to the rapidly evolving nature of this outbreak, and in the interests of rapid dissemination of reliable, actionable information, this paper went through expedited peer review. Additionally, information should be considered current only at the time of publication and may evolve as the science develops.

INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), was first discovered in humans in Wuhan China, late last year.[1] It has presented a unique challenge to a healthcare delivery system not prepared for major healthcare catastrophes. Without prior crisis management plans in place, many hospitals have faced a lack of medical supplies, increased patient load, and an exhausted medical staff. The current pandemic highlights these deficits in disaster preparedness and the importance of developing a systematic approach to deal with future healthcare crises.

On February 18, 2020, Iran's first positive test for SARS-CoV-2 was reported. One day later, Iran's Ministry of Health confirmed the beginning of the outbreak. The number of cases of COVID-19 in Iran has since increased substantially. On March 11, 2020, the World Health Organization (WHO) designated COVID-19 a pandemic. Globally, as of September 27, 2020, there were over 32.7 million confirmed cases of COVID-19 with 991,224 deaths reported to WHO. In Iran there were 443,086 confirmed cases of COVID-19 and a death toll of 25,394.[2]

Prehospital and hospital services were at first overwhelmed by fever and respiratory complaints in patients suspected of having COVID-19, which required the emergency medical services (EMS) to change its operating procedures. The EMS Organization in Tehran (EMS Tehran) created the Advanced Surveillance System of Coronavirus Committee. EMS Tehran increased the number of personnel working in order to adequately respond to the increase in patient numbers, and gave formal training to its employees to screen for and diagnose COVID-19. Employees were given more personal protective equipment (PPE) and essential supplies so that they could adequately care for patients. EMS Tehran also greatly extended its operations, limited the amount of time off for its employees, and added coronavirus-consulting phone lines to answer patient questions. The goal of this study was to determine the effects of COVID-19 on the workload of EMS Tehran and the associated changes to patient presentation on EMS arrival.

METHODS

We collected EMS data including the number of calls and dispatches, patient complaints, and vital signs before and after the beginning of the COVID-19 outbreak in Tehran, a city with a population of 8.7 million. We divided our study into two 28-day periods, defining the pre-outbreak period as January 21–February 17, 2020, and the post-outbreak period as February 18–March 16, 2020. This study was approved by the ethics committee of Tehran University of Medical Sciences.

Population Health Research Capsule

What do we already know about this issue?
Emergency medical services (EMS) has been forced to change protocols to maximize employee work hours and minimize waste of personal protective equipment.

What was the research question?
We sought to determine the effects of the COVID-19 pandemic on patient presentation and the workload of EMS Tehran.

What was the major finding of the study?
The number of dispatches, calls, and patients with fever and respiratory complaints increased after the outbreak in Tehran.

How does this improve population health?
By understanding the effects of the COVID-19 pandemic on EMS workload, we can optimize our policies to improve our response to future pandemics.

EMS in Iran

EMS Iran is an affiliate of Iran's Ministry of Health.[3] It oversees multiple departments including operations, administrative, financial, medical emergency communications, dispatch, quality control, method improvement, education, and research. Patients call "115" and speak with the emergency medical dispatcher (EMD) who takes a history and the caller's address. The EMD gives this information to a nearby unit if a dispatch is deemed necessary. Emergency medical technicians (EMTs) evaluate the patient at the scene and may consult a physician in the dispatch center to determine whether the patient needs transport to a hospital. The EMTs then coordinate with the hospitals prior to arrival. There are 216 ambulance bases in Tehran, most with one ambulance and one motorcycle ambulance. The motorcycle ambulance is driven by one EMT to scenes where transport is not predicted to be necessary based on the dispatch call. The EMT may perform limited medical care. A few bases have two ambulances, and a few bases have an ambulance bus, which is used for multiple casualties when air transport is limited. All stations are managed by one dispatch center. There are 118 hospitals in Tehran, including 49 publicly run, 55 privately run, and 14 government run for the armed forces.

All EMDs are nurses with bachelor degrees, and EMTs have degrees in nursing, anesthesiology, or medical emergency. EMTs have different ranks including basic, intermediate, and paramedic, and the EMD takes this into account for a tiered

response to calls. EMS personnel receive 60-200 hours of general training, and there are additional monthly in-service trainings. Since the COVID-19 outbreak, EMS Iran has also used virtual trainings including lectures and webinars.

Changes to EMS workflow in Tehran

Changes to EMS workflow included adding "distance shifts" for EMDs working for the emergency communication (dispatch) center. These distance shifts occurred from employee homes to promote social distancing. Supervisors also began to answer dispatch calls. The number of dispatchers receiving calls at any time increased 140% from 20-24 to 36-48. We added 50 ambulances to the existing fleet, a 20% increase, to respond to calls. These added missions were staffed by base officials who did not routinely go on missions.

The EMS communication center and operating units began to ask COVID-19 screening questions to all patients, to identify patients with COVID-19 associated symptoms or a recent travel history to China. All employees were given formal training in recognizing and diagnosing COVID-19. EMS Tehran increased the amounts of PPE and essential medical supplies available for dispatches and reduced the number of personnel involved in each dispatch. These measures led to an adequate supply of PPE throughout the outbreak.

Volunteers ran PPE donation drives, and we received international donations as well. For dispatches involving patients suspected or confirmed to have COVID-19, all EMTs directly interacting with the patient wore "full" PPE including a gown, face shield, surgical mask, and gloves. This usually involved only one EMT to help conserve PPE. The other EMTs involved in the dispatch wore surgical masks and gloves. All PPE was thrown away after every dispatch, and the entire ambulance was subsequently washed and cleaned with disinfectants. Given the shortage of N95 masks, we disinfected and reused elastomeric masks.

Volunteer physicians and nurses with emergency medicine experience answered the general public's questions on a different phone line. If they deemed medical attention was needed, they would connect the call to the dispatch center. This line received an average of 18,000 calls per day.

There was no change to the number of personnel performing dispatches. However, they did have increased overtime hours, reduced break time during shifts, and reduced number of hours between shifts. Before the COVID-19 outbreak, EMS personnel routinely worked 24-hour shifts and had 48 hours off between shifts. Time off between shifts decreased to 24 hours during the outbreak, resulting in an effective 50% increase in staff-hours.

At the beginning of the outbreak, Iran's Ministry of Health designated 10 hospitals to treat COVID-19 patients. These hospitals saw the majority of suspected cases and also received transfers after coordination with the central operations guidance headquarters. EMS worked to transport patients with or suspected to have COVID-19 to these hospitals. Three to four percent of all dispatches were inter-hospital transfers.

Data Analysis

We analyzed data using SPSS V.22 software (IBM Corporation, Armonk, NY). We verified normality with the Kolmogorov–Smirnov test. Data are presented as the mean ± SD or median with interquartile ranges as suitable. We used chi-square and Fisher's exact tests to compare proportions of qualitative variables. Student's t-test was used for parametric quantitative variables, and the Mann-Whitney U test was used for nonparametric quantitative variables. The level of significance was <0.05.

RESULTS

During the 56 days of the study, there were 182,208 EMS dispatches. The average number of daily dispatches in the pre- and post-outbreak periods was 2939 and 3569, respectively, a 21% increase (Table 1). The highest number of daily dispatches occurred on March 4, 2020, with 4557 dispatches (Figure 1). The number of daily dispatches during the second and third weeks of the post-outbreak period was consistently near 4000.

There was a substantially higher number of EMS phone calls during the post-outbreak period compared to the pre-outbreak period (Figure 2). We received 1,944,587 EMS calls, with a daily

Table 1. Emergency medical services dispatches and calls before and after the beginning of the COVID-19 outbreak.

Study variable	Pre-outbreak	Post-outbreak	Percent change	P-value
EMS calls N (% of total)	355,241 (18.2)	1,589,346 (81.8)	347	<0.001
EMS missions N (% of total)	82,282 (45.1)	99,926 (54.9)	21	<0.001
Time of call (min)				
Median (Q1, Q3)	0.7 (0.3, 2.1)	0.50 (0.32, 1.3)	-29	<0.001
Mean±SD	1.3 ± 1.4	1.1 ± 1.3	-15	<0.001
Time waiting on hold (sec)				
Median (Q1, Q3)	7.0 (7.0, 7.0)	7.0 (7.0, 7.0)	0	1.00
Mean±SD	10.6 ± 12.7	9.8 ± 11.8	-8	<0.001

**EMS,* emergency medical services; *Q1,* 25th percentile; *Q3,* 75th percentile; *SD,* standard deviation.

average of 12,687 EMS calls during the pre-outbreak period and 56,762 during the post-outbreak period (Table 1), a 347% increase ($p<0.001$). Phone call duration decreased from 1.3 ± 1.4 minutes (mean ± standard deviation) to 1.1 ± 1.3 minutes, a 20% decrease ($p<0.001$). The time waiting on hold decreased from 10.6 ± 12.7 seconds in the pre-outbreak period to 9.8 ± 11.8 seconds in the post-outbreak period, an 8% decrease ($p<0.001$). Peak time of day for phone calls to EMS occurred at 2 PM in the pre-outbreak period but at 10 PM in the post-outbreak period. Despite this trend, the peak time of day for dispatches occurred from 8 PM to 11 PM, which did not change between the pre- and post-outbreak periods.

We evaluated patient complaints and initial diagnoses as registered by EMTs. Fever and respiratory complaints were significantly more prevalent in the post-outbreak period, with a 211% and 245% increase, respectively.

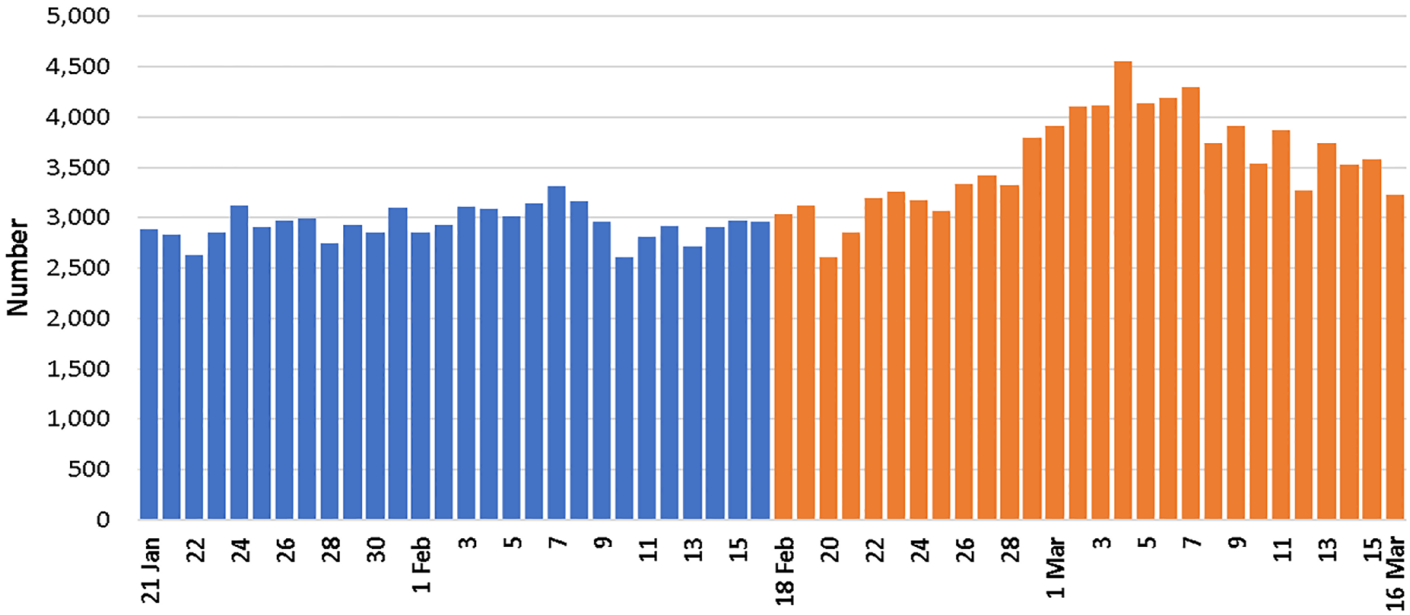

Figure 1. The number of emergency medical services dispatches before and after the beginning of the COVID-19 outbreak.

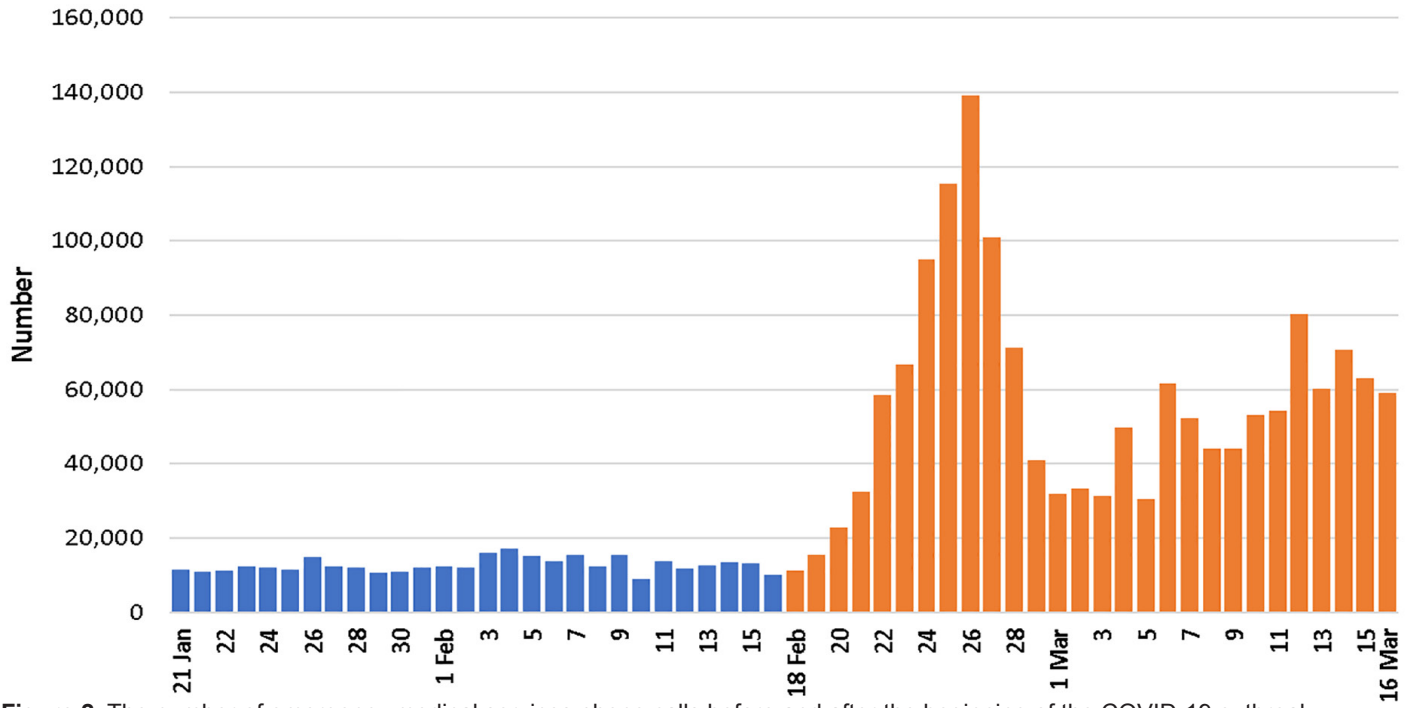

Figure 2. The number of emergency medical services phone calls before and after the beginning of the COVID-19 outbreak.

DISCUSSION

EMS is a crucial component of the healthcare delivery system and benefits from adapting its protocols during periods of high call volumes.[4-6] Importantly, improving outpatient care can reduce the emergency department (ED) patient census and reduce the risk of overwhelming hospitals with limited resources and staff. Having fewer patients in the hospital further helps to avoid unnecessary transmission of SARS-CoV-2.

To improve EMS response during pandemics, the United States National EMS Advisory Council proposed having more fully developed prehospital triage algorithms, an auto-answer and caller deferral system for non-emergency situations, and alternate shift structures.[7,8] Additionally, the council advocated for transporting patients to the closest hospital during high call periods and for minimizing the number of staff participating in each mission. During a pandemic, it is especially important to divert non-emergent patients to maximize EMS and hospital resources as well as to decrease the rate of disease transmission.[9-11] Applying a triage and classification system can reduce the number of EMS responses, transports, and ED visits without adversely affecting patient outcomes.[12,13] We used these advisories to our EMS response in Tehran.

We found that the number of calls to EMS and the number of EMS dispatches were both significantly increased during the post-outbreak period (Table 1). Chief complaints associated with COVID-19 were more prevalent during the post-outbreak period (Table 2). The increase in total EMS calls and EMS dispatches (Table 1), largely resulting from the increase in prevalence of chief complaints associated with COVID-19 (Table 2), demonstrates the significant impact COVID-19 had on the EMS system in Tehran. The number of traumas and motor vehicle accidents decreased during the outbreak period, which correlates with people staying home during the outbreak with quarantine precautions.

EMS increased the number of personnel responding to these calls and shortened their conversation times, which likely caused the call waiting time to decrease in the post-outbreak period, despite handling 4.5 times the number of EMS calls.

The EMS management center approved specific crisis management plans during the outbreak. The number of dispatch personnel receiving calls during each shift increased from 20-24 to 36-48 people, up to a 140% increase. A team of volunteer physicians and nurses responded to a different phone line to answer the general public's questions regarding COVID-19, which helped to limit the number of calls to the dispatch phone line. This hotline had an average of 18,000 calls per day.

EMS personnel wore gowns, overalls, face shields, surgical masks and gloves (Figure 3). Out of 118 total hospitals in Tehran, 10 were designated to take care of COVID-19 patients. Transferring patients to these hospitals was a priority. All employees of EMS Tehran used "How to Deal with COVID-19" guidelines created by Iran's Ministry of Health, which outlined standard operating procedures during the outbreak.

EMS was able to respond appropriately to the increase in the number of calls and the increase in the number of patients with COVID-19 symptoms. By increasing staff hours and changing EMS protocol, Tehran became better suited to deliver

Table 2. Comparison of chief complaints and vital signs in emergency medical services dispatches before and after the start of the COVID-19 outbreak.

Study variable	Pre-outbreak	Post-outbreak	Percent change	P-value
Chief complaint				
Trauma	6993 (11.4)	3282 (4.3)	-53	<0.001
Motor vehicle accident	5358 (8.7)	3699 (4.8)	-31	<0.001
Fever	578 (0.9)	1796 (2.3)	211	<0.001
Respiratory complaints	3299 (5.4)	11,371 (14.7)	245	<0.001
Cardiopulmonary arrest	1257 (2.1)	1492 (1.9)	19	0.128
Cardiovascular complaints	9122 (14.9)	9530 (12.3)	5	<0.001
Gynecologic emergencies	145 (0.2)	135 (0.2)	-7	0.012
Gastrointestinal complaints	3987 (6.5)	4371 (5.7)	10	<0.001
Neurologic complaints	8316 (13.5)	8147 (10.6)	-2	<0.001
Psychiatric complaints	5545 (9.0)	4057 (5.3)	-27	<0.001
Diabetic emergencies	14,064 (22.9)	20,295 (26.3)	44	<0.001
Toxicity	1252 (2.0)	614 (0.8)	-51	<0.001
Others	1524 (2.5)	8470 (11.0)	456	<0.001
TOTAL	61,440 (100)	77,259 (100)	26	<0.001

**EMS,* emergency medical services.

Figure 3. Iranian emergency medical services personnel during the COVID-19 epidemic.

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medical care to a larger number of patients while minimizing unnecessary exposure to COVID-19. The healthcare system in Iran must continue surveillance of its crisis plans for prehospital and hospital services in order to continue optimizing its response. Because the pandemic continues, all hospitals need to estimate their capacity and predict the amount of resources and number of staff required to fight this pandemic. Lessons learned from this pandemic will help us to guide specific management and disaster planning for future healthcare crises.

LIMITATIONS

This study is limited in its scope as it focuses on the EMS response in Tehran, Iran. While COVID-19 is causing a worldwide health crisis, these data are not, per se, generalizable. It is likely that other health systems have faced similar challenges with an increase in the number of EMS dispatches and calls. This study can provide guidance for other EMS units fighting this pandemic. We did not collect any outcome data regarding the EMS dispatches.

CONCLUSION

Tehran's medical system saw an increase in the number of patients with COVID-19 symptoms soon after the beginning of the outbreak. We found a 347% increase in EMS calls and a 21% increase in EMS dispatches. We increased the number of EMS personnel in dispatch by up to 140%, but did not change the number of first responders. The EMS in Tehran changed the way it delivered care by increasing the number of personnel, reducing time off between shifts, and increasing overtime hours, which helped to ease the burden of the pandemic. There has been continued in-service education during this outbreak. We hope that the COVID-19 pandemic is limited, but we should continue to consider better approaches that our patients and providers deserve. Working to mitigate this crisis will help us better prepare for future inevitable pandemics.

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Patient Age, Race and Emergency Department Treatment Area Associated with "Topbox" Press Ganey Scores

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Introduction: Hospitals commonly use Press Ganey (PG) patient satisfaction surveys for benchmarking physician performance. PG scores range from 1 to 5, with 5 being the highest, which is known as the "topbox" score. Our objective was to identify patient and physician factors associated with topbox PG scores in the emergency department (ED).

Methods: We looked at PG surveys from January 2015–December 2017 at an academic, urban hospital with 78,000 ED visits each year. Outcomes were topbox scores for the questions: "Likelihood of your recommending our ED to others"; and "Courtesy of the doctor." We analyzed topbox scores using generalized estimating equation models clustered by physician and adjusted for patient and physician factors. Patient factors included age, gender, race, ethnicity, and ED area where patient was seen. The ED has four areas based on patient acuity: emergent; urgent; vertical (urgent but able to sit in a recliner rather than a gurney); and fast track (non-urgent). Physician factors included age, gender, race, ethnicity, and number of years at current institution.

Results: We analyzed a total of 3,038 surveys. For "Likelihood of your recommending our ED to others," topbox scores were more likely with increasing patient age (odds ratio [OR] 1.07; 95% confidence interval [CI], 1.03-1.12); less likely among female compared to male patients (OR 0.81; 95% CI, 0.70-0.93); less likely among Asian compared to White patients (OR 0.71; 95% CI, 0.60-0.83); and less likely in the urgent (OR 0.71; 95% CI, 0.54-0.93) and vertical areas (OR 0.71; 95% CI 0.53-0.95) compared to fast track. For "Courtesy of the doctor," topbox scores were more likely with increasing patient age (OR 1.1; CI, 1.06-1.14); less likely among Asian (OR 0.70; 95% CI, 0.58-0.84), Black (OR 0.66; 95% CI ,0.45-0.96), and Hispanic patients (OR 0.68; 95% CI ,0.55-0.83) compared to White patients; and less likely in urgent area (OR 0.69; 95% CI ,0.50-0.95) compared to fast track.

Conclusion: Increasing patient age was associated with increased likelihood of topbox scores, while Asian patients, and urgent and vertical areas had decreased likelihood of topbox scores. We encourage hospitals that use PG topbox scores as financial incentives to understand the contribution of non-service factors to these scores. [West J Emerg Med. 2020;21(6)117-124.]

INTRODUCTION

In 2008, the Institute for Healthcare Improvement developed the Triple Aim framework to optimize health system performance by focusing on the following: improving the patient experience of care; improving the health of populations; and reducing the cost of healthcare.[1,2] Patient experience is often measured by patient satisfaction. Patient satisfaction is positively associated with improved physician-patient communication, medication compliance, provider job satisfaction, reductions in malpractice claims, and hospital profitability.[3-8] Hospitals have used financial incentives to link physicians' professional and financial success to their patient satisfaction scores. Some surveys demonstrated that up to 43% of physicians have some portion of their financial compensation linked to patient satisfaction measures.[9]

Press Ganey Associates Inc. (South Bend, IN) first developed patient satisfaction surveys in 1985, and have become the industry standard for measuring patient experience in the outpatient setting.[10-15] Hospitals typically distribute Press Ganey (PG) standardized surveys to a random sample of patients to solicit feedback regarding providers, staff, and clinical environments. PG uses a five-point Likert scale for patient responses. A score of 5, the most favorable, is known as the "topbox" score.[13,16] Topbox scoring is the standard for customer satisfaction and consumer research.[17]

Despite widespread adoption of patient satisfaction measurement systems and associated incentives, concern was raised about the validity of these tools since current literature does not consistently demonstrate key predictors of higher or lower scores.[18] Only a few studies have examined PG surveys specific to the emergency department (ED); some studies have found that ED PG scores are positively associated with employee satisfaction and retention, and negatively associated with ED crowding and wait times.[6,19,20] There is evidence that acuity of a patient's illness and the patient care setting affect PG scores. Critical, emergent patients were more likely to give higher scores than non-urgent patients.[21] Bendensky et al showed the same physicians had higher "courtesy of the doctor" scores from the urgent care setting than in the ED.[11]

Gender also influences the perceptions, behavior, and communication of patients and their providers.[22,23] Patients have different expectations from male and female physicians.[24] The ED setting is unique in that patients have unscheduled visits and cannot choose their healthcare provider in the ED. The influence of patient or physician factors specific to ED PG scores has been limited to a few studies.[21–23,25] We hypothesized that patient factors (age, gender, race, and/or ED area where patient was seen) and physician factors (age, gender, race, years at institution) influence topbox scores for two ED PG survey questions: "Likelihood to recommend ED," and "Courtesy of the doctor."

Population Health Research Capsule

What do we already know about this issue?
Press Ganey scores are often used to benchmark physicians. The relationship between patient and physician factors with the highest (topbox) score is unclear.

What was the research question?
Are patient and physician factors associated with topbox scores on Press Ganey surveys?

What was the major finding of the study?
Patient factors were associated with topbox scores, but physician factors were not associated with topbox scores.

How does this improve population health?
Physicians and administrators will be informed about the contribution of non-service factors associated with Press Ganey topbox scores.

METHODS

Study Design and Setting

This was an observational, population-based study at an urban, academic, tertiary care hospital. The hospital is a designated Level I adult and Level I pediatric trauma center and a comprehensive stroke center. The annual ED volume is approximately 78,000 visits a year. The ED has a separate pediatric ED and adult ED. The adult ED is divided into different care areas based on age and patient acuity: emergent; urgent; vertical (urgent but able to sit in a recliner rather than a gurney); and fast track (non-urgent). The emergent area is for adult patients 18 years and older who require acute resuscitations, require trauma assessments, or are otherwise clinically high-risk patients. The urgent and vertical areas were designed for patients who do not require emergent intervention or assessment. The fast-track area was designed for patients over six months old who are triaged as non-urgent with an estimated discharge within 90 minutes. Approximately, eight ED attendings worked only during the overnight shift. The overnight physicians only worked in the emergent and urgent areas since these two areas were the only open areas on the adult overnight shifts. All other general emergency physicians worked in the different areas of the adult ED.

Study Population

We collected PG survey data from January 2015–December 2017 for adult patients (age ≥18 years) who were

evaluated, treated, and discharged from the ED. All patients enrolled in the online patient portal received a PG survey after their ED visits. For patients without the online portal access, five unique patients per physician per month were randomly selected to receive a paper survey. If patients had multiple visits with several physicians within 21 days, only one visit was randomly chosen for evaluation. Patients did not receive a PG survey from the ED if they had received a PG survey from the hospital within one week of the ED visit. This study was approved by the Stanford University School of Medicine Institutional Review Board.

Measurements

Patient Factors

Self-reported patient demographic information obtained from PG surveys included age, gender, race, and ethnicity. Patients age 18-29 were grouped into age less than 30 years due to the small sample size. Patient age greater than 30 years was divided into 10-year intervals. Race and ethnicity were categorized as White, Asian, Black/African-American, Hispanic, Native American or Alaskan Native, and Native Hawaiian or other Pacific Islander. Surveys that reported race as "other" or "more than two racial backgrounds" were excluded from data analysis given low sample size in each category. We also excluded from the analysis surveys that reported race as "unknown". The ED area where patients were seen and treated was provided for each PG survey.

Physician Factors

Physician demographic data included age, gender, race, ethnicity, and years at the current institution. Age, race, and ethnicity data were categorized into the same groups as the patients.

Outcome

Two PG questions that are often used to inform hospital-related incentives for physicians were chosen for the outcomes. The two primary outcomes were topbox scores for "Likelihood of your recommending our emergency department to others," and "Courtesy of the doctor."

Statistical Analysis

We used chi-squared tests of independence (χ^2 tests) to assess the associations between patient and physician factors and impact of ED area on "Likelihood of your recommending our ED to others" and "Courtesy of the doctor" PG scores. Two generalized estimating equation (GEE) models were performed, one using topbox "Likelihood of your recommending our ED to others" as the outcome variable and the other using "Courtesy of the doctor." Models controlled for patient and physician factors, and the ED area where the patient was seen. We used GEE models to cluster surveys by physician, using an exchangeable correlation structure to account for possible correlations within survey responses for the same physician. Models were performed using surveys with complete patient and physician demographic information. A P value ≤ 0.05 was considered statistically significant for all tests, and 95% confidence intervals were reported. We performed analysis in SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

The response rate for ED PG surveys was 10%. Of the returned 5,325 surveys, 3,524 surveys answered both "Likelihood of your recommending our ED to others" and "Courtesy of the doctor" questions. From the 3,524 surveys with both outcomes questions answered, 3,038 surveys had complete patient demographic information including age, gender, race, and ethnicity. See Figure 1 for study design. Out of the 3,038 surveys, 2,400 were paper surveys, and 638 were online surveys. Most of the online responses 389 (61%) were in 2017. For each year of the study (2015-2017) the mean topbox scores "Likelihood of your recommending our ED to others" were 69%, 70%, and 66%. For each year, the mean topbox scores for "Courtesy of the doctor" were similar: 73%, 74%, and 72%.

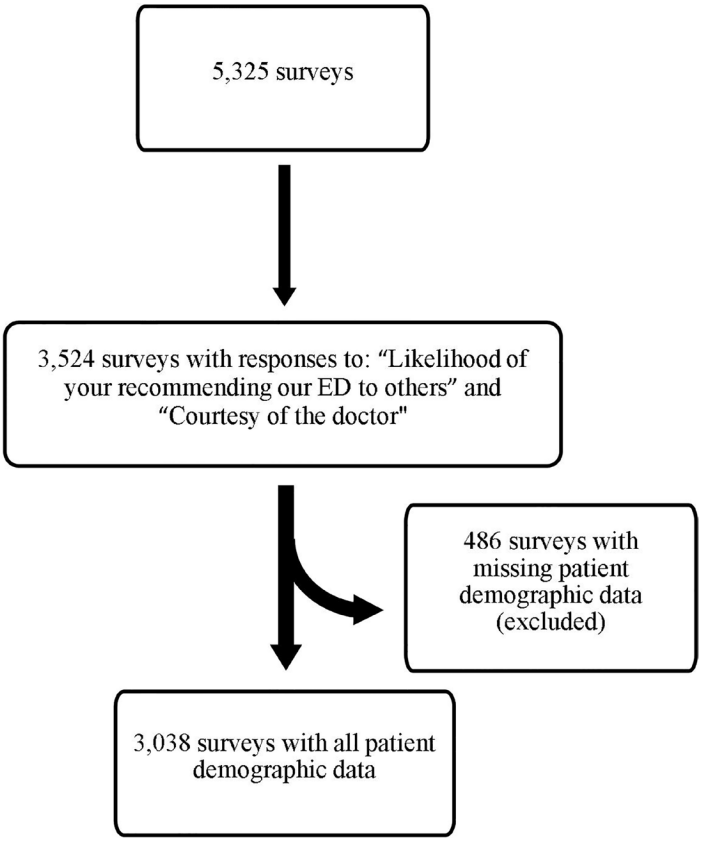

Figure 1. Study design of patients who completed Press Ganey surveys in the emergency department.
ED, emergency department.

Patient Characteristics

Patients who responded to the PG survey did not mirror the demographics of the patients discharged from the ED. Women patients were 58% of the PG study population but only 53% of the ED discharge population. Patients over the age of 60 were 51% of PG study population, while patients over 60 years made up only 25% of the ED discharge population. White patients were 63% of the PG study population, but only 32% of the ED discharge population. Asian patients were 16% of the PG population and 14% in the ED discharge population. Hispanic patients were only 15% of the PG population, in contrast to 36% in the ED discharge population. Most patients were assigned to the urgent area (43%), and the next largest group was assigned to the vertical area (23%). Patient demographics are shown in Table 1.

Physician Characteristics

Most of the PG surveys were completed for male physicians (64%). Physicians were younger than patients, with 76% of ED visits with physicians younger than 50 years old. Physician race was similar to that of the patient population, and most visits were with White physicians (75%). The mean number of years that a physician worked in the Stanford ED was eight years, standard deviation 9.1. Physician demographics are shown in Table 1.

Chi-squared Tests Results

The proportion of topbox scores for "Likelihood of your recommending our ED to others" and "Courtesy of the doctor" by patient and physician gender, race, and ED area are summarized in Table 2. Female patients gave significantly fewer topbox scores than male patients for "Likelihood of your recommending our ED to others" and "Courtesy of the doctor" ($P = 0.0023$ and $P = 0.027$, respectively). Asian patients gave significantly fewer topbox scores than White patients for "Likelihood of your recommending our ED to others" and "Courtesy of the doctor" ($P = 0.0018$ and $P < 0.0001$, respectively). Patients seen in urgent and vertical areas gave significantly lower topbox scores for "Likelihood of your recommending our ED to others" ($P < 0.0001$) and "Courtesy of the doctor" ($P = 0.0008$) than compared to fast track. Physician gender and physician race were not significantly associated with topbox scores for either question.

Chi-squared tests showed that gender concordance may influence "Likelihood of your recommending our ED to others" and "Courtesy of the doctor" (Table 3). After stratifying data by physician gender, female patients were shown to give significantly fewer topbox scores for "Likelihood of your recommending our ED to others" if the physician was also female ($P = 0.01$). Male patients did not show significant difference for topbox scores with physician gender.

Table 1. Physicians' and patients' demographics for Press Ganey surveys.

Variable	Demographic data n = 3,038 n (%)
Survey year	
2015	798 (26)
2016	991 (33)
2017	1,249 (41)
Patient age, in decades	
18 – 30	274 (9)
31 – 39	381 (12)
40 – 49	320 (11)
50 – 59	512 (17)
60 – 69	548 (18)
70 – 79	571 (19)
80 – 89	334 (11)
90+	98 (3)
Patient gender	
Male	1,275 (42)
Female	1,763 (58)
Patient race/ethnicity	
White	1,907 (63)
Asian	489 (16)
Black	149 (5)
Hispanic	443 (15)
Native Hawaiian or Pacific Islander	43 (1)
American Indian or Alaskan Native	7 (0.2)
Emergency department zone	
Emergent	664 (22)
Urgent	1,312 (43)
Vertical	706 (23)
Fast Track	356 (12)
Physician age, in decades	
<30	13 (1)
31 – 39	1,170 (39)
40 – 49	1,100 (36)
50 – 59	367 (12)
60 – 69	388 (12)
Physician gender	
Male	1,956 (64)
Female	1,082 (36)
Physician race/ethnicity	
White	2,290 (75)
Asian	742 (24)
Black	6 (<1)

Table 2. Topbox, or highest scoring, surveys by physician and patient demographics.

	Topbox likelihood to recommend emergency department n = 3038		Topbox courtesy of the doctor n = 3038	
Variable	n (%)	P-value	n (%)	P-value
Patient gender				
Men	905 (71)		955 (75)	
Women	1,161 (66)	0.0023	1,259 (71)	0.027
Patient race and ethnicity				
White	1,338 (70)		1,452 (76)	
Asian	300 (61)		333 (68)	
Black	97 (66)		99 (67)	
Hispanic	293 (66)	0.0018	290 (65)	<0.0001
Emergency department zone				
Emergent	506 (76)		517 (78)	
Urgent	856 (65)		923 (70)	
Vertical	451 (64)		503 (71)	
Fast track	253 (71)	<0.0001	271 (76)	0.0008
Physician gender				
Male	1327 (68)		1,430 (73)	
Female	739 (68)	0.76	784 (72)	0.76
Physician race and ethnicity				
White	1,555 (68)		1,682 (73)	
Asian	509 (69)	0.69	531 (72)	0.38

Generalized Estimating Equation Modeling Results for "Likelihood of Your Recommending Our ED to Others"

After controlling for patient and physician factors, we observed that patient age, patient gender and race, and ED area where they were seen were significantly associated with odds of a topbox score for "Likelihood of your recommending our ED to others" (Table 4). Each 10-year increase in patient age was associated with an increase in the odds of a topbox score (odds ratio [OR] = 1.07; 95% CI, 1.03 – 1.12, P = 0.001). Female patients had decreased odds of giving a topbox score when compared to male patients (OR = 0.81; 95% CI, 0.7 – 0.93, P = 0.003). Asian patients had lower odds of giving a topbox score when compared to White patients (OR = 0.71; 95% CI, 0.6 - 0.83, P <0.0001). Patients seen in the urgent area had lower odds of giving a topbox score when compared to patients seen in fast track (OR = 0.71; 95% CI, 0.54 – 0.93, P = 0.01), as did patients seen in the vertical area (OR = 0.71; 95% CI, 0.53 – 0.95, P = 0.02).

Generalized Estimating Equation Modeling Results for "Courtesy of the Doctor "

After controlling for patient and physician factors, we observed that patient age, patient race, and ED zone were significantly associated with odds of receiving a topbox score (Table 4). Each 10-year increase in patient age was associated with increased odds of a topbox score (OR = 1.1; 95% CI, 1.06 – 1.14, P <0.0001). Asian (OR = 0.70; 95% CI, 0.58 – 0.84, P = 0.0001), Black (OR = 0.66; 95% CI, 0.45 – 0.96, P = 0.03), and Hispanic (OR = 0.68; 95% CI, 0.55 – 0.83, P = 0.0001) patients all had lower odds of giving a topbox score when compared to White patients. Patients seen in the urgent area had a significantly lower odds of giving a topbox score when compared to patients seen in fast track, (OR = 0.69; 95% CI, 0.50 – 0.95, P = 0.02).

DISCUSSION

Our study found that patient factors were associated with topbox scores for PG questions while physician factors did not influence topbox scoring. As patients' ages increased by decade, they were more likely to give topbox scores for "Likelihood of your recommending our ED to others" and "Courtesy of the doctor." Asian patients and patients seen in the urgent and vertical zones of the ED were less likely to give topbox scores for "Likelihood to recommend emergency room" and "Courtesy of the doctor."

Table 3. Topbox scores by patient and physician gender.

	Topbox likelihood to recommend emergency department		Topbox courtesy of the doctor	
Patient-physician gender	N (%)	P-value	%	P-value
Male physicians				
Male patients	589 (70)		626 (75)	
Female patients	738 (66)	0.06	802 (72)	0.22
Female physician				
Male patients	316 (73)		329 (76)	
Female patients	423 (65)	0.01	455 (70)	0.06

Table 4. Odds of "likelihood to recommend emergency department" and "courtesy of the doctor" topbox scores by physician and patient demographics.

	Likelihood to recommend emergency department		Courtesy of the doctor	
Variable	OR (95% CI)	P-value	OR (95% CI)	P-value
Patient age, by decade	1.07 (1.03 – 1.12)	0.001	1.10 (1.06 – 1.14)	<0.0001
Patient gender				
Men	Reference		Reference	
Women	0.81 (0.7 – 0.93)	0.003	0.86 (0.73 – 1.02)	0.08
Patient race and ethnicity				
White	Reference			
Asian	0.71 (0.60 – 0.83)	<0.0001	0.70 (0.58 – 0.84)	0.0001
Black	0.87 (0.62 – 1.22)	0.43	0.66 (0.45 – 0.96)	0.03
Hispanic	0.95 (0.74 – 1.21)	0.67	0.68 (0.55 – 0.83)	0.0001
Emergency department zones				
Fast track	Reference		Reference	
Emergent	1.18 (0.87 – 1.59)	0.29	0.97 (0.67 – 1.40)	0.87
Urgent	0.71 (0.54 – 0.93)	0.01	0.69 (0.50 – 0.95)	0.02
Vertical	0.71 (0.53 – 0.95)	0.02	0.76 (0.54 – 1.06)	0.1
Physician age, by decade	1.02 (0.91 – 1.15)	0.69	0.99 (0.86 – 1.14)	0.9
Physician gender				
Men	Reference		Reference	
Women	1.07 (0.9 – 1.27)	0.45	1.03 (0.83 – 1.29)	0.76
Physician race/ethnicity				
White	Reference		Reference	
Asian	1.05 (0.87 – 1.27)	0.62	0.89 (0.71 – 1.13)	0.34
Physician years at institution	1.01 (0.99 – 1.03)	0.14	1.01 (0.99 – 1.02)	0.44

OR, odds ratio; *CI*, confidence interval.

Our study has multiple strengths that led to new results, which have not been previously published on PG surveys in the ED. First, our study detected a difference in race and topbox scores due to a diverse patient population. Boudreaux et al shows that ED patient demographics (age, gender, race) were unrelated to patient satisfaction scores but categorized patient race/ethnicity as "Black" or "other."[25] Due to our distinct patient population, we were able to demonstrate for the first time that Asian patients in the ED are less likely to give a topbox score compared to White patients. Second, our large study adds new information about patient satisfaction in the ED using topbox scoring. Topbox scoring is a more accurate measure for customer satisfaction in consumer research and is associated with predicting growth.[17,26]

A meta-analysis examined multiple PG studies in all specialties and found female physicians were slightly favored when the physician had less experience, when it was the first visit, and the survey was administered right after

a visit.[27] A subsequent study in 2017 by Chen et al found physician gender, ethnicity, and race were not associated with topbox scores, but the scores were associated with specialty; obstetrics and surgery had higher scores compared to medicine, but they did not examine emergency physicians.[28] Milano et al examined PG surveys in the ED and in a small study of 398 surveys showed that the median score for "Courtesy of the doctor" of male emergency physicians and female emergency physicians did not significantly differ.[23] Our study examined PG surveys over a three-year period with a large number of completed surveys, (n = 3,038) with topbox scores as our outcome.

A third strength of our study is that it is one of the few studies to have demonstrated significant association between the area of the ED where patients are seen and PG topbox scores. A prior study by Bendensky et al demonstrated that the mean score for "Courtesy of the doctor" was higher in the urgent care setting compared to the ED setting with the same physicians working in both locations.[11] Boudreaux et al found "emergent" patients were more satisfied than "urgent" and "routine" patients with the ED visits. This study was based on the initial ED Emergency Services Index, which was determined at triage, and "routine" patients were seen in a rapid care area with a mean ED length of stay of 136 minutes.[21] In contrast, our study demonstrated that patients seen in fast track were more likely to give topbox scores. In our fast track, patients were typically seen and discharged within 90 minutes of arrival to the ED. The second area of the ED associated with topbox scores was the "emergent" zone in which the most critical patients are seen, which is consistent with prior studies. Patients were least likely to give topbox scoring in the "vertical" zone where patients are classified as urgent, but able to sit in a recliner rather than a gurney.

Fourth, our study is the first to examine PG topbox scores in the ED and consider patient factors, physician factors, and the ED area where patients are seen. Prior studies of PG surveys in the ED focused only on physician gender and did not take into account patient gender or the area in the ED where the patient was seen.[23] By accounting for all of these factors, we found that age of the patient, Asian patient race, and ED area were associated with topbox scores.

LIMITATIONS

Our study has several limitations to consider. Our study is limited by the use of self-reported survey data that we cannot link with patient outcomes. Our response rate was 10%, which may have led to sampling bias. Patients who returned the survey may be different than those who did not respond. We did not have the response rate for each area of the ED, which may have led to sampling bias. Additionally, our study was conducted at one academic institution with a diverse patient population and may not be generalizable to other geographic areas of the country.

CONCLUSION

Many hospitals use Press Ganey surveys as a measure of quality of care and provide financial incentives to physicians based on their scores. Our study demonstrates that patient race, patient age, and location where patients are seen in the ED are associated with PG topbox scores. We encourage hospitals that use PG topbox scores as financial incentives to understand the contribution of non-service factors to these scores.

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Review of the Basics of Cognitive Error in Emergency Medicine: Still No Easy Answers

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Emergency physicians (EP) make clinical decisions multiple times daily. In some instances, medical errors occur due to flaws in the complex process of clinical reasoning and decision-making. Cognitive error can be difficult to identify and is equally difficult to prevent. To reduce the risk of patient harm resulting from errors in critical thinking, it has been proposed that we train physicians to understand and maintain awareness of their thought process, to identify error-prone clinical situations, to recognize predictable vulnerabilities in thinking, and to employ strategies to avert cognitive errors. The first step to this approach is to gain an understanding of how physicians make decisions and what conditions may predispose to faulty decision-making. We review the dual-process theory, which offers a framework to understand both intuitive and analytical reasoning, and to identify the necessary conditions to support optimal cognitive processing. We also discuss systematic deviations from normative reasoning known as cognitive biases, which were first described in cognitive psychology and have been identified as a contributing factor to errors in medicine. Training physicians in common biases and strategies to mitigate their effect is known as debiasing. A variety of debiasing techniques have been proposed for use by clinicians. We sought to review the current evidence supporting the effectiveness of these strategies in the clinical setting. This discussion of improving clinical reasoning is relevant to medical educators as well as practicing EPs engaged in continuing medical education. [West J Emerg Med. 2020;21(6)125-131.]

INTRODUCTION

Medical errors are a significant source of harm to patients and distress to physicians. Despite our desire to provide patients with the highest quality of care, rates of medical error remain high with some sources suggesting that diagnostic errors impact about 1 in 20 US adults.[1,2] Several cognitive debiasing strategies have been proposed for reducing diagnostic error.[3] Many of these techniques focus on how the individual can gain an awareness of their reasoning processes and train their mind to mitigate error from bias. There is real debate as to whether cognitive debiasing is effective. This article will review the existing evidence for using these strategies in the clinical environment, particularly in the emergency department (ED). We will also review theories of cognition and error as well as the research on methods to help decrease rates of medical error related to faulty reasoning.

Understanding How We Think

To understand how decision-making can lead to medical error, we must first understand how we make decisions. Our current understanding of higher cognitive processes relies on the "dual process theory," which is a universal model that originated from cognitive psychology and has been applied to the health professions. The theory distinguishes between two systems of thought. System 1 is rapid and intuitive while system 2 is slower and deliberative. Both cognitive systems are critical to decision-making, and each has unique strengths and weaknesses.[4,5] (Table 1).

In most situations, the unconscious, faster, and reflexive system 1 is our default cognitive pathway. This process makes associations between current events and similar past experiences using heuristics, which are cognitive shortcuts or maxims that save time and effort.[6] System 1 is especially useful in fast-paced, clinical settings like the ED, where it can ease cognitive load and facilitate efficient throughput while reserving working memory.[7,8] A qualitative study of emergency physicians (EP) supported this observation, by demonstrating that most of their diagnostic hypotheses were generated without conscious effort and either prior to or within the first five minutes of an initial patient evaluation.[9]

By contrast, system 2 is deliberative, measured, and analytical. This system uses our working memory to make decisions that require complex problem-solving and greater cognitive effort.[10] In practice, a physician is not confined to one type of thinking, but instead may alternate between the systems. Expertise develops from repeated use of system 2 thinking, allowing the development of pattern recognition and a subsequent default to system 1 thinking.

Table 1. Comparison of the dual-process theory of thought: system 1 (intuition) and system 2 (analytic)[5,7,8]

Intuition (system 1)	Analytic (system 2)
Familiar situations	Uncertain, unfamiliar, or undifferentiated situations
Relies on prior experience/ training	Relies on pursuit of new knowledge/information
Relatively fast	Relatively slow
Efficient, time-sparing	Rigorous, time-consuming
Unconscious, automatic	Deliberate, controlled
Pattern recognition, heuristics, associations	Logical, analytical, rule-based, hypotheticodeductive method
Default system	Activated when needed (eg, high-stakes situations or complex presentations) or when time permits
Requires context, personalized	Decontextualized, depersonalized
Interactional intelligence	Analytic intelligence

Understanding How We Make Mistakes

Systems 1 and 2 each have potential drawbacks when applied in the clinical setting. Consider the typical process for an EP assessing a new patient. He or she will gather relevant information through history and physical exam, generate differential diagnoses, and use additional testing to narrow the list of possible diagnoses. If the EP uses system 1 thinking, he or she may reach a working diagnosis efficiently using heuristics based on prior experience. For example, a patient with obesity and poorly-controlled diabetes presenting with left leg pain, warmth, and erythema may fit a known pattern of cellulitis. But, the pattern may be applied inappropriately if the EP is inexperienced, key information is missed, or data is misinterpreted.[11] For example, in the case above, a careful history that details recent surgery and immobilization plus a medication list that includes oral contraceptives may lead the physician to include deep vein thrombosis on the differential. In a review of closed malpractice claims related to a missed or delayed diagnosis in the ED, cognitive factors such as mistakes in judgment were identified in 96% of cases.[12]

System 1 processing is also more prone to error if the patient presentation is complex, evolving, or uncommon.[13] Greater experience does allow for increased accuracy of system 1 thinking.[14-16] However, more experienced physicians are also more likely to commit to a diagnosis earlier, predisposing them to premature closure and an increased risk of being overconfident in an incorrect diagnosis. This can make it difficult to recognize the need to engage the slower, more deliberate approach of system 2 processing.[17-19]

When using system 1, a physician may unconsciously place a higher weight on personal or patient-specific factors. They may over- or underemphasize the significance of a data point to "fit" or exclude a given diagnosis (eg, the lack of pleuritic chest pain means that the shortness of breath is not due to an acute pulmonary embolism). A small study of EPs found that residents were more likely than experienced attendings to reach a diagnosis quickly by discounting or explaining away data that did not "fit" their initial diagnosis.[19] Likewise, the physician may be influenced by patient-specific biases such as mental illness, obesity, or personality (eg, chest pain in a patient with a psychiatric history is due to anxiety rather than acute coronary syndrome). Additionally, physicians may anchor on a diagnosis due to availability (recently seeing a similar case) or triage bias (going on the diagnosis suggested in triage note). These may also impact the decision to pursue further evaluation or the selection of treatment options.

Despite system 2 being more methodical and systematic, it is not able to detect or correct all the potential cognitive errors of system 1. Furthermore, system 2 has its own vulnerabilities and limitations.[20] In this deliberate and analytical process, physicians may override their own sound judgments and defer to a physician with more seniority or external resources to guide their decision-making.[11] When using this system, physicians often generate a broader list of differential diagnoses and employ probability-based approaches to select next steps. Using such an approach will inevitability result in error in the small number of cases where the disease presentation is rare and therefore less likely than a similar but more common diagnosis.[19] When using system 2, overconfidence can also lead to error. Previous work has shown that lower performers greatly overestimate their abilities. Additionally, they fail to correct their self-assessment even after exposure to the performance of others, resulting in an inability to detect or correct their own errors. Therefore, the ability to engage in self-reflection and recognize one's

own limitations is crucial within this system.[13,21-24] Further, multitasking and taskswitching can lead to errors.

These thought processes are also susceptible to cognitive biases, which are systematic errors that affect decision-making. Bias is relevant to practitioners in emergency medicine who must account for deviations from ideal cognitive processing to arrive at the accurate diagnosis for their patient. Over 100 different cognitive biases have been identified in the literature with nearly 40 described in medicine.[3,21,25] For example, availability bias denotes the interpretation of clinical information in the framework of patients seen recently. If a physician recently missed a subarchnoid hemorrhage, he or she may be more likely to think about that diagnosis in the future, whether or not it is relevant to the future case. Bias can also impact other physicians at the time of transition of care. The initial evaluation started in the ED may need to be transitioned to the inpatient setting for ongoing care. The "framing effect" or description of the presentation and current working diagnosis may lead to cognitive bias in the receiving provider and can increase the risk for medical error in the care of these patients.

What Can We Do to Reduce Cognitive Error?

Strategies to reduce cognitive error in medicine are a growing area of research. Perhaps the most widely accepted approach is to increase expertise through improvement in clinical knowledge and experience.[26,27] This is the essence of training and continuing medical education, but given ongoing rates of error, additional strategies are required.[28] Various additional approaches have been proposed to decrease errors, but not all have shown benefit in the clinical setting.

Cognitive Debiasing

One potential solution is debiasing, which targets situations that predispose to bias and offers techniques to avoid errors in clinical reasoning. According to Croskerry, debiasing involves having "the appropriate knowledge of solutions and strategic rules to substitute for a heuristic response" and the ability to override system 1 processing.[6] For a physician to successfully apply debiasing tactics, he or she must first be aware of common biases and their impact on cognitive error. Then the physician must detect the bias, decide to intervene, and successfully apply strategies to mitigate risk, all the while not becoming paralyzed in decision- making.[29] Cognitive debiasing offers context-specific rules that substitute for flawed intuitive reasoning while technological debiasing uses external aids to deliver information and reduce cognitive burden.[30] An example to prevent premature closure might be to review the differential before admitting a patient, or to look for a second fracture when reviewing a hand radiograph, rather than anchoring on the first noted fracture. However, in a study of EM residents, internal medicine residents, and cardiology fellows, a tool to help identify and address cognitive biases in electrocardiogram interpretation had no overall effect in reducing diagnostic errors.[31]

Increase Clinical Expertise

Effective system 1, non-analytical reasoning relies on both formal and experiential knowledge. With increasing expertise comes the development of exemplars, pattern recognition, or a complex pattern of clinical features representing a diagnosis. These exemplars are stored in a network of associations and connections that facilitate nonanalytic knowledge.[32] Retrieval of these past associations from memory is less effective in novices who have not yet obtained sufficient experience. Effective training programs and continuing professional development may contribute to the development of a physician's expertise. Simulation and feedback offer targeted strategies for improving clinical knowledge and experience.[33,34] The success of these strategies relies on the physician's dedication to the time-intensive practice of identifying and closing gaps in knowledge.

Awareness of Cognitive Processes and Error Theory

Another strategy to reduce cognitive error is to develop an understanding of the clinical reasoning process and its inherent flaws. This includes knowledge of the major heuristics and biases and an understanding of how they may lead to cognitive error.[35] Education in these theories has been shown to increase knowledge about cognitive errors. For example, Reilly found that a longitudinal curriculum in diagnostic error and cognitive bias improved recognition and knowledge of cognitive biases by internal medicine residents.[36] Authors did not explore whether patient errors were reduced. ED faculty who participated in a workshop about biases and debiasing strategies reported improvement in their self-assessed ability to identify common biases encountered in the ED and apply cognitive debiasing strategies to improve diagnostic reasoning.[37]

Slow-down Strategies

One general error reduction strategy is to encourage physicians to "slow down and be thorough" to allow time for analytical reasoning. The recommendation is that physicians "slow down" when there is something unexpected (cognitive dissonance) or high risk. It is the recognition that the case requires full attention and focus. Multiple studies of this technique have shown little benefit in improving cognitive performance.[38] As demonstrated by Norman, encouraging residents to slow down during clinical reasoning increased time spent on the task, but had no effect on diagnostic accuracy.[39] In a trial of EPs and residents, slow conditions and the absence of interruptions also did not improve diagnostic accuracy.[40] In a randomized controlled trial of trainees and faculty, use of a slow-down strategy while solving bias-inducing clinical vignettes did not improve diagnostic accuracy.[41] Thus, while it may seem prudent to slow down

when the physician does not know an answer, this strategy has not yet proven to be effective.

Consider Alternatives

The hindsight bias describes how knowledge of an outcome may influence the perception of what actually occurred.[42] When the outcome of an event is reported, its perceived likelihood increases. "Consider-the-opposite" is a tactic that has been studied in other fields. Considering *what* other outcomes may have occurred and *how* they may have occurred may neutralize the overconfidence that led to the biased judgment.[43] Considering alternatives may be used as part of slowing down. Hirt and Markman found that asking people to consider any alternative outcome, not only the opposite, had similar benefits.[44] Evidence for using this strategy to improve clinical reasoning is limited. One study used a novel presentation format to help medical students express their diagnostic reasoning. Students using this technique to present clinical cases offered broader differential diagnosis and provided more justification for their decisions than those using a typical presentation style.[45] Further investigation is needed to determine the impact of this strategy on diagnostic accuracy.

Heuristic-based Strategies

Another approach to mitigating bias is to bring attention to the decision-making process and deliberately choose analytic reasoning in situations where the intuitive approach may lead to error. This debiasing technique is known as a cognitive forcing strategy. This strategy can be designed for generic error-prone situations or tailored to a specific clinical context where clinical biases are frequently seen.[35] There has been mixed success with this approach in the cognitive laboratory setting. EM residents who experienced a simulation of cognitive error traps followed by didactics on cognitive forcing strategies self-reported increased knowledge about cognitive strategies and heuristic techniques.[46] Additionally, the use of a mnemonic checklist to facilitate metacognition and cognitive debiasing improved diagnostic decision-making by medical students in case scenarios.[47]

Jenkins performed a randomized trial to improve diagnosis in pediatric bipolar disorder. Mental health professionals trained in cognitive errors and debiasing strategies made fewer diagnostic errors and demonstrated higher diagnostic accuracy in clinical vignettes designed to test for specific cognitive errors.[48] But Sherbino found that training in the use of cognitive forcing strategies did not reduce diagnostic errors by medical students in computer-based cases.[49] Smith and Slack designed a workshop that introduced family medicine residents to cognitive error and debiasing techniques. Trained faculty helped learners apply these concepts to patients in clinic visits involving a new diagnosis**.** The intervention did not increase the residents' ability to recognize their risk of cognitive bias in the clinical setting.[50]

While there is evidence that physicians can gain knowledge of clinical biases, there is less evidence that they can recognize biases in practice. Recognizing and mitigating biases is a challenge given that they occur during decision-making at the subconscious level.[32] It is uncertain whether debiasing approaches can be effective at reducing cognitive error in the clinical setting.[34]

Reflective Practice

Reflective practice, also known as a diagnostic "time out," is a strategy to promote metacognition. The practice involves re-evaluating experience and considering alternatives to produce insights with the potential to change behavior in future practice.[33] In one study using this strategy, medical students were asked to review case-based scenarios and offer an initial diagnosis. Next, they were asked to reflect on and revise their initial diagnoses, resulting in minimal incremental benefits to diagnostic accuracy.[51] Mamede et al had medical students and residents diagnose clinical cases under conditions that promoted unconscious and conscious deliberation. With residents, this strategy led to improved diagnostic accuracy on complex cases. However, medical students demonstrated worse diagnostic accuracy under the same conditions.[52] It is unclear whether the benefits seen with residents were due to reducing bias, or just allowing additional time for assessment.

In another study by the same author, reflective reasoning counteracted diagnostic error due to the availability bias in internal medicine residents.[53] Hospitalists who used a guided reflective-practice tool to review patient readmissions changed their discharge planning behaviors and experienced a sustained reduction in 30-day readmissions.[54] Given that the benefits of reflective practice were demonstrated with residents and physicians, but not students, it is possible that adequate background knowledge is a prerequisite for success of this strategy. Further study is needed to determine whether this strategy can be successful for junior learners, or if it is a more advanced strategy that should be reserved for those with more clinical expertise.

Second Opinions

One method to address errors is to obtain additional expertise through consultation. While the contribution of others may be helpful it is important to not be over-reliant on an authoritative consult. Obtaining a second opinion had a variable impact on identifying errors in studies involving interpretation of pathology specimens and radiographic images.[25] In one successful study, Duijm demonstrated that additional independent readings of screening mammograms resulted in a modest increase in breast cancer detection rates.[55] Other related strategies include consulting and learning from experts and relying on the collective wisdom gained through group decision-making.[33] For example, in a recent study of EPs, use of systematic cross-checks was associated with a decreased risk of adverse events.[56]

Checklists, Guidelines and Algorithms

When physicians experience high levels of stress and fatigue, cognitive function can suffer. Checklists are effective tools for reducing error in these environments by reducing reliance on memory, but can also help minimize cognitive errors. Checklists may serve a variety of purposes, including assisting with diagnosis, ensuring standardization, and providing reminders of evidence-based practice**.** Evidence shows that checklists not only reduce error but also improve outcomes.[57] For example, Haynes demonstrated that implementation of a surgical safety checklist reduced complications and in-hospital mortality**.**[58] In EM, there are mental checklists for intubation, central line insertion, and other domains. Similarly, clinical guidelines and algorithms may support decision-making in situations prone to error.[33] For example "MUDPILES" as the mnemonic for anion- gap acid-base disorders helps to ensure considering a broad differential.

Clinical Decision Support

Clinical decision support systems (CDSS) analyze data to provide physicians with recommendations that aid clinical decision-making. For example, CDSS can detect early evidence of clinical deterioration or give alerts about potentially dangerous drug interactions. These systems have been shown to reduce medication errors and improve adherence to best practice.[59,60] However, systematic reviews of these systems suggest that not all CDSS are successful. Features of the most effective CDSS include the following: the system is computer-based; it offers actionable recommendations; it gives support at the time and location of decision- making; and it functions automatically within the physician workflow.[59]

LIMITATIONS

There are limitations to our understanding of clinical reasoning and cognitive debiasing. Many of the suggested strategies for reducing cognitive error in medicine are drawn from evidence in other fields. The evidence on reducing errors in clinical reasoning is drawn from mostly single-center studies with small sample sizes and lack of randomization. Most studies enrolled medical students or residents, leaving gaps in knowledge regarding effectiveness of these strategies for practicing physicians. Intervention studies mainly involved laboratory settings, raising questions about the potential impact of these techniques in the clinical environment.

CONCLUSION

Mistakes in diagnosis are a considerable source of error in medicine. The clinical reasoning process includes dual-process theory, which includes both intuitive and analytical reasoning. A broad array of interventions has been proposed to reduce cognitive error in medicine, but evidence regarding the effectiveness of these strategies in the healthcare setting is limited.[61-62] In particular, there is not yet strong evidence to support a reduction in cognitive errors by bringing attention to error-prone clinical situations and offering tools to mitigate bias. Techniques that reduce cognitive burden through technological or other external means offer some promise and warrant further investigation. Strategies to reduce cognitive error are a growing area of research.

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A Case for Risk Stratification in Survivors of Firearm and Interpersonal Violence in the Urban Environment

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The emergency department (ED) serves as the main source of care for patients who are victims of interpersonal violence. As a result, emergency physicians across the nation are at the forefront of delivering care and determining dispositions for many at-risk patients in a dynamic healthcare environment. In the majority of cases, survivors of interpersonal violence are treated and discharged based on the physical implications of the injury without consideration for risk of reinjury and the structural drivers that may be at play. Some exceptions may exist at institutions with hospital-based violence intervention programs (HVIPs). At these institutions, disposition decisions often include consideration of a patient's risk for repeat exposure to violence. Ideally, HVIP services would be available to all survivors of interpersonal violence, but a variety of current constraints limit availability. Here we offer a scoping review of HVIPs and our perspective on how risk-stratification could help emergency physicians determine which patients will benefit most from HVIP services and potentially reduce re-injury secondary to interpersonal violence. [West J Emerg Med. 2020;21(6)132-140.]

INTRODUCTION

Firearm and interpersonal violence have costly downstream effects that continue to burden the health of many communities across the nation. In the United States from 2006 through 2014, over 700,000 emergency department (ED) visits were related to firearm violence.[1] In 2016 alone, approximately 37,900 deaths in the U.S. were due to firearm violence, 82% of which occurred in urban settings.[2] Those who survive interpersonal violence are at a one in four risk of being repeat victims of interpersonal violence, also known as injury recidivism.[3,4] Injury recidivism is associated with a five percent mortality rate over five years.[5] Studies have shown that hospital-based violence intervention programs (HVIPs) are a promising step toward helping these high-risk patients.[6-8] Ideally, all survivors of firearm and interpersonal violence would receive aid from a hospital-based violence intervention program. However, given resource limitations, we believe that risk stratification of interpersonal violence survivors in the ED offers the opportunity to target valuable resources to those most in need, and potentially decrease costs directly and indirectly related to interpersonal violence.

In this article, we discuss injury recidivism and HVIP in survivors of interpersonal violence, current management strategies for disposition of victims of interpersonal violence including a scoping review of hospital-based violence intervention programs, and considerations of how to improve outcomes. Ultimately, we advocate for research to develop a clinical decision tool that can be used in the emergency department to identify those at highest risk for reinjury and those that would benefit most from focused intensive intervention. In this paper, we will refer to "interpersonal violence" as a term that includes penetrating injuries and assault, but excludes intimate partner violence and self-harm. We will also use the terms "injury recidivism" and "reinjury" interchangeably to refer to repeat injuries suffered by those who were previously survivors of interpersonal violence.

INJURY RECIDIVISM

High rates of injury recidivism have been well documented in urban settings for decades. As early as the 1980s, Henry Ford Hospital in Detroit, Michigan identified that survivors of violent trauma had a 44% rate of recurrent traumatic injury with a 5-year mortality rate of 20%.[9] More recent studies in Baltimore, Oakland, and New York City are similarly disheartening.[3-5] In Baltimore, survivors of interpersonal violence experience a 15.7% rate of injury recidivism, with the rate of subsequent mortality for survivors of penetrating trauma increasing by more than twofold for each additional instance of penetrating trauma.[4] In New York City, patients presenting with penetrating trauma had a 27% chance of fatal injury if they had a previous encounter for penetrating trauma, compared to 3% in those who did not.[3] In Oakland, homicide was the cause of death in 80% of gunshot victims who survived the index injury.[5] It is clear that the circumstances that contribute to interpersonal violence put survivors at high risk of reinjury. Each presentation to the ED offers an opportunity to intervene in hopes of reducing future morbidity, mortality, and healthcare expenditures.

CURRENT PRACTICE FOR VICTIMS OF INTERPERSONAL VIOLENCE

Despite the high rate of injury recidivism, the disposition of survivors of interpersonal violence is driven primarily by medical history, physical exam, labs, and imaging used to assess the extent of physical injury. At most institutions, the potential for repeat traumatic injury does not factor into the decision of whether or not a patient is dispositioned home or whether additional resources are indicated. Exceptions to this include an increasing number of hospitals located in cities with high rates of interpersonal violence that are pioneering HVIPs to reduce the risk of reinjury. At the majority of these institutions, HVIPs offer services to all individuals and do not tailor care based on risk of reinjury.

Population Health Research Capsule

What do we already know about this issue?
Survivors of interpersonal violence are more likely to be repeat victims of violence with high rates of associated mortality. Risk-stratification tools have helped determine who receives limited resources in other disease states.

What was the research question?
We examined the current literature on hospital-based violence intervention programs (HVIP) to understand their role in reducing injury recidivism and explore the role of risk-stratification tools to predict reinjury.

What was the major finding of the study?
The effect of HVIPs is promising but inconclusive. Longitudinal research, risk tools, and trainee education may improve their effectiveness.

How does this improve population health?
A risk-stratification tool that identifies the patients who would most benefit from HVIP services would mitigate the downstream implications – physical, mental, and financial – for patients as well as their communities.

METHODS

We chose a scoping review for this project to provide a preliminary overview of the existing gaps in the literature. We utilized the PRISMA-ScR checklist to adhere to methodically build and summarize our findings.

Our research question aimed to review studies that measure the impact that HVIPs have on injury recidivism. We organized our results by study design and summarize significant results and concordant discussion sections.

Our search was designed to capture primary research that explored the impact of HVIPs on injury recidivism. We explored two comprehensive libraries (Pubmed and SCOPUS) with relevant MeSH terms and keywords, i.e. "injury recidivism", "hospital-based violence intervention programs". One reviewer (GNW) performed a search and screening of all abstracts identified in PubMed. A second reviewer (AMD) performed a search and screening of all abstracts identified in SCOPUS. We restricted search to English language, United States, and time period of January 2000 to December 2018. We then built an Endnote library that included all of the selected research articles. To ensure we extracted the appropriate research for our paper, we examined the bibliography of all selected papers accordingly and added any additional findings.

We included primary research papers that reported implementation of hospital-based violence intervention programs through the ED or hospital with a defined patient population, intervention, and follow-up period. Our outcome measures included either injury recidivism or other potential markers of experience with violence including attitudes toward violence, criminal offenses, and additional parameters focused on future injury reduction.

The primary author (GNW) reviewed the title and abstract extracted from PUBMED of each article to assess relevance to our research question. AMD reviewed title and abstracts extracted from SCOPUS. Both AMD and GNW each reviewed the full text to assess the methodology and strength of each study. Studies were extracted from SCOPUS by AMD then abstracts reviewed separately by GNW.

Table 1. Hospital-based violence intervention programs.

Project Name	Location	Who	Methodology	Intervention	Follow-up	Outcomes injury recidivism	Other outcomes
Borowsky et al[10]	Minneapolis-St Paul MN metropolitan area	Ages 7-15 with positive psychological screening	*Randomized control trial	Telephone based parenting education program	9 mo	Decrease in fight related injuries requiring medical care (adjusted OR 4.7; 95% CI 1.33-16.59)	Patients who received the intervention had decrease in aggressive behavior, attention problems, parent reported bullying, physical fighting, child reported victimization
Case Management - Cheng et al[22]	Baltimore, MD; Washington, DC	Ages 12-17 with peer assault injury	*Randomized control trial	Case management for 4 months	6 mo	No change (injuries requiring intervention RR 0.12 95% CI 0.01-2.42)	No significant program effect on service utilization or risk factors for injury
Caught in Crossfire Youth ALIVE [26–28]	Oakland, CA	Ages 12-20 with violent injury	Retrospective case control (Becker); Retrospective cohort study (Shibru); Cost utility analysis (Chong)	Match with Crisis Intervention Specialists to provide close peer support including counseling, job placement, probation, school, housing, referrals	Up to 1 year (Becker); 18 mo (Shibru)	No change (Becker); no change (Shibru); 4% to 2.5% (Chong)	70% less likely to be arrested for any offense; 60% less likely to have any criminal involvement (Becker); cost reduction when compared to juvenile detention center costs $750,000 to $1.5 million annually (Shibru); incremental cost effectiveness for HVIP $2,941 (Chong)
Mentor Violence Intervention Prevention - Cheng et al[11]	Baltimore, MD; Washington, DC	Ages 10-15 with peer assault injury	*Randomized control trial	Youth received 6 session problem solving sessions, parents received 3 home visits	6 mo	No change (fight related injuries in last 30 days RR 0.58 95% CI 0.09-3.94)	Reduced misdemeanor activity, youth-reported aggression scores, and increasing youth self efficacy
Operation Cease Fire (now Cure Violence)[44]	New Orleans, LA	Age unknown with intentional penetrating trauma	Ecological study	Family engagement, home visits, social service needs, conflict resolution	Up 1 year	N/A	Less penetrating injuries in target zip code 20% compared to 55.6% and 93.2% in surrounding zip codes
Operation Peace Works[16]	Ventura County, CA	Age unknown gang members referred from criminal justice system	Ecological study	Mentoring, counseling, job training, education/ employment	Up to 3 year	N/A	Decrease in gang assaults (-16% P<0.001); assaults with firearms (-32% p<0.001); and homicides (-47% p=0.05)
Project Prescription Hope[12,13]	Indianapolis, IN	Ages >18 with interpersonal violent injury	*Prospective cohort trial (Gomez); retrospective chart review (Bell)	Tailored service plan and referred community services. Goals include 1) health insurance; 2) PCP; 3) full time employment or return to school; 4) resolve legal issues	Variable	Violent injury recidivism rate 8.7% to 2.9% (Gomez); 4.4% recidivism rate from 2009-2016 among individuals part of program (Bell)	>half of new violence related injuries outside of HVIP affiliated trauma center (Bell)

Table 1. Continued.

Project Name	Location	Who	Methodology	Intervention	Follow-up	Outcomes injury recidivism	Other outcomes
Project UJIMA[45]	Milwaukee, WI	Ages 10-18 with interpersonal violent injury	Retrospective cohort	Home visits, mental health services, youth activities	Up to 1 year	1% injury recidivism (no comparison)	N/A
SaferFlint Teens[19-21]	Flint, MI	Ages 14-18 that report alcohol and violence in past year	*Randomized control trial	35-minute BI delivered by computer or therapist	3 mo, 6 mo, 12 mo	N/A	Significant reductions in positive attitudes for alcohol use and violence and increase in self efficacy related to violence - at 0 months and 3 months (Cunningham 2009). Significant reduction in peer aggression in therapist group only at 12 months (Cunningham 2012)
Turning Point[14]	Philadelphia, PA	Age >18 with GSW or stab wound and admitted to hospital	Prospective randomized trial	Social work; outpatient case manager, psychiatric assessment, watch trauma bay video, meet GSW survivor	Up to 2 year	N/A	50% reduction in aggressive response to shame, 29% reduction in comfort with aggression, 19% reduction in overall proclivity toward violence
VCU Bridging the Gap[29]	Richmond, VA	Ages 10-24 with intentional injury	Randomized control trial	Brief hospital based intervention + intensive community-based case management services	6 mo	No change	Better hospital service utilization, CMS, and risk factor reduction with additional case management services
Violence Intervention Project[15]	Baltimore, MD	Ages >18 with prior violent injury and involvement in criminal justice system	Randomized control trial	Culturally sensitive violence intervention program including case/social worker and parole officer	Up to 2 year	35% (control) vs 5% (intervention)	Control group 3x more likely arrested for violent crime, 2x more likely convicted of any crime, 4x more likely convicted of violent crime with potential cost savings $1.5 million
Within Our Reach[23-25]	Chicago, IL	Ages 10-24 with interpersonal violent injury	Randomized control trial	Case management for 6 months	6 mo, 12 mo	Repeat victim of violence 20.3% (control) vs 8.1% (intervention)	Return ED visit control 7.4% vs 6.5% intervention. No change in self reported arrests, state reported reinjuries via trauma register, or state reported incarcerations
Wraparound Project[17,18,30,46]	San Francisco, CA	Ages 10-30 with intentional injury and determined to be at high risk for reinjury based on structured screening process	Longitudinal observational study (Julliard 2016); Cost utility analysis (Julliard 2015); Retrospective cohort study (Smith 2013)	Intensive culturally competent case management	6-12 mo	8% (historical) to 4% (Julliard 2016); 16% (historical) vs 4% (Smith 2013)	VIP costs less than having no VIP; VIP yields health benefits (24 QALYs) and savings ($4100) if implemented for 100 individuals OR $6000 saved per patient over 5 years (Julliard 2015); most successful when meeting needs with mental health and employment (Smith 2013)

Table 1. Continued.

Project Name	Location	Who	Methodology	Intervention	Follow-up	Outcomes injury recidivism	Other outcomes
Zatzick et al[47]	Seattle, WA	Ages 12-18 that survived intentional and unintentional injuries	Randomized control trial	Collaborate care intervention with motivational interviewing, medication and cognitive behavioral therapy targeting PTSD and depressive symptoms	2 mo, 5 mo, 12 mo	N/A	Decrease in carrying weapon 7.3% intervention vs 21.3% control patients 12 months after injury
James et al[48]	Boston, MA	ED patients >18yr enrolled in Violence intervention advocacy program (VIAP)	Exploratory Qualitative study	Structural interviews that underwent content analysis with grounded theory for identified themes of VIAP effectiveness	Active enrollment in VIAP	Participants described positive, life-changing behaviors on their journey to healing through connections to caring, supportive adults. Information gained	N/A

RR, relative risk; *OR*, odds ratio; *CI*, confidence interval; *mo*, month; *PCP*, primary care provider; *HVIP*, hospital-based violence intervention program; *GSW*, gunshot wound; *CMS*, Centers for Medicare & Medicaid; *QUALYS*, quality adjusted life years.

For each study, we tabulated the year of publication, authors, sample size, location, intervention, design, follow-up, and primary and secondary outcomes. (See Table 1) We summarized the data using common themes related to the research question.

RESULTS

We reviewed 727 publications, of which 16 articles met our inclusion criteria. (see PRISMA flowchart Figure 1) The age range of patient participants differed among programs from pediatric patients only[10,11] to those eighteen years and older.[12-15] All studies except one had a minimum inclusion criterion that participants had suffered intentional violent injuries. The exception was Operation Peace Works in California, which was based on referrals from the criminal justice system.[16] A few studies focused more specifically on those who suffered violent injuries and had an additional risk factor, such as involvement with the criminal justice system[15,16] or admission to the hospital.[14] Only one program, the Wraparound Project (WAP) at San Francisco General Hospital, focused interventions on individuals determined to be at high risk for reinjury.[17,18] This determination of high risk for reinjury was based on structured case-manager screening assessments including, but not limited to, physical signs, social cues, emotional volatility, prior exposure to violence, and unstable family situations.[17,18]

Specific violence intervention strategies also differed. A few sites utlized brief interventions that were delivered via electronic-mail or performed by an in-person therapist such as SaferFlint Teens in Flint, Michigan,[19-21] or through telephone-based parent education in the Minneapolis metropolitan area.[10] Other interventions used focused case management for several months.[22-25] Finally, several programs, including Youth ALIVE! in Oakland, California and Project Prescription Hope in Indianapolis, Indiana, provided intensive interventions that included personnel with specialized training, peer support, education opportunities, employment options, and legal services.[12,13,26–28]

Nine HVIPs included injury recidivism as an outcome measure. Four programs found no statistically significant change in injury recidivism after their intervention.[11,22,26,27,29] A prospective cohort study of the Project Prescription Hope intervention in Indianapolis found a reduction in injury recidivism from 8.7% to 2.9%.[12] Analogously, a retrospective cohort study of WAP data demonstrated a reduction in injury recidivism from 16% to 4% in the intervention group.[17] Lastly, three randomized control trials found reductions in injury recidivism (control group vs intervention), including: 1) the Violence Intervention Project (VIP) in Baltimore, Maryland (35% vs. 5%[15]); 2) Within Our Reach in Chicago, Illinois (20.3% vs 8.1%[24,25]); and 3) telephone-based parenting education in the Minneapolis metropolitan area (OR: 0.2 95% CI: 0.06-0.75[8-10]).

Secondary HVIP outcomes were also assessed. HVIP participants were found to have lower aggression scores,[10,11,19,20] crime rates,[26,27] and associated financial burden[15,28] compared to control groups. Two studies that assessed the cost effectiveness

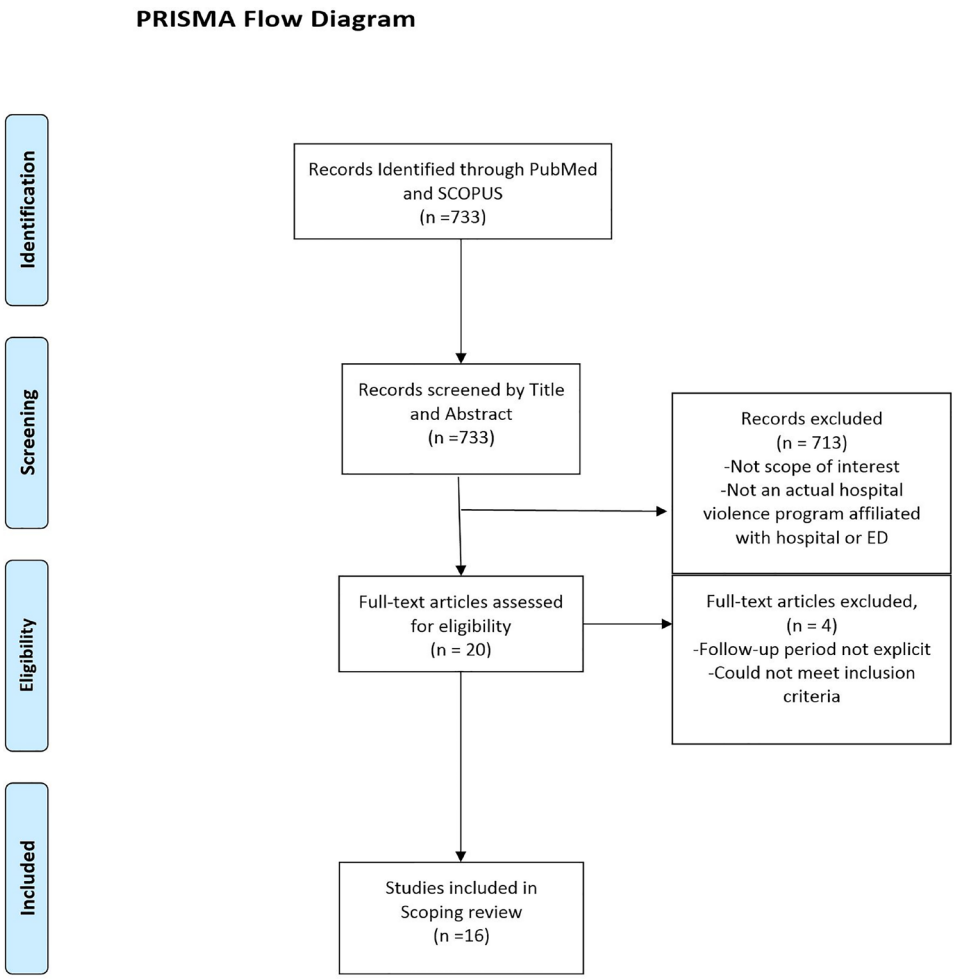

Figure 1. The PRIMSA diagram details our search and selection process applied during the overview. *ED,* emergency department.

of Youth ALIVE! found the program directly contributed to a significant municipal budget savings. The first estimated a $750,000 to $1.5 million annual savings based on juvenile detention centers cost reduction.[27] The second found an incremental cost effectiveness of $2,491 per person due to injury recidivism reduction.[28] The Baltimore program found similar cost savings, including a reduction in costs associated with incarceration ($2 million control group vs $500,000 intervention group), hospitalization ($736,000 control group vs $1380,000 intervention group) and unemployment (80% control group vs 18% intervention group).[15] Finally, a cost-effectiveness analysis of WAP suggested health benefits of 24 quality-adjusted life years (QALYs) and a $4,100 savings when implemented for 100 individuals.[30]

DISCUSSION

What is Missing? The Case for Stratification

Hospital-based violence intervention programs have a significant impact on injury recidivism and other outcomes in a number of cities across the United States. It is possible that all survivors of interpersonal violence would benefit from participation in a violence intervention program. While studies suggest a reduction in both mortality from recurrent trauma as well as associated costs, the logistical and financial barriers to implementing HVIPs are high. First, the interventions are intensive and long lasting, following patients for months to years after their initial injury. Second, the majority of traumas occur during weekends and nights, making it challenging to provide appropriate counseling in the ED.[31,32] Third, with frequent ED and hospital overcrowding, boarding or admitting all patients to facilitate further intervention creates barriers that may preclude inclusion of all patients.[33,34] Finally, the rate of follow-up in this patient population is notoriously low, making delayed intervention during follow-up appointments unlikely to succeed.[35]

Wide implementation of a broadly inclusive violence intervention program should remain the goal. Well-resourced programs based in the ED can be helpful in aiding successful case management or social tools for patients at risk for injury recidivism. In the absence of such a program, however, we recognize the need for targeted use of resources. In order to

make the most impactful use of available resources, EPs need to be able to identify those who are at the highest risk of repeat injury in real time that evaluate patients risk holistically in the context of social and structural factors related to race, gender, and socioeconomic variables.

Development of a Risk Stratification Tool

The development of a risk stratification tool requires: 1) identification of risk factors for reinjury; 2) internal validation; 3) external validation; and 4) feasibility and implementation studies. Based on clinical experience and existing medical literature, criteria would need to be identified that are both predictive of injury recidivism and practically implementable in the ED by physicians or other staff members that are found in an average ED. Approaches that require intensive inpatient or specialized case management interventions will be severely limited in their generalizability.

Literature suggest that certain social determinants of health and structural drivers such as: 1) male gender; 2) black race; 3) low socioeconomic status; 4) zip code; and 5) uninsurance/Medicaid, are risk factors for injury recidivism.[36-39] A study based in Oakland, California that followed survivors of interpersonal violence ages 12-24 found that independent predictors of violent injury recidivism included male gender (OR: 2; 95% CI: 1.06-3.80; p = 0.03), black race (OR: 2.1; 95% CI: 1.44-3.06; p < 0.001), and living in the lowest zip code socioeconomic quartile (OR: 1.59; 95% CI 1.12-2.25; p = 0.01).[37] This was also demonstrated for individual survivors of firearm injury (OR:1.67; 95% CI: 1.12-2.50; p = 0.01).[37] Similarly, a Florida study investigating injury recidivism found independent predictors of severe recurrence of violent injury included black race (OR: 1.4 95% CI: 1.1-1.8; p = 0.018), zip code median income below national median (OR: 1.3; 95% CI 1.0-1.9; p = 0.085), and being insured by Medicaid (OR:1.5; 95% CI 1.0-2.4; p = 0.061).[39]

Other literature suggest structural risk factors such as prior incarceration lead to increased risk of injury. A study of black men who were part of a Baltimore HVIP found increased rates of hospitalization due to repeat injury in individuals with previous incarceration (OR: 8.42; CI -1,73-40.92; p <0.05) and report of using a weapon or being in a fight in the past year (OR = 2.56; CI 1.08-6.06; p <0.05).[40] One pilot study attempted to create a clinically feasible risk index for firearm violence.[41] The study proposed a 4-item questionnaire (SaFETy score) that evaluated: 1) serious fighting; 2) friend weapon carrying; 3) community environment; and 4) firearm threats to grade risk of future injury from firearm violence. The SaFETy score has shown potential but has not yet been externally validated or applied to individuals >24 years of age or those who do not use substances.

Finally, a recent study based on experiences from the WAP at San Francisco General Hospital proposed a clinical tool called the violent reinjury risk assessment instrument (VRRAI).[42] The study included 11 semi-structured interviews and two focus groups with HIVP case managers and key information. The result was the development of four tiers of risk factors based on seven domains, including environment, identity, mental health, behavior, conflict, indicators of lower risk, and case management. One potential limitation is that the tool must be conducted by an individual with experiential knowledge, such as a case manager trained for the specific HVIP, rather than the emergency physicians (EP) who is most likely to determine the disposition for such patients. This requirement limits the potential for the VRRAI to be implemented widely.

The SaFETy and VRRAI are two potential clinical tools, in addition to others yet developed, that should be considered for further internal and external validation. Ultimately, feasibility and implementation studies must be considered to ensure that the risk stratification tool achieves the intended goals, including reduction of injury recidivism, associated mortality, and cost through targeted interventions.

We recognize that the ultimate outcome of such risk stratification may not prove worthwhile. Research may find that a risk stratification tool proves no more useful than clinical gestalt. Furthermore, implementation studies may find that even the lowest risk survivors of interpersonal violence still benefit from intervention. Nonetheless, we believe that in order to facilitate research that allows the growth and cost effective implementation of violence intervention programs, the development of a comprehensive risk stratification tool is a critical first step. While most EPs are exposed to penetrating trauma during their training, many are not accustomed to evaluating risk for reinjury and may benefit significantly from an evidence-based decision aid to inform their clinical decision-making. Furthermore, stratification tools and their partnership with successful HVIP may address other unmet social needs such as employment, housing, or substance use. For example, Bell et al noted that when HVIPs are associated with community partners that work to address health insurance, legal issues, and return to school, injury recidivism dropped significantly.[13]

Resident Education

Finally, we recognize that EPs develop many of their practice patterns during residency. With this in mind, we feel it is essential that graduate medical education incorporate formalized teaching on how to consider risk factors for reinjury in clinical decision-making. The Model of the Clinical Practice of Emergency Medicine (EM model) acknowledges that residents should be able to recognize age, gender, ethnicity, barriers to communication, socioeconomic status, and other factors that affect patient management. Currently, however, there are no specific recommendations that address the role of social determinants of health in survivors of interpersonal violence.[43] In order to cultivate future EPs who play an active role in reducing injury recidivism, we recommend that residencies: 1) educate residents on the high rates of injury recidivism and associated mortality; 2) teach residents about what risk factors, including social determinants of health and structural drivers, affect a patient's risk of injury recidivism; 3) train residents to consider risk

of injury recidivism when determining the management of a survivor of interpersonal violence; and finally 4) forge appropriate relationships across academic, non-profit, and other community stakeholders to implement strategies for violence prevention and intervention.

LIMITATIONS

Our paper has several limitations. First, scoping reviews do not formally evaluate the quality of evidence and are thus more descriptive. We tried to reduce the bias of descriptive pitfalls by adhering closely to PRISMA-ScR standards and having several reviewers screen independently. Secondly, scoping reviews are prone to selection bias. We attempted to safeguard against selection bias by including several keywords that would capture a broad array of HVIP-related studies and adhering closely to our inclusion criteria during the review. Lastly, due to lack of formal analysis due to the heterogeneity of end points evaluated by studies collected we deemed a scoping review would be best equipped for the current landscape.

CONCLUSION

Emergency physicians lack an evidence-based tool to help identify and manage patients at high risk for reinjury. Future research should continue to identify social and structural risk factors for injury recidivism and explore how these factors might help build a risk-stratification tool. HVIPs have shown promise in reducing physical, mental, and financial costs of reinjury however more high levels studies are needed to further understand the overall impact. Until HVIPs are more universally available, emergency physicians should be empowered through education and clinical decision aids in identifying at-risk patients who could most benefit from these services to not only reduce injury recidivism but also further explore the impact of ED and HVIP collaboration in addressing interpersonal violence.

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Consolidating Emergency Department-specific Data to Enable Linkage with Large Administrative Datasets

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Introduction: The American Hospital Association (AHA) has hospital-level data, while the Centers for Medicare & Medicaid Services (CMS) has patient-level data. Merging these with other distinct databases would permit analyses of hospital-based specialties, units, or departments, and patient outcomes. One distinct database is the National Emergency Department Inventory (NEDI), which contains information about all EDs in the United States. However, a challenge with merging these databases is that NEDI lists all US EDs individually, while the AHA and CMS group some EDs by hospital network. Consolidating data for this merge may be preferential to excluding grouped EDs. Our objectives were to consolidate ED data to enable linkage with administrative datasets and to determine the effect of excluding grouped EDs on ED-level summary results.

Methods: Using the 2014 NEDI-USA database, we surveyed all New England EDs. We individually matched NEDI EDs with corresponding EDs in the AHA and CMS. A "group match" was assigned when more than one NEDI ED was matched to a single AHA or CMS facility identification number. Within each group, we consolidated individual ED data to create a single observation based on sums or weighted averages of responses as appropriate.

Results: Of the 195 EDs in New England, 169 (87%) completed the NEDI survey. Among these, 130 (77%) EDs were individually listed in AHA and CMS, while 39 were part of groups consisting of 2-3 EDs but represented by one facility ID. Compared to the individually listed EDs, the 39 EDs included in a "group match" had a larger number of annual visits and beds, were more likely to be freestanding, and were less likely to be rural (all $P<0.05$). Two grouped EDs were excluded because the listed ED did not respond to the NEDI survey; the remaining 37 EDs were consolidated into 19 observations. Thus, the consolidated dataset contained 149 observations representing 171 EDs; this consolidated dataset yielded summary results that were similar to those of the 169 responding EDs.

Conclusion: Excluding grouped EDs would have resulted in a non-representative dataset. The original vs consolidated NEDI datasets yielded similar results and enabled linkage with large administrative datasets. This approach presents a novel opportunity to use characteristics of hospital-based specialties, units, and departments in studies of patient-level outcomes, to advance health services research. [West J Emerg Med. 2020;21(6)141-145.]

INTRODUCTION

The American Hospital Association (AHA) and the Centers for Medicare & Medicaid Services (CMS) each provide important data for health services researchers. Specifically, the AHA Annual Survey database contains hospital-level data, including the number of beds.[1] CMS maintains several "Hospital Compare" datasets with hospital metrics, in addition to a claims-level dataset that includes information about patient visits.[2] Merging these data with other datasets would permit novel analyses of the relationship between individual hospital-based specialties, units, and departments, and patient outcomes.

That said, it is not clear whether this type of merge is possible. Focusing on emergency departments (ED), a potential dataset for merging with AHA and CMS is the National Emergency Department Inventory (NEDI).[3] NEDI collects information about basic ED characteristics, including total and child visit volumes. NEDI lists all EDs in the United States individually. By contrast, AHA and CMS list some EDs individually but group others by hospital network, and they exclude some EDs completely (eg, all autonomous freestanding EDs [FSED]).[4] As more EDs become part of larger hospital networks, the more likely they are to become grouped in AHA or CMS over time. Because of potential differences between grouped and ungrouped EDs, consolidating data for this merge may be preferential to simply excluding grouped EDs. Our two objectives were to consolidate department-specific (ED) data to enable linkage with AHA and CMS datasets and to determine the effect of excluding grouped EDs on ED-level summary results.

METHODS

Using the 2014 NEDI-New England database, we identified all 195 New England EDs open that year. We sent a three-page survey to all EDs to obtain more facility data, including information about basic characteristics (eg, visit volumes) and staffing (Supplemental Material). We mailed a hardcopy of the survey up to three times and then contacted non-responding EDs by phone to administer the survey by interview. The number of ED beds, annual number of ED visits, and 24/7 consultant availability were obtained through this survey. FSED status,[4,5] rural location, and academic status were obtained from publicly-available sources, as part of ongoing NEDI-USA database maintenance.[3] The Partners Human Research Committee classified this project as exempt.

To link NEDI-New England with other datasets, we individually matched NEDI EDs with corresponding EDs in the 2014 AHA and CMS Provider of Services files. We determined that an ED was listed in both datasets if the names and addresses matched exactly. In instances where either differed, we confirmed the match by investigating the ED's website or calling the ED about the discrepancy. Furthermore, CMS lists all facilities that have ever had an identification number in their annual Provider of Services dataset. This CMS dataset includes EDs that are closed, provider numbers that are no longer active, and facilities without EDs.[2] This has led to instances where multiple facilities with similar names are listed under a single address. Thus, to only view EDs with active CMS ID numbers in 2014, we filtered by provider category subtypes of "Short Term", "Children's" or "Critical Access Hospitals," and "Active."

When an ED was not individually listed in AHA or CMS but was affiliated with another listed ED, we considered this a "group match." We confirmed these affiliations by reviewing a hospital/ED's website. In instances when an FSED was part of a group match, we used NEDI to further confirm that it was grouped with the appropriate listed parent hospital. Thus, each group included one listed ED and at least one unlisted ED.

Within each group, we consolidated individual ED data to create a single observation, based on calculated totals (eg, number of ED beds) or visit volume-weighted averages of binary responses (eg, rural location). We converted categorical variables into separate binary variables to apply the same visit-volume weighting (Supplemental Material). If the listed ED in a group responded to the NEDI survey, we included that group's data in the consolidated dataset. We then created two versions of the consolidated dataset: one where final, weighted values were rounded to the nearest integer, and a second where values were unrounded. We used chi square, Fisher's exact, and Wilcoxon rank-sum tests, as appropriate, to compare NEDI variables in the ungrouped vs grouped EDs and the consistency of results from the original vs consolidated NEDI datasets.

RESULTS

Of all 195 New England EDs, 169 (87%) completed the NEDI survey. Among these, there were 130 (77%) EDs individually listed in both AHA and CMS. The remaining 39 EDs were part of 21 groups consisting of 2-3 EDs but represented by one facility ID number. There were no instances where a NEDI ED was part of a group in AHA but ungrouped in CMS. Comparing NEDI-New England responses between 130 ungrouped EDs and the 39 grouped EDs, the grouped EDs had a larger number of annual visits and beds. They also were more likely to be FSEDs, more likely to have access to pediatricians, and less likely to be rural (all $P < 0.05$, Table 1). The ungrouped and grouped EDs did not differ by academic status, nor by their access to ED consultants other than pediatricians (eg, psychiatrists, surgeons).

Two grouped EDs were excluded because the listed ED in the group did not respond to the original NEDI survey; the remaining EDs were consolidated into 19 observations. Specifically, these 19 observations represented 41 total EDs: 19 EDs that were listed in AHA and CMS and completed the NEDI survey; 18 EDs grouped with an AHA- and CMS-listed ED that completed the NEDI survey; and four EDs that did not complete the NEDI survey but that were grouped with an AHA- and CMS-listed ED that did.

The consolidated dataset contained 149 observations representing 171 EDs. Both the rounded and unrounded consolidated datasets yielded aggregated results that were similar to those of the 169 responding EDs (Table 2). For example, 12%

Table 1. Characteristics of emergency departments that were not part of groups and parts of groups among National Emergency Department Inventory–New England survey responders, n = 169.

	EDs not in groups n=130	EDs part of groups n=39	
Basic ED characteristics	n (%)	n (%)	P-value
Freestanding ED	0 (0)	6 (15)	<0.001
Rural location	21 (16)	0 (0)	0.004
Academic	6 (5)	5 (13)	0.13
Number of ED beds, median (IQR)	20 (10-30)	29 (15-42)	0.01
Annual # of vistis, median	27,900 (14,000-50,000)	41,019 (20,310-57,000)	0.03
ED staffing, timing of consultants	n (%)	n (%)	P-value
Consutant availability 24/7			
Anesthesiologist	112 (86)	29 (74)	0.08
Cardiologist	78 (60)	29 (74)	0.10
General surgeon	111 (85)	30 (77)	0.21
Neurologist	58 (45)	22 (56)	0.20
Obstetrician-gynecologist	106 (82)	26 (67)	0.08
Pediatrician	81 (62)	17 (44)	0.04
Plastic surgeon	23 (18)	10 (26)	0.27
Psychiatry	45 (35)	11 (28)	0.46

ED, emergency department, *IQR,* interquartile range; *24/7*, 24 hours per day and 7 days per week.

of 169 EDs were in rural areas vs 14% of 149 observations in both the rounded and unrounded consolidated datasets. Likewise, 7% of 169 EDs were academic vs 6-7% of observations in the rounded and unrounded consolidated datasets. Finally, the median annual total visit volumes of responding EDs and observations were also similar (30,000 versus 32,398 visits, respectively).

DISCUSSION

Using EDs as an example, our study shows that it is possible to consolidate individual hospital-based data to enable linkage with large administrative datasets, and that this method preserves the integrity of the original dataset better than the alternative method of excluding grouped EDs. Excluding all grouped EDs would result in the omission of 23% of collected data (39/169 EDs). Our consolidation methods, however, preserved most of the data from these EDs, with only 1% of collected data omitted (2/169 EDs). We found that the consolidated and original datasets yielded similar results, but excluding all grouped EDs would have resulted in a biased dataset. For example, compared to ungrouped EDs, the grouped EDs had more visits and beds, and were less likely to be rural. Since the rounded and unrounded values in the consolidated dataset yielded similar aggregated results, we propose using the rounded consolidated dataset going forward, which better reflects the variable type of the original, granular dataset. These methods may also be applicable to the linkage of datasets of other individual, hospital-based specialties, units, and departments within administrative datasets.

While prior research and methods favor the use of publicly-available AHA or CMS datasets,[6-12] our results demonstrate that the exclusion of EDs in those datasets may lead to information bias. Most clearly, none of the FSEDs included in NEDI are individually listed in AHA or CMS. While FSEDs make up only 4% of all responding New England EDs open in 2014, the number of FSEDs has increased sharply since then, both in New England and even more so on a national level.[13] For example, as of 2017 FSEDs made up 12% of all US EDs,[4] and as of August 2020 there were 684 total FSEDs open in the US (unpublished data). Since all New England FSEDs were part of groups, excluding them completely would have disregarded an increasingly important provider of emergency care.

Furthermore, given that EDs that were part of groups were all also part of hospital networks, we would anticipate that an increase in health networks would result in an increase in EDs requiring grouping in future datasets, especially given that hospital and health system mergers increased in the years leading up to and after 2014, peaking in 2017.[14] This increase conveys that these methods may perhaps be of increasing importance going forward. Further supporting this observation is that the number of facilities listed in AHA have decreased each year since 2008,[15] whereas the number of individual EDs in NEDI has increased each year since 2001,[16] suggesting that although EDs continue to open, the increase in number of EDs in health networks leads to a lower number of facilities individually listed in AHA.

Table 2. Emergency department characteristics based on all responses and based on consolidated datatset, among National Emergency Department Inventory–New England survey responders.

	All NEDI respondents n=169 EDs	Rounded responses based on consolidated dataset n=149 observations*	Difference in % or medians	Unrounded responses based on consolidated dataset n=149 observations*	Difference in % or medians
Basic ED characteristics	n (%)	n (%)		n (%)	
Freestanding ED	6 (4)	1 (1)	3	1 (1)	3
Rural location	21 (12)	21 (14)	-2	21 (14)	-2
Academic	11 (7)	10 (7)	0	9 (6)	1
Number of ED beds, median (IQR)	22 (11-33)	23 (11-37)	-1	23 (11-37)	-1
Annual # of vistis, median	30,000 (16,000-51,000)	32,398 (15,650-57,000)	-2,398	32,398 (15,650-57,000)	-2,398
ED staffing, timing of consultants	n (%)	n (%)		n (%)	
Consutant availability 24/7					
Anesthesiologist	141 (83)	129 (87)	-4	128 (86)	-3
Cardiologist	107 (63)	97 (65)	-2	95 (64)	-1
General surgeon	141 (83)	130 (87)	-4	128 (86)	-3
Neurologist	80 (47)	73 (49)	-2	71 (48)	-1
Obstetrician-gynecologist	132 (78)	123 (83)	-5	121 (81)	-3
Pediatrician	98 (58)	93 (62)	-4	92 (62)	-4
Plastic surgeon	33 (20)	30 (20)	0	29 (19)	1
Psychiatry	56 (33)	53 (36)	-3	52 (35)	-2

*149 observations represent 171 individual EDs: 19 EDs that completed the NEDI survey and that were listed in AHA and CMS, 18 EDs that completed NEDI survey and grouped with an ED individually listed in AHA and CMS, and 4 EDs that did not complete NEDI survey but that were grouped with an ED listed in AHA and CMS that did.
NEDI, National Emergency Department Inventory; *ED,* emergency department; *IQR,* interquartile range; *24/7,* 24 hours per day and 7 days per week; *AHA,* American Hospital Association; *CMS,* Centers for Medicare and Medicaid Services.

LIMITATIONS

The NEDI-New England survey relies on self-reported results. However, we mitigated this limitation by obtaining facility data from the ED director, who presumably is the most knowledgeable person about the operations of his or her ED. Also, our consolidation methods still required that among groups where not all EDs completed the survey data had to be dropped if the listed ED did not participate. However, this resulted in minimal data loss among responding New England EDs, with only two (1%) having dropped data. Finally, the consolidation of ED-specific data for linkage may introduce bias. However, we believe this bias is limited, given that the data of most EDs are preserved during this process, which improves the overall representativeness of the dataset. Furthermore, the consolidated and granular results are similar.

CONCLUSION

ED-specific data can be consolidated to enable linkage with large administrative datasets in a way that maintains the integrity of the original data. Excluding all grouped EDs would have resulted in a smaller, non-representative dataset. In contrast, the original vs consolidated NEDI datasets yielded similar results. We propose using the rounded consolidated dataset to better reflect the variable type of the original, granular dataset. This novel approach presents an opportunity to use characteristics of hospital-based specialties, units, or departments in studies of patient-level outcomes, to advance health services research.

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United States' Emergency Department Visits for Fever by Young Children 2007-2017

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Introduction: Our goal in this study was to estimate rates of emergency department (ED) visits for fever by children <2 years of age, and evaluate frequencies of testing and treatment during these visits.

Methods: We performed a cross-sectional study of ED encounters from 2007-2017 using the National Hospital Ambulatory Medical Care Survey, a cross-sectional, multi-stage probability sample survey of visits to nonfederal United States EDs. We included encounters with a visit reason of "fever" or recorded fever in the ED. We report demographics and management strategies in two groups: infants ≤90 days in age; and children 91 days to <2 years old. For patients 91 days to <2 years, we compared testing and treatment strategies between general and pediatric EDs using chi-squared tests.

Results: Of 1.5 billion encounters over 11 years, 2.1% (95% confidence interval [CI], 1.9-2.2%) were by children <2 years old with fever. Two million encounters (95% CI, 1.7-2.4 million) were by infants ≤90 days, and 28.4 million (95% CI, 25.5-31.4 million) were by children 91 days to <2 years. Among infants ≤90 days, 27.6% (95% CI, 21.1-34.1%) had blood and 21.3% (95% CI, 13.6-29.1%) had urine cultures; 26.8% (95% CI, 20.9-32.7%) were given antibiotics, and 21.1% (95% CI, 15.3-26.9%) were admitted or transferred. Among patients 91 days to <2 years in age, 6.8% (95% CI, 5.8-7.8%) had blood and 7.7% (95% CI 6.1-9.4%) had urine cultures; 40.5% (95% CI, 40.5-40.5%) were given antibiotics, and 4.4% (95% CI, 3.5-5.3%) were admitted or transferred. Patients 91 days to <2 years who were evaluated in general EDs had higher rates of radiography (27.1% vs 15.2%; P<0.01) and antibiotic utilization (42.3% vs 34.2%; P<0.01), but lower rates of urine culture testing (6.4% vs 11.6%, p = 0.03), compared with patients evaluated in pediatric EDs.

Conclusion: Approximately 180,000 patients ≤90 days old and 2.6 million patients 91 days to <2 years in age with fever present to US EDs annually. Given existing guidelines, blood and urine culture performance was low for infants ≤90 days old. For children 91 days to <2 years, rates of radiography and antibiotic use were higher in general EDs compared to pediatric EDs. These findings suggest opportunities to improve care among febrile young children in the ED. [West J Emerg Med. 2020;21(6)146-151.]

INTRODUCTION

Fever is the most common reason for the evaluation of pediatric patients in acute care settings.[1,2] Among those evaluated in emergency departments (ED), febrile infants <90 days of age are at risk of serious bacterial infections (SBI), including urinary tract infection (UTI), bacteremia, and meningitis.[3] Therefore,

experts recommend routine testing for SBI, including blood and urine cultures, among infants <90 days with fever.[4-9] In contrast, the incidence of bacteremia in children 3-36 months of age is lower, allowing for selective testing and treatment.[10,11] In such patients, routine blood culture is generally not recommended.[12] However, for febrile children older than three months of age, cross-sectional studies estimate that the overall incidence of UTI remains high (between 3-8%).[13,14] Therefore, it remains important for providers to remain vigilant in evaluating for UTI. Across both age groups (<90 days and 91 days <2 years), routine use of chest radiographs is generally not recommended.[15]

Despite extensive research performed on the risk stratification of febrile children, few epidemiological data are available describing the frequency of presentation of this condition to acute care settings and rates of testing performed. Prior investigations have provided limited data with respect to infants <90 days, or have been only reported from pediatric institutions, where practice patterns may differ compared to general EDs where most children seek care.[16-18] Our primary objective was to estimate the rate of ED visits for fever by infants ≤90 days, and children 91 days <2 years of age. Our secondary objective was to evaluate frequencies of blood and urine culture acquisition, radiographs, and antibiotic administration in this population and compare the management of pediatric patients 91 days <2 years between pediatric and general EDs.

Population Health Research Capsule

What do we already know about this issue?
Infants ≤90 days are at risk of serious bacterial infections. In contrast, rates of bacteremia and meningitis are lower in older febrile children (91 days to 2 years).

What was the research question?
Our goal was to report rates of presentation and testing among children <2 years with fever in US emergency departments.

What was the major finding of the study?
A lower proportion of infants ≤90 days in age are evaluated for infections. Testing in older children may be high.

How does this improve population health?
Findings have implication for quality improvement efforts: more testing is needed among young infants, whereas some testing among older children may be of low value.

METHODS

We performed a cross-sectional analysis of the National Hospital Ambulatory Medical Care Survey (NHAMCS), a nationally representative sample survey conducted annually by the Centers for Disease Control and Prevention National Center for Health Statistics (NCHS).[19] NHAMCS is a cross-sectional probability sample survey of ED encounters to nonfederal and short-stay hospitals in the United States. Research with NHAMCS is approved by NCHS Ethics Review Board.

We included ED encounters from 2007-2017. We evaluated two cohorts, given the disease prevalence and evidence-based management strategies: a) infants ≤90 days of age; and b) children 91 days <2 years. We identified patients with fever as those encounters with either 1) a reason for visit code (RFV) classified as "fever" (RFV 1010.0) or "feeling hot" (RFV 1012.2); or 2) a documented temperature in the ED of 100.4°F (38.0°C) or greater. NHAMCS does not document the route of temperature acquisition.

We abstracted the following: demographics; testing (including blood culture, urine culture, radiographs); antibiotics (in ED and/or prescribed); disposition; and diagnoses. We classified EDs as pediatric if >75% of encounters were by patients under 18 years of age.[20] Results were provided using survey-weighting procedures accounting for the NHAMCS sampling design, with 95% confidence intervals (CI).[21] We assessed presentation rates using quasibinomial regression. For patients 91 days to <2 years old, we compared rates of testing and treatment between pediatric vs non-pediatric EDs using the Rao-Scott adjusted chi-squared test. We assessed SBI rates among infants <90 days, and rates of SBI, UTI, pneumonia, and otitis media among children 91 days to <2 years in age (Supplementary Table 1).[16,22,23] Estimates with fewer than 30 records or with a relative standard error >30% were considered unstable.[24] We conducted analyses using the survey package[25] in R, version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria).

To evaluate specific rates of presentation and testing in 0-28, 29-60, and 61-90 day age groups, we conducted an exploratory analysis. For this, we broadened our inclusion to the years 2002-2017 in order to obtain sufficient numbers of raw patients to generate reliable estimates.

RESULTS

An estimated 2.0 million encounters for infants ≤90 days and 28.4 million encounters for children 91 days to <2 years of age occurred over the 11 years (Supplementary Figure). Among infants ≤90 days of age, 14.8% (95% CI, 10.6-19.0%) were 0-28 days old, 41.5% (95% CI, 34.3-48.7%) were 29-60 days old, and 43.7% (95% CI, 36.6-50.9%) were 61-90 days old. There was no trend in presentation rates over time ($P = 0.21$ for ≤90 days and $p = 0.10$ for 91 days to <2 years).

Among patients ≤90 days, 27.6% (95% CI, 21.1-34.1%) had blood cultures, 21.3% (95% CI, 13.6-29.1%) had urine cultures, and 37.2% (95% CI, 30.4-44.0%) had radiographs

(Table 1). Antibiotics were administered to 26.8% (95% CI, 20.9-32.7%). Among patients 91 days to <2 years, 6.8% (95% CI, 5.8-7.8%) had blood cultures, 7.7% (95% CI, 6.1-9.4%) had urine cultures, and 24.5% (95% CI, 22.2-26.8%) had radiographs. In this group, 40.5% (95% CI 38.5-42.5%) were given antibiotics.

Among infants 91 days to <2 years in age, encounters from general EDs had a lower proportion of urine cultures (6.4% vs 11.6%, $P = 0.03$) and a higher proportion of radiograph (27.1% vs 15.2%, $P<0.01$) and antibiotic use (42.3% vs 34.2%, $P<0.01$) compared to pediatric EDs (Table 2). Among patients 0-90 days, 9.3% (95% CI, 5.5-13.0%) were diagnosed with a SBI. Of

Table 1. Demographics, testing and treatment of febrile children <2 years of age.

	≤90 days of age N = 2.0 million (95% CI, 1.7-2.4 million)			>90 days to <2 years N = 28.5 million (95% CI, 25.5-31.4 million)		
Variable	Raw count*	Estimate (millions)	Estimated percent (95% CI)	Raw count*	Estimate (millions)	Estimated percent (95% CI)
Male gender	223	1.2	59.1 (51.8-66.3)	3,229	15.4	54.0 (52.2-55.8)
Race						
White	253	1.3	64.8 (57.4-72.1)	3,764	18.5	65.0 (61.6-68.4)
Black	108	0.6	27.6 (20.5-34.7)	1,735	8.1	28.6 (25.2-32.1)
Other	34	0.2	7.7 (3.2-12.2)	425	1.8	6.4 (5.2-7.5)
Ethnicity						
Hispanic	122	0.6	29.4 (22.9-35.9)	1,851	8.8	30.8 (27.4-34.2)
Non-Hispanic	273	1.4	70.6 (64.1-77.0)	4,073	19.7	69.2 (65.8-72.6)
Type of emergency department						
General	313	1.5	73.9 (65.6-82.3)	4,830	22.2	78.2 (72.5-83.8)
Pediatric	82	0.5	26.1 (17.7-34.4)	1,094	6.2	21.8 (16.2-27.5)
Seen by PA or NP without attending	50	0.2	12.2 (7.2-17.1)	877	4.7	16.5 (14.5-18.5)
Source of payment						
Private	100	0.5	23.0 (17.8-28.3)	1,306	6.4	22.6 (20.1-25.1)
Public	241	1.3	64.0 (57.6-70.4)	3,826	18.1	63.6 (60.7-66.5)
Other or not stated	54	0.3	13.0 (8.4-17.6)	792	3.9	13.8 (11.6-16.0)
Census region						
Northeast	71	0.3	13.4 (8.0-18.8)	1,115	4.0	14.1 (11.7-16.4)
Midwest	89	0.5	24.3 (16.2-32.4)	1,246	5.8	20.2 (16.4-24.0)
South	155	0.9	43.4 (35.3-51.5)	2,378	12.6	44.4 (39.1-49.7)
West	80	0.4	19.0 (13.3-24.6)	1,185	6.1	21.3 (16.7-25.9)
Cultures						
Blood culture	109	0.6	27.6 (21.1-34.1)	465	1.9	6.8 (5.8-7.8)
Urine culture†	48	0.2	21.3 (13.6-29.1)	223	1.2	7.7 (6.1-9.4)
Procedures						
Lumbar puncture†	15‡	0.1‡	6.1 (2.6-9.6)‡	9‡	0.1‡	0.5 (0.0-0.9)‡
Other diagnostic testing						
Urinalysis	179	0.8	41.4 (34.6-48.2)	908	3.9	13.8 (12.5-15.1)
Complete blood count	185	1.2	43.4 (36.2-50.7)	911	3.9	13.7 (12.1-15.2)
Radiography	139	0.8	37.2 (30.4-44.0)	1,450	7.0	24.5 (22.2-26.8)
Groups of testing†						
Blood and urine culture	37	0.2	10.5 (6.0-15.0)	58	0.3	1.2 (0.7-1.6)
Blood and urine culture with lumbar puncture	5‡	0.0‡	1.3 (0.1-2.5)‡	1‡	0.0‡	0 (0.0-0.0)‡

Table 1. Continued.

Variable	Raw count*	Estimate (millions)	Estimated percent (95% CI)	Raw count*	Estimate (millions)	Estimated percent (95% CI)
Therapy						
Any antibiotic	120	0.5	26.8 (20.9-32.7)	2,377	11.5	40.5 (38.5-42.5)
Disposition						
Discharged	256	1.4	66.7 (59.8-73.6)	4,908	24.1	84.7 (82.6-86.8)
Transfer	21‡	0.1‡	5.9 (2.1-9.8)‡	45	0.2	0.7 (0.4-0.9)
Admitted	77	0.3	15.2 (10.0-20.4)	259	1.1	3.7 (2.9-4.5)
Other/not stated	41	0.2	12.2 (7.0-17.5)	712	3.1	10.8 (8.9-12.8)

CI, confidence interval; *PA*, physician's assistant; *NP*, nurse practitioner.
*Raw counts are the number of actual encounters available within the NHAMCS dataset; these are used with encounter-level survey weights to generate estimates and percents with confidence intervals.[21]
†Urine and lumbar puncture data were only available for years 2012-2016.
‡Calculated from a low number of raw counts or with a high relative standard error, which may lead to estimate instability per the National Center for Health Statistics guidelines.

Table 2. Testing and treatment of febrile children 90 days to <2 years of age, by type of emergency department.

	Pediatric emergency department visits (N = 6.2 million)	General emergency department visits (N = 22.2 million)	
Variable	Estimated percent (95% CI)	Estimated percent (95% CI)	P-value
Seen by PA or NP without attending	15.4 (10.6-20.3)	16.8 (14.5-19.0)	0.762
Cultures			
Blood culture	8.1 (5.5-10.6)	6.5 (5.4-7.5)	0.22
Urine culture†	11.6 (6.9-16.2)	6.4 (4.6-8.3)	0.03
Other diagnostic testing			
Urinalysis	15.4 (12.3-18.4)	13.4 (12.0-14.9)	0.24
Complete blood count	11.3 (8.0-14.7)	14.3 (12.6-16.0)	0.15
Radiography	15.2 (11.4-19.0)	27.1 (24.6-29.6)	<0.01
Therapy			
Any antibiotic	34.2 (29.3-39.0)	42.3 (40.1-44.5)	<0.01
Disposition			0.10
Discharged	82.8 (77.1-88.4)	85.3 (83.2-87.4)	
Transfer	0.0 (0.0-0.1)‡	0.8 (0.5-1.2)‡	
Admitted	5.0 (3.0-7.1)	3.4 (2.5-4.3)	
Other/not stated	12.2 (7.1-17.2)	10.5 (8.5-12.5)	

CI, confidence interval; *PA*, physician's assistant; *NP*, nurse practitioner.
*P-values assessed by Rao-Scott adjusted Pearson chi-squared statistic.
†Urine and lumbar puncture data were only available for years 2012-2016.
‡Calculated from a low number of raw counts or with a high relative standard error, which may lead to estimate instability per the National Center for Health Statistics guidelines.

infants 91 days to 2 years, 2.4% (95% CI, 1.8-3.0%) had a SBI (of which 91.0% [95% CI, 86.1-95.9%] had UTIs), 6.0% (95% CI, 5.1-6.8%) were diagnosed with pneumonia, and 23.4% (95% CI, 21.9-24.8%) were diagnosed with otitis media.

In our exploratory analysis for febrile infants ≤90 days old for the years 2002-2017, rates of blood cultures and urine cultures were similar between those 0-28 days and 29-60 days (Supplementary Table 2). A higher proportion of patients in older subgroups were discharged from the hospital.

DISCUSSION

In this nationally representative sample of ED encounters, approximately 180,000 infants ≤90 days and 2.6 million children 91 days to <2 years old presented annually for fever. One-third of febrile infants ≤90 days had blood and urine cultures, while 7% of older febrile children had blood cultures. Given higher rates of bacteremia in febrile infants <90 days old, routine acquisition of blood and urine cultures is recommended by guidelines.[8] While specific guidelines vary, all support blood and urine cultures in infants <60 days of age.[4-8] While rates of bacteremia in infants 61-90 days old may be lower than rates in 0-60 days old infants, data from one recent prospective study suggest that the prevalence of bacteremia even in the third month of life is still high (1%).[26] One study limited to pediatric hospitals found the rate of culture acquisition among febrile infants ≤90 days was 69% for blood and 75% for urine cultures.[16]

Our investigation found a low frequency of culture acquisition (27.6% having blood cultures, and 21.3% having urine cultures). However, as the rate of SBI in our study was 9% in this age group, comparable to prior research,[3,7] our findings suggest a need for education and quality improvement. Quality-based measures, such as the recently reported Reducing Excessive Variability in the Infant Sepsis Evaluation, which includes clinical algorithms, order sets, education, and a mobile phone application for the management of febrile infants, can reduce variability with respect to hospital admission and lengths of stay.[27]

Bacteremia is relatively uncommon among infants >90 days of age. In one multicenter review of 57,000 blood cultures from children 3-36 months of age, rates of bacteremia were <0.5%.[11] However, we observed that blood culture performance in this group was high (at approximately 1 in 14) and approached the rates of urine culture. Frequent use of blood cultures in this setting may lead to downstream effects, such as false positives and repeated testing.[28] Our findings may represent adherence to older guidelines recommending empiric treatment for occult bacteremia in patients with fever. The 2003 American College of Emergency Physicians guidelines provided "Level B" evidence supporting empiric antimicrobial use for children having fever without a source.[29] Acknowledging lower rates of bacteremia in the post-pneumococcal vaccine era, specific recommendations regarding empiric antimicrobial use were removed in a 2016 update to this guideline.[15] Given the prevalence of viral infections in febrile children,[30] a large number of patients may receive antibiotics unnecessarily. Educational sessions and individualized audits may be beneficial in limiting unnecessary antibiotic use.[31]

LIMITATIONS

Our findings carry limitations, including potential errors with respect to documentation, abstraction, and coding.[32] Some variables were not present during the entire study period. In addition, we were unable to provide reliable estimates for some tests, or obtain testing trends over time. Indications for performing particular testing and antibiotic prescribing were not available in this dataset. In particular, we were unable to directly correlate antibiotic use for specific infectious diagnoses.

CONCLUSION

Approximately 180,000 children ≤90 days old and 2.6 million children between 91 days and <2 years present to US EDs annually with fever. Fewer than 1/3 of infants ≤90 days were evaluated with blood and urine cultures, which appears to be low. Blood culture testing and antibiotic use among children 91 days to <2 years appear to be high, in light of practice guidelines. These findings suggest important opportunities to improve the care of febrile children in the ED.

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Prevalence of Emergency Department Social Risk and Social Needs

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Introduction: Social risks, or adverse social conditions associated with poor health, are prevalent in emergency department (ED) patients, but little is known about how the prevalence of social risk compares to a patient's reported social need, which incorporates patient preference for intervention. The goal of this study was to describe the relationship between social risk and social need, and identify factors associated with differential responses to social risk and social need questions.

Methods: We conducted a cross-sectional study with 48 hours of time-shift sampling in a large urban ED. Consenting patients completed a demographic questionnaire and assessments of social risk and social need. We applied descriptive statistics to the prevalence of social risk and social need, and multivariable logistic regression to assess factors associated with social risk, social need, or both.

Results: Of the 269 participants, 100 (37%) reported social risk, 83 (31%) reported social need, and 169 (63%) reported neither social risk nor social need. Although social risk and social need were significantly associated ($p < 0.01$), they incompletely overlapped. Over 50% in each category screened positive in more than one domain (eg, housing instability, food insecurity). In multivariable models, those with higher education (adjusted odds ratio [aOR] 0.44 [95% confidence interval {CI}, 0.24-0.80]) and private insurance (aOR 0.50 [95% CI, 0.29-0.88]) were less likely to report social risk compared to those with lower education and state/public insurance, respectively. Spanish-speakers (aOR 4.07 [95% CI, 1.17-14.10]) and non-Hispanic Black patients (aOR 5.00 [95% CI, 1.91-13.12]) were more likely to report social need, while those with private insurance were less likely to report social need (private vs state/public: aOR 0.13 [95% CI, 0.07-0.26]).

Conclusion: Approximately one-third of patients in a large, urban ED screened positive for at least one social risk or social need, with over half in each category reporting risk/need across multiple domains. Different demographic variables were associated with social risk vs social need, suggesting that individuals with social risks differ from those with social needs, and that screening programs should consider including both assessments. [West J Emerg Med. 2020;21(6)152-161.]

INTRODUCTION

Social determinants of health (SDoH) affect health outcomes and healthcare utilization.[1] The World Health Organization defines SDoH as "conditions in which people are born, grow, live, work and age," which are "shaped by the distribution of money, power and resources at global, national and local levels."[2] These conditions include housing, income, education, transportation systems, neighborhoods, and many others. In a recent study evaluating the association between income and life expectancy, there was a 10- to 15-year difference between the richest 1% and the poorest 1%.[3] Additionally, housing instability and food insecurity have been associated with increased emergency department (ED) use and hospitalizations.[4] With rising pressures to improve health outcomes, reduce healthcare costs, and the transition from fee-for-service to accountable care organizations, the US healthcare system has become increasingly focused on identifying and addressing patients' SDoH.[5] Although most screening efforts have primarily focused on the outpatient clinical setting,[6,7] studies have shown an association between adverse SDoH and ED visits.[8,9] This relationship suggests that encounters in the ED may provide a unique screening opportunity, as many individuals who use the ED for healthcare may not otherwise have access to outpatient services, [8-10] and the ED may be their only opportunity for screening and intervention.

While SDoH may affect health for better or worse, *social risk* is defined as "specific adverse social conditions that are associated with poor health, like social isolation or housing instability."[11] Recently, Alderwick et al proposed a distinction between social risk and social need in order to incorporate patients' preferences and priorities.[11] In contrast to social risk, *social need* refers to the patient's perceptions of adverse SDoH for which they would like assistance, allowing for patient prioritization of social interventions.[11] Although subtle, this distinction is paramount, as there may be important differences between positive answers to screening questions about social risk vs social need, which in turn have critical implications for targeting interventions. For example, one study investigated screening for food insecurity using a screening questionnaire (social risk) vs a referral menu, the latter of which offered assistance obtaining food (social need).[12] While the authors found that 31% reported food insecurity and 32% desired referrals to food resources, only 17% reported both.[12] This implies that those who have social risk factors (ie, those who screen positive on a questionnaire inquiring about food insecurity) may not necessarily perceive themselves as needing extra resources (assistance with obtaining food).

The incomplete overlap highlights the importance of screening separately for social risk and social need, as the incorporation of patient preference for social assistance (ie, the expression of social need) is fundamental to understanding how and when to best connect patients to resources.

Population Health Research Capsule

What do we already know about this issue?
Social risk refers to adverse social conditions associated with poor health; social need refers to adverse social conditions with which patients would like assistance.

What was the research question?
What was the prevalence of social risk and social need among ED patients, and how were they related?

What was the major finding of the study?
Social risk/need were present in 1/3 of patients and significantly associated, but with incomplete overlap.

How does this improve population health?
Understanding the relationship between social risk and social need will improve screening for adverse social determinants of health that can subsequently be addressed.

Furthermore, it is unclear whether the same populations of patients who are screening positive for social risk are also screening positive for social need, and there are limited studies comparing patient answers to those questions across multiple domains. Thus, understanding the similarities and differences between social risk and social need screening with a multi-domain standardized questionnaire is important to determine which patients will most benefit from social interventions and how best to design those interventions.

Existing screening tools have primarily focused on social risk alone and have used a heterogeneous set of questions.[6,8,13] In an attempt to standardize screening, the Centers for Medicare & Medicaid Services (CMS) and National Academy of Medicine recently published a screening tool focusing on social risk in five domains: housing instability; food insecurity; transportation needs; utility needs; and interpersonal safety.[14] However, the length of the CMS tool makes it challenging to use in time-limited settings such as the ED, and some of the questions remain under copyright protection. Furthermore, the CMS tool assesses social risk, but does not assess social need.

The objectives of this study were to describe and identify the following: 1) the prevalence of social risk and social need among patients in a large, urban ED using a brief screening tool; 2) the relationship between positive screens for social

risk and social need; and 3) patient factors associated with differential responses to social risk and social need questions.

METHODS

Study Design

We conducted a cross-sectional study with 48 hours of time-shift sampling (spanning all 24 weekday hours and 24 weekend hours, 12 AM-11:59 PM) between September 2018–April 2019 in each of five treatment areas within a large, urban, academic ED, with a yearly patient census of 114,433 (2019). The sampling method was designed to eliminate sampling bias associated with the inherently different patient populations likely to report to the ED during different times (weekday vs weekend or daytime vs nighttime) as well as with differing levels of acuity (ie, in a fast track vs higher acuity area of the ED). Bilingual (English-Spanish) research assistants (RA) approached patients for eligibility, and consenting patients completed both a brief demographic questionnaire and the social risk/need assessment. The assessment consisted of two sections, one assessing social risk and another assessing social needs, in each of the five recommended domains outlined by the National Academy of Medicine[14] for standardized screening (Table 1).

Given that the CMS tool was under copyright restriction, we adapted the tool, using similar, publicly available and previously reported social risk questions in each domain. With regard to social need, given there is no existing validated screening tool spanning multiple domains, we added explicit, simplified questions regarding patient desire for social assistance across the same five domains. This method is similar to that employed in other studies assessing social need.[12] Notably, others have highlighted the lack of gold standards for SDoH screening tools,[15] the limited data on psychometric properties of screening tools,[16] the large variation in prevalence of SDoH across domains, and the variable availability of community services across geographic locations that limits those SDoH that may be amenable to intervention.[15] Given that these limitations preclude a formal validation of the tool, we felt that using questions from the scientific literature was the next best option.

In a private room, the RA verbally administered the survey to the participant, recording all responses directly into the secure online REDCap system. Patients were asked first about social risk and then social need. The survey altogether took approximately 5-7 minutes. Of note, regardless of screening results, all participants were provided with a sheet of local resources mapping to the domains of the survey. The study was approved by the institutional review board of Partners HealthCare.

Selection of Participants

During each sampling shift in the ED, all newly arriving eligible patients and parents of pediatric patients (<18 years of age) entering the treatment area who spoke English or Spanish were approached for participation. Exclusion criteria included determination by the attending physician that the patients were inappropriate for enrollment, eg, intoxication or altered mental status to the degree of inhibiting decision-making capacity, or high medical acuity requiring immediate attention (such as emergent intubation or active resuscitation).

Outcomes

The primary outcome was the prevalence of social risk and social need in a large, urban, academic ED. Secondary outcomes included the association between social risk and social need, as well as the association of demographic variables with social risk and social need, respectively.

Analysis

We used descriptive statistics to summarize participants' demographic characteristics and the prevalence of social risk and social need. We employed multivariable logistic regression models to assess the association between social risk and social need with demographic characteristics, including gender, race/ethnicity, language, education, health literacy, and insurance. For the multivariable logistic regression models, education was divided into two groups—high school or less vs some college or more—given the small number of participants with less than eighth-grade education. This cutoff is further supported by studies showing significant association of comprehension[17] and mortality[18] among those who have graduated high school and attained some college compared to those who have not. Given the potential colinearity between education and health literacy, these two variables were analyzed in two different models. We conducted analyses in STATA 15 (StataCorp, College Station, TX).

RESULTS

Characteristics of Study Subjects

Of the 614 patients or parents of patients who were approached, 483 (79%) were eligible for participation, with the primary reasons for ineligibility being intoxication and high medical acuity. Of the 483 eligible patients, 269 (56%) patients consented to and completed the survey. Eligible patients who did not participate did so because they were either transported elsewhere for a diagnostic procedure (eg, imaging) or declined participation, citing disinterest or pain. Among the 269 participants, 79 (29%) had completed only an elementary or high school education, and 121 (45%) had public or no health insurance. Twenty-four participants (9%) chose to complete the survey in Spanish.

Main Results

Overall, 100 participants (37%) screened positive for social risk, while 83 (31%) screened positive for social need. Regarding social risk questions by domain, 23% were positive for housing insecurity, 17% for food insecurity, 9% for transportation needs, 4% for utility needs, and 17%

Table 1. Social risk and social need questions.

Domain	Questions	Sources
Social risk		
Housing instability	1a. In the last month, have you slept outside, in a shelter or in a place not meant for sleeping? 1b. In the last month, have you had concerns about the condition or quality of your housing? 1c. In the last 12 months, how many times have you or your family moved from one home to another? 1d. Are you worried that in the next 2 months, you may not have stable housing?	HealthBegins[27] Health Leads[28]
Food insecurity	2a. Within the past 12 months, we worried whether our food would run out before we got money to buy more. 2b. Within the past 12 months, the food we bought just didn't last and we didn't have money to get more.	American Academy of Pediatrics[29]
Transportation needs	3a. How often is it difficult to get transportation to or from your medical or follow-up appointments? 3b. How often is it difficult to get transportation to or from your other non-medical activities (work, school etc.)?	HealthBegins[27]*
Utility needs	4. In the past 12 months, have you had any utility (electric, gas, water or oil) shut off for not paying your bills?	Health Leads[28]*
Interpersonal safety	5a. Do you have any concerns about safety in your neighborhood? 5b. Are you afraid you might be hurt in your apartment building or house?	HealthBegins[27] Health Leads[28]
Social need†		
Housing instability	Would you like help with shelter or housing?	
Food insecurity	Would you like help with obtaining food?	
Transportation needs	Would you like help with transportation?	
Utility needs	Would you like help paying for your utility bills?	
Interpersonal safety	Would you like help regarding your personal or neighborhood safety?	

*Question has been slightly modified for ease of understanding in the ED setting.
†Questions internally developed.

for neighborhood safety concerns. Regarding social need, 15% screened positive for housing insecurity, 13% for food insecurity, 11% for transportation needs, 17% for utility needs, and 11% for safety concerns. Results for the individual questions are shown in Table 2. Of those 100 individuals who reported social risk, 57 (57%) reported having more than one social risk, and 45 of 83 (54%) reported more than one social need—suggesting a high co-prevalence across multiple domains. There was a significant association, but incomplete overlap, between the presence of social risk and social need in each domain (Table 3).

In unadjusted analyses, education was significantly associated with social risk and social need, with those patients having lower education being more likely to report the presence of both. Language, race/ethnicity, and insurance were also associated with social need but not social risk (Table 4); those patients who were Spanish-speaking, non-Hispanic Black, and/or possessed state/public insurance were more likely to report social need.

We created two multivariable logistic regression models, one for social risk and one for social need. Models 1A and 2A controlled for gender, race/ethnicity, language, education, and insurance status. Models 1B and 2B controlled for the same variables, with the exception of education, which was exchanged for health literacy. With regard to social risk, Model 1A demonstrated that participants who possessed higher than high school education had lower odds of reporting social risk (adjusted odds ratio [aOR] 0.44 [95% confidence interval [CI], 0.24-0.80]). Model 1B demonstrated that participants with private insurance had lower odds of reporting social risk (aOR 0.50 [95% CI, 0.29-0.88]) (Table 5). With regard to social need, Model 2A demonstrated that the characteristics independently associated with higher odds of reporting social need were Spanish speakers (aOR 4.07 [95% CI, 1.17-14.10]) and non-Hispanic Black race (aOR 5.00 [95% CI,1.91-13.12]). These results were corroborated by Model 2B: Spanish speakers (aOR 3.57 [95% CI, 1.01-12.57]) and non-Hispanic Black patients (aOR 4.96 [95% CI, 1.88-13.11])

Table 2. Prevalence of social risk and social need, by question and by group, N = 269.

Questions	n	%
Social risk		
In the last month, have you slept outside, in a shelter or in a place not meant for sleeping?	18	7
In the last month, have you had concerns about the condition or quality of your housing?	35	13
In the last 12 months, how many times have you or your family moved from one home to another?	16	6
Are you worried that in the next 2 months, you may not have stable housing?	37	14
Housing total	61	23
Within the past 12 months, we worried whether our food would run out before we got money to buy more.	35	13
Within the past 12 months, the food we bought just didn't last and we didn't have money to get more.	34	13
Food total	45	17
How often is it difficult to get transportation to or from your medical or follow-up appointments?*	20	7
How often is it difficult to get transportation to or from your other non-medical activities (work, school, etc.)?*	19	7
Transportation total	24	9
In the past 12 months, have you had any utility (electric, gas, water or oil) shut off for not paying your bills?	11	4
Utility total	11	4
Do you have any concerns about safety in your neighborhood?	40	15
Are you afraid you might be hurt in your apartment building or house?	13	5
Safety total	45	17
Social need		
Would you like help with shelter or housing?	40	15
Would you like help with obtaining food?	34	13
Would you like help with transportation?	29	11
Would you like help paying for your utility bills?	45	17
Would you like help regarding your personal or neighborhood safety?	29	11

*Answer options included the following: "doesn't apply," "never," "sometimes," "often," "always"; positive answers included "sometimes," "often,", and "always."

(Table 6). Additionally, in both models, private, self-pay/none and unknown insurances were all associated with lower odds of reporting social need than those with state/public insurance, suggesting that those with state/public insurance were more likely to report social need.

Table 3. Overlap and association of social risks and social needs.*

	Social risk, x	Overlapping social risks and social needs (xy)	Social need, y
Housing	61	32	40
Food	45	21	34
Transportation	24	16	29
Utility	11	6	45
Safety	45	18	29

*All associations between social need/risk in each domain were statistically significant with p <0.01.

DISCUSSION

In a sample of 269 patients in a large, urban, academic ED, we found a high prevalence of social risk (37%) and social need (31%), with over 50% of those who reported either social risk or social need screening positive in more than one domain. Additionally, although answers to social risk and social need questions were significantly associated among all domains, the overlap was incomplete. This study employed an adaptation of a standardized screening tool spanning the five domains proposed by CMS[14] to screen for social risk, with the addition of social need questions. Prior studies have either focused on one social risk or need[12] or have identified a heterogeneous set of social risks or social needs specific to their study populations.[7,13,19]

Attempts to address these SDoH have included the creation of an ED-based help desk staffed by volunteers to help with patient navigation,[13] the development of coordinated care models,[20] partnership with community resources,[21] and intervention programs targeting specific SDoH, such as interpersonal safety.[22] However, understanding the co-prevalence of social risk and social need across multiple domains is important, particularly when designing interventions, as social needs in one domain may directly affect those in other domains. An intervention that targets social need in one domain without considering the patient's needs across other domains may prove ineffective. For example, a program that addresses food insecurity by providing canned foods requiring reheating would be of limited benefit to a homeless individual (one with housing instability) who has no means to easily store or cook the food. Thus, screening across multiple domains provides a more comprehensive picture of an individual's needs, such that each need can be identified and addressed with appropriate interventions. The optimal resource-linkage strategies are less clear and outside the scope of this paper; however, ideally they would be comprehensive and brief to ensure scalability.

This study also enabled the multi-domain direct comparison of social risk vs social need with two separate sets of questions. A prior study in pediatric outpatient clinics found

Table 4. Association of demographic variables with social risk and social need.

	Social risk			Social need		
	No	Yes†	P-value	No	Yes†	P-value
Respondent			0.55			0.83
Patient	149 (88)	91 (91)		163 (89)	75 (90)	
Guardian	20 (12)	9 (9)		21 (11)	8 (10)	
Language			0.83			0.005
English	153 (91)	92 (92)		174 (95)	69 (83)	
Spanish	16 (9)	8 (8)		10 (5)	14 (17)	
Race/ethnicity			0.41			0.003
Non-Hispanic White	100 (59)	55 (55)		115 (63)	39 (47)	
Non-Hispanic Black	13 (8)	14 (14)		11 (6)	16 (19)	
Other	17 (10)	8 (8)		19 (10)	5 (6)	
Hispanic	39 (23)	23 (23)		39 (21)	23 (28)	
Gender			0.57			0.86
Male	85 (50)	57 (57)		98 (53)	43 (52)	
Female	83 (49)	43 (43)		85 (46)	40 (48)	
Other	1 (1)	0 (0)		1 (1)	0	
Insurance			0.10			< 0.001
State/public	58 (34)	50 (50)		50 (27)	58 (70)	
Private	84 (50)	38 (38)		104 (57)	16 (19)	
Self-pay/none	9 (5)	4 (4)		11 (6)	2 (2)	
Unknown	18 (11)	8 (8)		19 (10)	7 (8)	
Education			0.01			< 0.001
< 8th grade	10 (6)	12 (12)		10 (5)	12 (14)	
High School	28 (17)	29 (29)		30 (16)	27 (33)	
Some college/ finished college/ graduate degree	131 (77)	59 (59)		144 (78)	44 (53)	
Health literacy*			0.50			0.11
Extremely/quite a bit	144 (85)	82 (82)		159 (86)	65 (78)	
Somewhat/a little bit/not at all	25 (15)	18 (18)		25 (14)	18 (22)	

*As assessed with the question, "How confident are you filling out medical forms by yourself?"
†"Yes" corresponds to screening positive for at least one social risk or need.

limited overlap between screening positive for food insecurity and desiring referrals to food resources.[12] Our study extends these results to adult and pediatric patients in the ED—screening individuals who may not otherwise have access to outpatient services—demonstrating incomplete overlap across multiple domains. The implications of this incomplete overlap are important to consider in designing interventions to improve a patient's SDoH. By way of illustration, it may be that an individual who frequently has an insecure food supply is adequately connected to existing resources and does not need further support at the present time (social risk without social need). Similarly, another individual may in the short term have a stable housing situation, while simultaneously knowing that a future event (eg, rent increase at lease renewal) will lead to a more precarious position; they may thus need additional housing resources (social need without social risk).

Furthermore, this study exposed notable differences among patient factors associated with screening results for

Table 5. Multivariable logistic regression models assessing associations between social risk and demographic variables (n = 100).

	Model 1A OR (95% CI)	Model 1B OR (95% CI)
Gender		
Male	1.00	1.00
Female	0.82 (0.49-1.39)	0.74 (0.44-1.24)
Race/ethnicity		
Non-Hispanic White	1.00	1.00
Non-Hispanic Black	1.78 (0.75-4.20)	1.81 (0.78-4.21)
Other	1.04 (0.41-2.63)	0.96 (0.38-2.43)
Hispanic	1.14 (0.53-2.45)	1.19 (0.56-2.51)
Language		
English	1.00	1.00
Spanish	0.49 (0.16-1.52)	0.65 (0.21-1.96)
Education		
< 8th grade or high school	1.00	--
Some college/finished college/graduate degree	0.44 (0.24-0.80)	--
Health literacy		
Extremely/quite a bit	--	1.00
Somewhat/a little bit/not at all	--	1.13 (0.56-2.29)
Insurance		
State/public	1.00	1.00
Private	0.61 (0.34-1.09)	0.50 (0.29-0.88)
Self-pay/none	0.55 (0.15-2.01)	0.50 (0.14-1.75)
Unknown	0.52 (0.20-1.34)	0.51 (0.20-1.29)

OR, odds ratio; *CI*, confidence interval.

social risk vs social need. For example, language, race/ethnicity, and insurance status were significantly associated with social need, but not social risk. These results have several implications. First, directly soliciting social needs as opposed to social risk may be more sensitive for particular populations. Different groups may be more or less comfortable asking for or accepting support. Thus, programs focused only on social risk screening may undercount the social needs of their patient population and subsequently miss important opportunities for intervention. Second, given the time constraints of the ED, it may be preferable to screen for social need over social risk, given that doing so inherently allows patients to express their priorities. The utility of social risk screening may be primarily in predicting patients' future healthcare utilization[8,9] and understanding underlying population-level risk, rather than identifying individual patients who would be willing to receive social assistance.

Additionally, the significant association of language, race/ethnicity, education, and insurance status with the presence of social needs emphasizes the importance of screening in multiple languages, with program and referral materials that are accessible to patients across a broad range of educational attainment and health literacy. Furthermore, the high rate of co-prevalence of social risk and social need across domains suggests that screening should target multiple domains, in addition to assessing both social risk and social need. In our study, the brevity of the screening process allowed it to be accomplished during the ED visit without significant disruption in care—suggesting it may be performed at time of registration or in the waiting room, with few additional resources required. To minimize the personnel required for screening, electronic screening may be considered for future studies.

LIMITATIONS

Our study has several limitations. First, the sample size was relatively small, which could lead to the under-detection of social risk and social need, as well as their associated demographic variables. Additionally, although the sampling strategy was carefully balanced across days of the week and times of day, the study captured 269 (56%) patients who were eligible to participate, leaving a significant proportion of patients – 214 (44%) – who were eligible but were unable

Table 6. Multivariable logistic regression models assessing associations between social need and demographic variables (n=83).

	Model 2A OR (95% CI)	Model 2B OR (95% CI)
Gender		
Male	1.00	1.00
Female	1.04 (0.56-1.91)	0.97 (0.53-1.77)
Race/ethnicity		
Non-Hispanic White	1.00	1.00
Non-Hispanic Black	4.96 (1.88-13.11)	5.00 (1.91-13.12)
Other	1.31 (0.41-4.17)	1.20 (0.37-3.86)
Hispanic	0.82 (0.32-2.05)	0.88 (0.35-2.16)
Language		
English	1.00	1.00
Spanish	3.57 (1.01-12.57)	4.07 (1.17-14.10)
Education		
< 8th grade or high school	1.00	--
Some college/finished college/graduate degree	0.52 (0.27-1.02)	--
Health literacy		
Extremely/quite a bit	--	1.00
Somewhat/a little bit/not at all	--	1.32 (0.60-2.94)
Insurance		
State/public	1.00	1.00
Private	0.15 (0.07-0.30)	0.13 (0.07-0.26)
Self-pay/none	0.11 (0.02-0.59)	0.10 (0.02-0.53)
Unknown	0.33 (0.12-0.90)	0.34 (0.13-0.92)

OR, odds ratio; *CI*, confidence interval.

or did not consent to being screened. Although this raises the potential for sampling bias, it also likely represents the "real-life" population of patients who would be screened in the ED, as patients who are disinterested, in significant pain, or undergoing necessary diagnostic studies would also be unlikely to respond to screening by their ED providers. Nevertheless, for future studies there may be opportunities to increase enrollment by providing incentives to participate, or enrolling patients later in their clinical course. Such studies would clarify the impact of non-participation—both in research and, presumably, future clinical screening—on the observed prevalence of social risk and social need.

Future studies might also consider temporality and its effects on social risk and social need, ie, patients presenting at the beginning of the month may have different needs than those presenting at the end of the month. Similarly, patients presenting during the summer months may have different needs than those presenting during the winter months. One study illustrating the former concept demonstrated that low-income individuals were more likely to report to the ED for hypoglycemia at the end of the month, as opposed to the beginning of the month.[23]

With regard to external validity, this study recruited participants from a large, urban, academic ED in the US. The prevalence of social risk and social need was thus specific to this population. The generalizability to hospitals serving different (eg, more rural, racially diverse, or socioeconomically disadvantaged) populations is limited. However, studies suggest that social risk and social need are widely prevalent in EDs across the country.[9,24,25,26]

Lastly, the topics broached in the patient interviews related to social risk and social need are considered sensitive and are often kept private. As a result, participants may not always disclose accurate information, which may lead to the under-detection of social risk/need. Ultimately, however, the determination of social risk and social need is dependent on self-report, as there is no gold standard for assessing true prevalence.[12] Furthermore, in this study we asked first about social risk and then social need. To our knowledge, whether the order in which these questions are asked affects patient response is not known and merits further study.

CONCLUSION

In summary, these data demonstrate that multi-domain, as opposed to single-domain, screening is necessary, given the high rate of co-prevalence of social risk and social need. Although there is significant overlap among those who screen positive for social risk vs social needs, there remain notable differences that merit further consideration when optimizing screening tools and designing interventions. These data also suggest that strategies aiming to identify and address social risk and social need should be accessible and easy to understand for those with limited education or health literacy. Future research questions include how best to conduct screening within the ED (eg, in-person vs electronic), how to successfully connect patients to social services, and whether these linkage strategies should be employed during the ED visit or after discharge.

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User Characteristics of a Low-Acuity Emergency Department Alternative for Low-Income Patients

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Introduction: Emergency department (ED) use for healthcare that can be treated elsewhere is costly to the healthcare system. However, convenience settings such as urgent care centers (UCC) are generally inaccessible to low-income patients. Housing an UCC within a federally qualified health center (FQHC UCC) provides an accessible convenience setting for low-income patients. In 2014 a FQHC UCC opened two blocks from an ED in the same health system. Our goal was to compare characteristics, access to care, and utilization preferences for FQHC UCC and low-acuity ED patients through retrospective chart review and prospective surveying.

Methods: We completed a retrospective chart review of all patients from March 1, 2018–March 1, 2019, and compared characteristics of low-acuity ED patients (N = 3,911) and FQHC UCC patients (N = 12,571). We also surveyed FQHC UCC patients (N = 201) and low-acuity ED patients (N = 198) from January–July 2019.

Results: Half of FQHC UCC patients had private insurance. Of ED patients, 29% were aware of the FQHC UCC. Both groups had similar rates of primary care providers. The most common reason for choosing the ED was perceived severity, and for choosing a FQHC UCC was speed.

Conclusion: These findings show similarities and differences between these two patient populations. Future research is needed to determine utilization patterns and in-depth reasons behind them. Interventions that help patients decide where to go for low-acuity care may create more utilization efficiency. [West J Emerg Med. 2020;21(6)162-171.]

INTRODUCTION

Emergency department (ED) visits in the United States increased by 14.8% from 2006 to 2014,[1] with nearly 146 million total in 2016.[2] Simultaneously, the proportion of ED visits that resulted in admissions decreased for all age groups.[3] Because ED crowding can lead to poor patient outcomes,[4-8] there is increased interest in diverting low-acuity patients to alternative sites for care. Urgent care centers (UCC) are one type of alternative site, or "convenience setting," and tend to have availability beyond usual office hours and a broader scope of services than most primary care offices.[9] UCCs also tend to have much lower average costs ($168)[10] than the ED ($978-$2,259).[10,11] However, these convenience settings are a topic of debate regarding their ability to replace EDs for care.

One study found that 13.7-27.1% of all ED visits could be treated at an UCC or retail clinic, which would result in a cost savings of approximately $4.4 billion per year.[12] Others argue that patients who are more likely to use the ED for low-acuity conditions have little access to other types of care, including convenience settings.[13] Convenience settings generally do not

accept Medicaid[13] and tend to be located in affluent areas where Medicaid patients do not live.[14] Based on a national survey of 436 UCCs, 51% of patients had private insurance, 15% had Medicare, 12% were uninsured, and 10% had Medicaid.[9]

Comparatively, federally qualified health centers (FQHC) are much more accessible to a low-income patient population. FQHCs provide services regardless of patients' ability to pay, charge for services on a sliding fee scale, and are located in underserved areas.[15] Thus, the national FQHC patient/payor mix differs widely from the UCC payor mix, with 18% private insurance, 13% with Medicare or Medicare and Medicaid, 23% uninsured, and 49% with Medicaid.[16] Housing an UCC within a FQHC allows for more accessibility for low-income patients than a freestanding UCC. This study compares characteristics of low-acuity ED and FQHC UCC patients. We also explored patient reasons and preferences behind their use of one site over the other. Housing an UCC within a FQHC is a unique concept, and as such is a largely unexplored topic.

Population Health Research Capsule

What do we already know about this issue?
Emergency department (ED) use for care that can be treated elsewhere is costly, but settings such as urgent care centers (UCC) are generally inaccessible to low-income patients.

What was the research question?
What are the characteristics of federally qualified health center (FQHC) UCC patients compared to low-acuity ED patients?

What was the major finding of the study?
Half of FQHC UCC patients had private insurance. Groups had similar access to care. Most common reason for ED use was severity and for FQHC UCC speed.

How does this improve population health?
Helping patients decide where to seek low-acuity care may create more use efficiency, especially for the low-income patient population that FQHCs support.

METHODS

Study Setting

The University of Illinois (UI) Hospital ED is a 24-hour, state-funded academic facility with 31 licensed treatment spaces, within the 495-bed UI Hospital. In 2018 there were 48,835 ED visits, of which 18% were pediatric. Of total patients seen 1% were uninsured, 23% had Medicare, 43% had Medicaid, 32% had private insurance, and 1% had other insurance. The ED is not a trauma center and has a four-bed fast track area for low-acuity conditions that is staffed by nurse practitioners. Patients are triaged by a nurse using the Emergency Severity Index (ESI) on a scale of 1 to 5, which takes into account acuity and resource needs, and prioritizes incoming patients who need to be seen immediately.[17] One is resuscitation (most urgent), 2 is emergent, 3 is urgent, 4 is less urgent, and 5 is non-urgent.[17]

Mile Square FQHC, which is part of the same health system as the ED,[18] has predominantly minority patients with public or no insurance, many of whose incomes are below the federal poverty level.[18] In addition to clinic services, the main location of the FQHC – approximately two blocks from the ED – houses an UCC, which opened in March 2014. The FQHC UCC is advertised as "Less wait. Less cost. Many of the same services as the E.R."[19] It treats injuries that require radiographs, simple lacerations, cold/flu symptoms, and other minor illnesses and injuries, and is open beyond normal business hours, including on weekends and holidays.[19] The FQHC UCC is staffed by physicians and midlevel providers; it has 10 rooms with two additional rooms for triage.

The FQHC UCC has seen more patients each year, with 7881 in 2014 and 16,608 in 2018. From 2014 to 2018 the proportion of ED visits categorized as ESI 2 (second highest severity) increased from 12.0% to 17.3%, ESI 4 (second lowest severity) visits decreased from 32.0% to 25.4%, and hospitalizations from the ED increased from 26.5% to 28.5%. The State of Illinois expanded Medicaid in January 2014, so the number of people with insurance also increased during this time.

There are similarities in access for both sites. Since they are two blocks apart, there are no geographic differences between the site locations. Additionally, because both sites are within the same healthcare enterprise, patients who prefer the continuity of being seen within the same system can be seen at either site, and providers can access patient health information across both sites. Because it is within a FQHC, the FQHC UCC cares for patients regardless of insurance status or ability to pay. As a result, the FQHC UCC may be more substitutive of low-acuity ED visits than other UCCs for low-income patients.

Procedure and Participants

To study the entire patient population for each site, we accessed electronic health record (EHR) data (Cerner Corporation, Kansas City, MO) for visits from March 1, 2018–March 1, 2019, for two groups of adult patients (18 years and older): 1) ED patients with ESI of 4 or 5; and 2) FQHC UCC patients. We only included ED patients who arrived when the FQHC UCC was open. From March 1–December 31, 2018, the FQHC UCC was open from 12–8 PM on weekdays and 10 AM–6 PM on weekends and holidays. These hours changed on January 1, 2019, to 8 AM–7 PM on weekdays and 10 AM–5:30 PM on weekends and holidays.

To obtain more detailed information from FQHC UCC and low-acuity ED patients, we also conducted a survey at each site about demographics, the current day's visit, access to care, healthcare utilization and satisfaction, and reasons for choosing one site over the other for current day's care. Survey questions were pilot tested to ensure patient comprehension and appropriate survey length.

At both locations, patients were approached between 9 AM–5 PM, Monday–Friday, and surveys were available in English and Spanish. Research assistants (RA) confirmed eligibility by reviewing the patient list on FirstNet Organizer, the ED patient board, and with some provider assistance. Eligible ED patients were adults with ESI of 4 or 5, and eligible FQHC UCC patients were all adults. After approaching the potential participant using a recruitment script, the RA gave the ED patients five minutes to think about whether they wanted to participate and then returned. (The five-minute wait was not required due to the fast pace of the UCC).

After obtaining written consent, the RA read the survey questions aloud and recorded responses, in order to avoid literacy barriers. The surveys took approximately 10 minutes to complete. Upon completion, surveys were entered in REDCap (Center for Clinical and Translational Science (CCTS) UL1TR002003) using double-data entry. To determine whether there were significant differences between patients who presented to the ED with low-acuity needs and patients who presented to the FQHC UCC, we ran t-tests for continuous variables and chi-square and Fisher's exact tests were run for categorical variables. We completed all data cleaning and analysis using Stata Version SE 15 (StataCorp LP, College Station, TX). The study was approved by the Institutional Review Board of the University of Illinois at Chicago.

RESULTS

Chart Review Results

Table 1 shows a comparison of demographic characteristics between FQHC UCC patients and low-acuity ED patients for the EHR review over the period of March 1, 2018–March 1, 2019. The proportions of female, White, and private insurance patients were significantly higher for the FQHC UCC. The ED had significantly higher proportions of Medicaid, Medicare, uninsured, and other insurance patients compared to the FQHC UCC. More ED patients than FQHC UCC patients were seen outside of regular business hours.

Survey Results

Demographics

Looking across site for survey participants, FQHC UCC patients tended to have more education; the site had higher proportions of patients with full-time employment, and lower proportions of students and unemployed patients than those in the ED. There were more FQHC UCC survey participants who lived in the immediate ZIP codes of the ED and FQHC UCC, but not at a significant difference than survey participants in the ED.

Current Day's Visit

Table 1 also shows that more ED patients reported excellent health (17.7%) than FQHC UCC patients (4.5%). A small proportion of patients (4.6%) arrived by ambulance, whereas that mode of arrival was not available for FQHC UCC patients. More ED patients arrived by public transportation compared to FQHC UCC patients (24.2% and 18.4%, respectively), and more ED patients than FQHC UCC patients received a ride from family/friends (31.3% and 12.4%, respectively). FQHC UCC patients had more than double the proportion of patients who drove themselves in their own vehicles (53.2%), compared to ED patients (25.8%).

Access to Care/Healthcare Utilization and Satisfaction

Table 2 shows that patients at both sites had similar responses to how often it was easy to get care, tests, or treatment in the prior six months, with the majority (68.2% for ED and 64.7% for FQHC UCC) responding with "always." For patients who did not respond "always," the most common reason for both groups to not be able to get care was because the wait took too long (32.8% for ED, and 50.0% for FQHC UCC). While not significant, there were higher proportions of ED than FQHC UCC patients with socioeconomic-related issues such as inability to get care because they could not afford it, their health plan would not cover it, they could not get transportation to the doctor's office, or could not take time off/get child care.

When asked about what kind of place you go to most often for your medical care, a much higher proportion of ED patients selected the ED (18.9%) than FQHC UCC patients (3.5%), and a higher proportion of FQHC UCC patients selected "other place" (19.4%) compared to ED patients (0.0%). Presumably, this "other place" is the FQHC UCC, although it was not explicitly asked in the survey.

There was not a significant difference between the percent of patients in each group with a primary care provider (PCP), the length of time with their current PCP, and their satisfaction with their PCP. Approximately 35% of ED patients surveyed had ever been to a FQHC. ED patients who had used a FQHC before had significantly more FQHC visits in the prior year (2.6) than FQHC UCC patients (1.4) with no significant difference in satisfaction. About 36% of ED patients said they were not sure how available FQHCs were in their neighborhood, and 18.3% said that they were not at all available.

Forty-two percent of low-acuity ED patients had been to an UCC before. Of those patients who had been to an UCC, ED patients had used one an average of 1.3 times in the prior year, which was significantly less than FQHC UCC patients who had used one 2.4 times. The mean satisfaction rating of UCCs for ED patients was lower (7.9) than for FQHC UCC patients (9.0). Half of low-acuity ED patients said UCCs were not at all available in their neighborhood or they were unsure about availability, and 18% said they were very available. For FQHC UCC patients, 40% said they were unsure or not at all available, and 41% said they were very available. For ED utilization and

Table 1. Emergency department patients with Emergency Severity Index (ESI) 4 or 5 survey respondents, and federally qualified health center urgent care center patient survey respondents: demographics and the current day's visit.

	Chart review findings			Survey findings		
	ED (N=3,911)	FQHC UCC (N=12,571)	P-value	ED (N=198)	FQHC UCC (N=201)	P-value
Age, mean (SD)	38.0 (15.8)	39.0 (14.3)	0.001	38.7 (15.9)	38.7 (14.2)	0.984
% Female	60.2	71.0	<0.001	66.0	69.7	0.434
Race[a]						
% White	9.4	12.3	<0.001	7.9	20.9	0.002
% Black	58.9	57.2		68.6	54.7	
% Asian	2.8	3.0		3.1	4.0	
% Other	29.0	27.6		20.4	20.4	
Ethnicity						
% Hispanic	24.0	24.3	0.706	20.2	22.9	0.515
Insurance type[a]						
% Medicaid	45.1	36.8	<0.001	40.8	35.8	0.368
% Medicare	6.0	4.6		9.2	6.5	
% Uninsured	22.0	12.6		9.2	8.0	
% Private insurance	24.1	45.2		44.9	52.7	
% Other[b]	2.9	0.7		0.0	0.0	
% Patients living in ZIP codes that encompass the medical campus (ED and FQHC UCC) (60608 & 60612)	17.8	20.3	0.001	17.2	22.4	0.602
% Patients seen on weekend	26.0	19.9	<0.001			
% Patients seen during business hours (8 AM-5 PM, Monday-Friday)	51.0	63.0	<0.001			
Employment status[a]						
% Full time				41.9	54.7	0.030
% Part time				15.2	14.4	
% Unemployed				24.8	18.4	
% Student				13.1	5.0	
% Other[c]				7.1	9.0	
Highest level of education completed						
% 8th grade or less				1.5	1.0	0.001
% Some high school, but did not graduate				11.6	6.5	
% High school graduate or GED				30.8	23.9	
% Some college or 2-year degree or trade school grad				37.4	30.9	
% 4-year college graduate				12.1	19.4	
% More than 4-year college graduate				6.6	18.4	
Self-reported health status						
% Excellent				17.7	4.5	0.001
% Very good				24.2	31.0	
% Good				34.3	36.5	
% Fair				19.7	23.5	
% Poor				4.0	4.5	

Table 1. Continued.

	Chart review findings			Survey findings		
	ED (N=3,911)	FQHC UCC (N=12,571)	P-value	ED (N=198)	FQHC UCC (N=201)	P-value
Mode of transportation for the current day's health visit[d]						
% Ambulance				4.6	0.0	<0.001
% Public transportation				24.2	18.4	
% Taxi or ride share				7.6	8.5	
% Drove self in own vehicle				25.8	53.2	
% Received ride from family/friend				31.3	12.4	
% Medicab				0.5	0.0	
% Walked				6.1	7.5	

[a]More than one response could be selected.
[b]Other insurance includes those that did not fit in other categories, such as Worker's Compensation and Civilian Health and Medical Program of the Uniformed Services (CHAMPUS).
[c]Includes self-employed (n=4), in between jobs (n=1), disability (n=9) , retired (n=17), and other not specified (n=1).
[d] "% Ambulance" has been included in the table but was excluded from statistical analysis between the two groups because FQHC UCC patients do not have the ability to arrive by ambulance.
Note: For the chart review, analysis was conducted at the visit level, so it was possible for the same patient to be included more than once if they presented multiple times or would be included in both groups if they were seen at both sites.
ED, emergency department; *FQHC UCC*, federally qualified health center urgent care center; *GED*, General Educational Development.

satisfaction, the low-acuity ED group had significantly more ED visits on average in the prior year (2.5), compared to the FQHC UCC group (1.1). Of those who used the ED, the low-acuity ED group had higher satisfaction with their experience (8.4) than the FQHC UCC group (6.0).

Unique questions for ED patients.

Table 3 shows the questions that were only asked of the low-acuity ED patients. The top three reasons for choosing the ED were the following: problem was too serious for the doctor's office (44%); doctor's office/clinic was open but could not get an appointment (15%); and patient gets most care from the ED (8%). Approximately 17% had called their PCP prior to coming to the ED. Twenty-nine percent knew that there was an UCC at the FQHC, and 21% had ever used the FQHC UCC.

Unique Questions For FQHC UCC Patients

Table 4 shows questions that were only asked of the FQHC UCC patients. The top three reasons for choosing the FQHC UCC instead of the ED were the following: faster/more efficient/less wait (36%); perceived their medical issue to be less urgent (31%); and less cost (12%). When asked how they heard about FQHC UCC, the top three places were from a medical professional (doctor, clinic, or hospital) (33%), family/relatives (21%), and the Internet (15%).

DISCUSSION

There were several interesting findings from this study. The chart review and survey showed that approximately half of FQHC UCC patients had private insurance, and the FQHC UCC had lower proportions of Medicaid and uninsured patients than the ED. This was surprising, given that the private insurance population has more available alternatives to the ED than Medicaid and uninsured patients. Since a FQHC UCC is unique, Medicaid and uninsured patients may be hesitant to visit the FQHC UCC if they know that they would have to pay higher costs at freestanding UCCs or be unaware of how UCCs work if they have never used one before. Despite these differences, self-reported access to care was similar across both sites with both groups having similar proportions of patients with PCPs, and similar proportions of patients who "usually" or "always" got the care or treatment they needed.

A higher proportion of ED patients said that UCCs were not available or they were unsure if they were available in their neighborhood compared to FQHC UCC patients, and more FQHC UCC patients said that UCCs were very available in their neighborhood than ED patients. It is unclear whether ED patients truly have fewer UCCs in their neighborhood, or whether they were unaware of UCCs in their neighborhood because they were unsure of their purpose or because they did not see them as a site of care that was accessible for them. Likewise, only one-third of ED survey participants had been to a FQHC (despite one being two blocks from the ED where they presented for care), and about one-quarter were aware of the FQHC UCC. These findings suggest that basic education for ED patients with low-acuity conditions on the purpose and benefits of FQHCs and UCCs might be an appropriate first step in having patients understand their ability to use such healthcare sites. Additionally, future work could compare the payor mix of the FQHC UCC patients and other nearby freestanding UCCs.

Table 2. Survey findings: Emergency department patients with Emergency Severity Index 4 or 5 survey respondents and federally qualified health center urgent care center patient survey respondents–access to care/healthcare utilization and satisfaction.

	ED (N=198)	FQHC UCC (N=201)	P-value
In the last 6 months, how often was it easy to get care, test, or treatment you needed?[a]			
% Never	3.0	3.0	0.791
% Sometimes	14.1	13.9	
% Usually	14.7	18.4	
% Always	68.2	64.7	
(If Never, Sometimes, or Usually:) What is the main reason you were not able to get medical care, tests, or treatments that you or a doctor believed necessary?[a] (ED n=58, FQHC UCC n=62)			
% Couldn't afford	12.1	9.7	0.481
% My health plan wouldn't approve/ cover/pay for care	19.0	12.9	
% Doctor refused to accept my insurance	8.6	6.5	
% Doctor doesn't speak my language	0.0	0.0	
% Couldn't get transportation to doctor's office	6.9	1.6	
% Couldn't take time off work/get child care	19.0	16.1	
% Didn't know where to go to get care	1.7	3.2	
% The wait took too long	32.8	50.0	
What kind of place do you go to most often for your medical care?[a]			
% Clinic or health center	42.4	47.8	<0.001
% Doctor's office or HMO	32.1	26.9	
% Hospital ED	18.9	3.5	
% Hospital outpatient department	5.6	1.5	
% Other place	0.0	19.4	
% Don't go to one place most often	0.0	1.0	
% There is no place visited often for medical care	1.0	0.0	
Primary care provider (PCP)			
% with a PCP	75.8	71.6	0.681
Of those with a PCP, length of time with current PCP (in years)	26.4 (13.2)	25.6 (1.1)	0.632
Of those with a PCP, satisfaction with PCP (1=least, 10=best)	8.7 (2.2)	8.6 (1.8)	0.786
Federally qualified health center (FQHC)			
% who have ever been to a FQHC	34.9	N/A	N/A
Frequency of usage in past year, mean (SD)	2.6 (4.7)	1.4 (2.2)	0.003
Satisfaction with FQHC experience (1=least, 10=best)	8.1 (2.8)	8.7 (1.6)	0.111
How available are FQHCs in your neighborhood?			
% Not at all available	18.3	N/A	N/A
% Rarely available	6.6		
% Somewhat available	19.8		
% Very available	19.8		
% Unsure	35.5		
Urgent care center			
% who have ever been to an urgent care center	41.9	N/A	N/A
Frequency of usage in the past year	1.3 (1.4)	2.4 (2.5)	<0.001
Satisfaction with urgent care center experience (1=least, 10-=best)	7.9 (2.5)	9.0 (1.7)	<0.001

Table 2. Continued.

	ED (N=198)	FQHC UCC (N=201)	P-value
How available are urgent care centers in your neighborhood?			
% Not at all available	19.9	15.9	<0.001
% Rarely available	10.2	4.0	
% Somewhat available	21.9	14.9	
% Very available	17.9	41.3	
% Unsure	30.1	23.9	
Emergency department			
Frequency of usage in the past year	2.5 (2.3)	1.1 (2.5)	<0.001
Of those who used the ED, satisfaction with ED experience (1=least, 10=best)	8.4 (2.2)	6.0 (3.2)	<0.001

[a]Question Source: Nationwide Adult Medicaid Consumer Assessment of Healthcare Providers and Systems questionnaire, Medicaid.gov. Centers for Medicare & Medicaid Services. https://www.medicaid.gov/medicaid/quality-of-care/performance-measurement/adult-cahps/index.html
ED, emergency department; *FQHC UCC*, federally qualified health center urgent care center; *HMO*, health maintenance organization; *SD*, standard deviation.

Table 3. Unique questions for emergency department patients with Emergency Severity Index score 4 or 5 survey respondents (N = 198).

Main reason for emergency department visit today	
% Problem was too serious for the doctor's office	43.9
% Doctor's office/clinic was open, but could not get an appointment	15.2
% Get most of my care at the emergency department	8.1
% Didn't have a doctor	6.6
% Doctor's office/clinic was not open	5.6
% Other (n=41)	20.7
Told to go or brought to ED by medical professional (n=12) ED is more efficient/quick than other healthcare options (n=8) Preference for ED over other healthcare providers (n=4) Location/convenience (n=4) Connection to the hospital (self or family member is employee or existing patient) (n=3) Went to ED without thinking about other options (n=3) Lack of experience with the healthcare system (n=2) Needed x-ray (n=2) Wanted to be extra careful (n=1) No transportation to doctor's office (n=1) Insurance card expired so went to ED (n=1)	
% who called PCP prior to coming to the ED	16.7
% who know that there is an urgent care center in the FQHC	28.8
% who have used the urgent care center at the FQHC	21.2

ED, emergency department; *PCP*, primary care provider; *FQHC*, federally qualified health center.

Research has shown that low-income patients tend to prefer hospital care over primary care,[20] which may help explain the larger proportion of Medicaid patients in the ED. In our survey, we found that satisfaction with the ED was significantly higher for ED patients than FQHC UCC patients, and satisfaction with an UCC (for those who have used them previously) was significantly higher for FQHC UCC survey participants than ED survey participants. Also, it may be beneficial to create future interventions that share the positive reasons that FQHC UCC patients gave for using the FQHC UCC with ED low-acuity patients.

This study is a first step in exploring utilization of a FQHC UCC compared to low-acuity ED visits at a nearby ED. Future work should look at changes in utilization patterns for low-acuity conditions when the FQHC UCC opened in 2014, and determining characteristics of patients who shifted their low-

acuity care from the ED to the FQHC UCC. Prior literature has suggested a shift away from EDs for certain low-acuity conditions when new UCCs open nearby for non-Medicaid patients, as Medicaid patients do not have access to UCCs.[21] Another study has shown that after an ED patient had his or her first visit to an UCC, his or her non-emergent ED use decreased by 48%.[22] Hence, we would want to explore whether these trends are present with the FQHC UCC, which is more accessible to Medicaid and uninsured patients than regular UCCs.

Our findings concur with qualitative interviews where Medicaid enrollees presented to the ED for non-urgent needs because they believed their condition was too serious for the PCP and that the ED provided more comprehensive services.[23] Authors of this study stressed the importance of improving patients' understanding of where to seek care, and look beyond logistical and access-related concerns.[23] These conclusions support our study, where logistically and geographically, the ED and FQHC UCC were very similar, and both groups had similar access to care availability. Furthermore, the fact that our study was a brief survey only begins to touch on patient barriers and facilitators to using the FQHC UCC for low-acuity conditions, as well as decision-making and preferences. Future in-depth qualitative work with low-acuity ED and FQHC UCC patients can tell a more complete story.

LIMITATIONS

This study had several limitations. First, our eligibility criteria for low-acuity ED patients was based on ESI, which can be subjective, as it is determined by humans and is prone to human error and opinions. However, it was our best proxy for the patient's acuity level in the ED. There are several ways to look at low-acuity ED visits, and future research may incorporate additional methods, such as the NYU Algorithm, which incorporates the probability that given the ED patient's diagnosis, he or she could have been seen elsewhere.[24] Second, the proportions were very similar between survey participants and all low-acuity ED and FQHC UCC patients (Table 1), which suggests that the survey sample was representative of these patient populations. However, the one area where proportions were different was insurance type. There was a much higher proportion of private insurance patients for survey participants in the ED, compared to the chart review of all low-acuity ED patients. Likewise, being uninsured was much lower for ED survey participants than for all low-acuity ED visits in the chart review. As a result, patients with private insurance may have been more likely to complete the survey than uninsured patients and/or there may have been more private insurance patients than uninsured patients in the ED during regular business hours, when the survey was being administered. This is a limitation of the study and our results might not fully represent the experiences of all low-acuity ED patients. Additionally, the survey did not ask about whether FQHC UCC patients knew about the nearby ED, which would have helped to determine the degree of overlap between the

Table 4. Unique questions for federally qualified health center urgent care center patient survey respondents (N = 201).

Why did you decide to use Mile Square instead of the ED today? *(Multiple reasons could be mentioned by one person) Top 5 Reasons Mentioned:*	
Faster/more efficient/less wait (n=72) Less urgent issue (n=63) Cost/cheaper (n=25) Referred by medical professional (n=13) Familiarity/comes to this FQHC regularly/been to this FQHC urgent care before (n=12)	
How did you hear about the FQHC urgent care center?	
% Family/relatives	21.2
% Online website	15.3
% Friend	5.9
% Other	57.6
Doctor/clinic/hospital (n=66) Drove by/saw it/lives close by (n=15) Work (n=10) Insurance (n=10) Has been a patient at this FQHC before (n=10) "Always knew" (n=2) General word of mouth (n=2) "Visiting" (n=1) "Myself" (n=1) Community based organization (n=1)	

ED, emergency department; *FQHC,* federally qualified health center.

two groups and general awareness of the ED. Lastly, the study only included one ED and one FQHC UCC. More work should be done in similar models to determine whether these findings persist with additional sites.

CONCLUSION

While these findings provide a starting point for similarities and differences between these two patient groups, future research is needed to determine utilization patterns for these patients, as well as more in-depth reasons behind these patterns. The concept of a federally qualified health center urgent care center is new and lacks research. Expansion of the model may provide more accessible and cost-saving healthcare options for low-income patients.

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Point-of-care Ultrasound in Morbidity and Mortality Cases in Emergency Medicine: Who Benefits the Most?

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Introduction: Point-of-care ultrasound (POCUS) is an essential tool in the timely evaluation of an undifferentiated patient in the emergency department (ED). Our primary objective in this study was to determine the perceived impact of POCUS in high-risk cases presented at emergency medicine (EM) morbidity and mortality (M&M) conferences. Additionally, we sought to identify in which types of patients POCUS might be most useful, and which POCUS applications were considered to be highest yield.

Methods: This was a retrospective survey of cases submitted to M&M at an EM residency program that spans two academic EDs, over one academic year. Postgraduate year 4 (PGY) residents who presented M&M cases at departmental sessions were surveyed on perceived impacts of POCUS on individual patient outcomes. We evaluated POCUS use and indications while the POCUS was used.

Results: Over the 12-month period, we reviewed 667 cases from 18 M&M sessions by 15 PGY-4 residents and a supervising EM attending physician who chairs the M&M committee. Of these cases, 75 were selected by the M&M committee for review and presentation. POCUS was used in 27% (20/75) of the cases and not used in 73% (55/75). In cases where POCUS was not used, retrospective review determined that if POCUS had been used it would have "likely prevented the M&M" in 45% (25/55). Of these 25 cases, the majority of POCUS applications that could have helped were cardiac (32%, 8/25) and lung (32%, 8/25) ultrasound. POCUS was felt to have greatest potential in identifying missed diagnoses (92%, 23/25), and decreasing the time to diagnosis (92%, 23/25). Patients with cardiopulmonary chief complaints and abnormal vital signs were most likely to benefit. There were seven cases (35%, 7/20, 95% CI 15-59%) in which POCUS was performed and thought to have possibly adversely affected the outcome of the M&M.

Conclusion: POCUS was felt to have the potential to reduce or prevent M&M in 45% of cases in which it was not used. Cardiac and lung POCUS were among the most useful applications, especially in patients with cardiopulmonary complaints and in those with abnormal vital signs. [West J Emerg Med. 2020;21(6)172-178.]

INTRODUCTION

Medical errors have been reported to be the third leading cause of death in the United States.[1] Specifically, diagnostic errors account for an estimated 40,000-80,000 annual deaths in this country.[2] In critical care patients this is further exemplified as one study showed that upwards of 10% of intensive care unit (ICU) patients had lethal misdiagnoses on autopsy.[3] Diagnostic errors are under-reported and underemphasized; this is an understudied area of patient-safety that can affect the well-being of providers involved with the errors.[4]

Point-of-care ultrasound (POCUS) is an essential tool in the timely evaluation of critically ill patients and those with undifferentiated diagnoses. For this reason, POCUS training is a growing part of medical education, particularly in emergency medicine (EM) where accreditation training requirements exist, and residents are required by the Accreditation Council for Graduate Medical Education to demonstrate POCUS competency.[4] Additionally, the American College of Emergency Physicians has released a policy statement including guidelines and recommendations for POCUS education for emergency physicians.[5] Successful implementation of POCUS requires emergency physicians to acquire and interpret images, as well as apply and integrate these interpretations into clinical practice.

There is an ever-growing body of literature describing the diagnostic utility of POCUS for specific diseases.[6-8] Further, there is extensive research describing how experienced practitioners can improve diagnostic certainty in undifferentiated hypotensive patients.[9] For example, in hypotensive trauma patients, a positive focused assessment with sonography in trauma (FAST) exam in the ED has shown to decrease time to the operating room and length of stay with very high specificity.[10] Also, POCUS evaluation of patients with acute dyspnea has shown to reduce diagnostic time with good concordance with admission diagnosis.[11] In the ED, POCUS plays an increasingly important role in a patient's ultimate timely diagnosis and thereby treatment.[6,10-12] This has led practitioners to believe that POCUS may improve patient outcomes.

Departmental morbidity and mortality (M&M) conferences are routinely held to investigate individual and systematic errors that contribute to preventable medical errors that lead to patient morbidity and mortality. M&M review has been used in the past to draw meaningful data about preventable deaths and trends in the care of these patients.[13] In this paper, we use similar methodology to review M&M cases for the purpose of assessing the impact that POCUS might have on patient outcomes.

Our primary goal was to determine the perceived role of POCUS on affecting clinical outcomes on M&M cases by performing a descriptive analysis of the use of POCUS in cases reviewed for M&M. We also sought to determine which POCUS applications and in which types of patients ultrasound had the most perceived value. Having this information could guide emergency physicians as to what POCUS to perform and in whom. Our goal was to improve patient care by sharing and examining our collective experiences in high-yield M&M cases for using POCUS. Despite recognition that clinical integration is essential, there is limited published data on actual patterns of usage of POCUS by emergency physicians. To our knowledge no study has examined the potential role of POCUS on cases reviewed in two emergency departments' (ED) M&M conferences.

Population Health Research Capsule

What do we already know about this issue?
Point-of-care ultrasound (POCUS) is an essential tool in the timely evaluation of an undifferentiated patient in the emergency department (ED).

What was the research question?
The objective was to determine the perceived impact of POCUS in high-risk cases presented at morbidity and mortality (M&M) conferences.

What was the major finding of the study?
POCUS has the potential to reduce or prevent M&M in 45% of cases in which it was not used.

How does this improve population health?
As diagnostic errors account for an estimated 40,000-80,000 annual deaths in the United States, POCUS may help reduce this within the ED.

METHODS

Study Setting and Population

This retrospective study was done at two large academic EDs with annual volumes of 120,000 and 70,000 patients. Both institutions have an emergency ultrasound (US) division, emergency US fellowship program, and share a four-year EM residency training program with 60 EM residents postgraduate years 1-4 (PGY). This study was reviewed by the institutional review board and determined to be exempt.

Selection of Participants

Cases were reviewed monthly in the departmental M&M conference as part of routine departmental quality assurance. PGY-4 EM residents prepared M&M cases for review with a faculty EM attending physician as part of this process, and not for research purposes. All PGY-4 EM residents were asked to participate in the study survey. Participation was voluntary. There were no exclusion criteria.

Study Design

All ED cases were subject to review from July 2018–June 2019. All cases that resulted in a death in the ED, all deaths within 24 hours of an ED encounter, and all upgrades to an ICU within 24 hours were automatically reviewed for possible clinical or system errors. In addition, any cases referred by nursing, ED providers, and providers from other departments were reviewed.

For each M&M session, a PGY-4 resident was provided a list of all cases for review over a designated time period. This resulted in approximately 60-75 cases over about a 40-day period. Each M&M conference was specific to one hospital. All information was obtained by retrospective chart review. After

reviewing each case, the PGY-4 resident submitted a summary of each case to a faculty mentor, an attending physician responsible for departmental M&M review. Together, the PGY-4 resident and attending physician identified all cases that were considered to have potential patient care concerns while in the ED. This review was done as routine departmental quality assurance and not for purposes of the study.

After all cases were reviewed, a study investigator surveyed the PGY-4 residents about all of the cases in which there were possible concerns about patient care as determined by the PGY-4 EM resident and an EM attending. The survey addressed questions regarding the use of POCUS in M&M cases. Specifically, the resident was asked:

- In cases when POCUS was performed, did POCUS contribute to the M&M?
- In cases when POCUS was not performed, would it likely have prevented the M&M if it had been done?
- If so, which application(s) would have helped, and how?

Residents were instructed that when assessing the potential of POCUS to prevent M&M, they should assume that POCUS would have been appropriately performed, interpreted, and integrated. In addition, we collected information regarding patients' initial chief complaints and initial triage vital signs. An US fellow and/or an US fellowship-trained EM attending administered the survey. Verbal consent was obtained for all participants. The PGY-4 resident was blinded to the purposes of the study. An EM attending with fellowship training in POCUS was then presented with the same cases. The attending, blinded to the resident's assessment, was then asked the same questions. Additionally, the attending was asked specifically if he or she would have performed a POCUS if presented with the same clinical case and timeline.

We collected and managed study data using REDCap (Vanderbilt University, Nashville, TN) electronic data capture tools hosted at Massachusetts General Hospital.[14,15] The same software stored and de-identified all demographic and clinical data obtained.

Data Analysis

All data obtained was de-identified, exported to, and analyzed in Microsoft Office 365 Excel (Microsoft Corporation, Redmond, WA). We used descriptive statistical analysis to compare the data. We calculated the overall percentage of cases where M&M may have been affected by POCUS, as assessed by a PGY-4 resident. We then performed subgroup analyses stratified by chief complaint, vital signs, type of POCUS, and how POCUS may have affected M&M. A kappa value was then calculated for interobserver agreement between the PGY-4 residents and the US EM attending. We calculated proportion confidence intervals (CI) of 95% using our sample sizes.

RESULTS

Between the two academic hospitals, there were a total of 18 M&M conferences (nine per each hospital) over the 12-month period. These were reviewed by 15 different PGY-4 residents; three residents reviewed cases for two different conferences. There was a 100% response rate among residents.

Of the 667 cases reviewed 75 cases were determined to have patient care concerns. POCUS was used in 27% (20/75, 95% CI, 17-38%) and not used in 73% (55/75, 95% CI, 62-83%) (Figure 1). In cases where POCUS was not used, retrospective review determined that if POCUS had been used it would have "likely

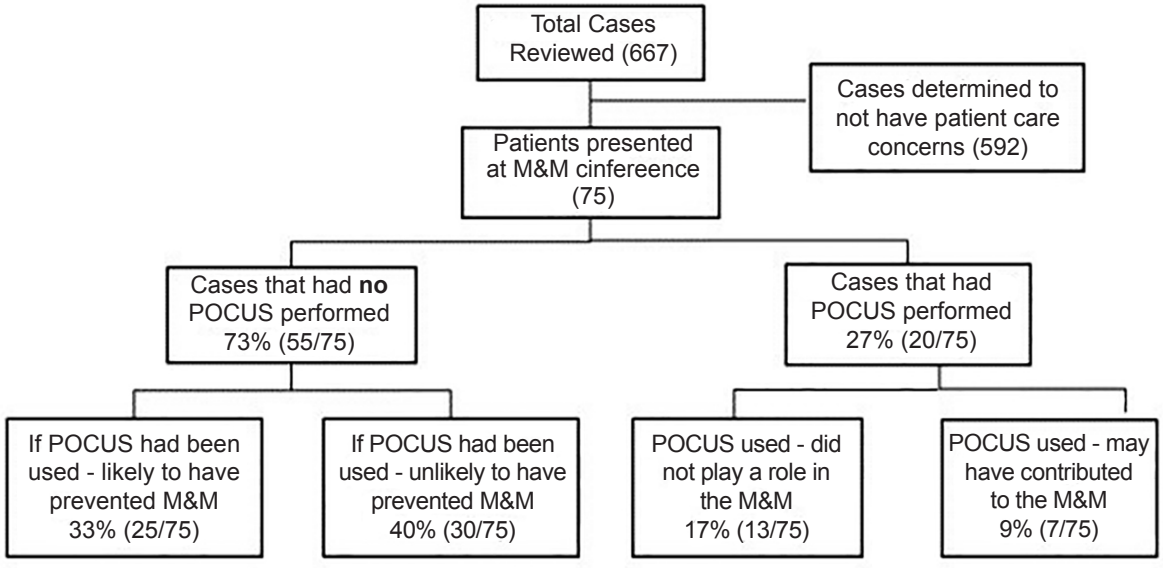

Figure 1. Flow diagram of morbidity and mortality cases.
POCUS, point-of-care ultrasound; *M&M,* morbidity and mortality.

prevented the M&M" in 45% (25/55, 95% CI, 32-59%) There was a kappa value of 0.85 between the PGY-4 residents and the fellowship-trained EM attending in making this assessment. The US EM attending would have clinically used POCUS in 52% (13/25, 95% CI, 31%-72%) of these cases.

The most common chief complaints were shortness of breath 23% (17/75), trauma 15% (11/75), and cardiac arrest 12% (9/75) (Table 1). Thirty-six percent (27/75) were deaths within the ED. Of the 45% (25/55) of cases in which POCUS was not used but was felt would have likely prevented the M&M, the most common presentations were chest pain (75%, 6/8), shortness of breath (47%, 8/17), and trauma (36%, 4/11).The most common vital sign abnormalities were tachycardia 49% (37/75) and hypoxia 26% (20/75). Of the cases with these abnormalities, POCUS was felt likely to have made an impact if it had been used in 40% (8/20, 95% CI, 19-64%), of the hypoxic cases and 30% (11/37, 95% CI, 16-47%), of the tachycardic cases.

The perceived benefit of POCUS in preventing M&M was varied. POCUS often had the potential to have improved care by multiple different mechanisms. Mechanisms by which POCUS might have prevented the M&M were as follows: identified a missed diagnosis (92%, 23/25, 95% CI, 74-99%); decreased time to diagnosis (92%, 23/25, 95%, CI 74-99%); improved triage to an area of higher level of care (80%, 20/25, 95% CI, 59-93%); guided appropriate treatment (60%, 15/25, 95% CI, 39-79%); earlier consultation (24%, 6/25, 95% CI, 9-45%); and prevented inappropriate imaging (24%, 6/25, 95% CI, 9-45%). The POCUS applications that would have helped the most were cardiac (32%, 8/25, 95% CI, 15-54%), and lung (32%, 8/25, 95% CI 15-54%). This data is summarized in Figure 2.

There were seven cases (35%, 7/20, 95% CI 15-59%) in which POCUS was performed and thought to have possibly adversely affected the outcome of the M&M. The cases were classified by type to characterize the errors. Of these errors, in four POCUS was incorrectly integrated into clinical care, in two POCUS was incorrectly performed, and in two POCUS was incorrectly interpreted. These cases are summarized in Table 2.

DISCUSSION

An aggregate review of M&Ms over a one-year period showed the perceived potential for POCUS to prevent M&M. This is the first report of which we are aware that examines POCUS through a hospital's M&M conference. In this pool of high-yield cases we determined that in up to 33% (25/75) of cases of M&M, POCUS had not been done but might have helped to prevent the M&M. Of course, POCUS findings would be only one of many needed pieces of information that could have changed management, identified diagnoses, or decreased time to diagnoses.

Whether or not POCUS would have been done is harder to assess. An EM attending with US training stated that based on the retrospective information about the case, he would have personally performed a POCUS in only 52% (13/25) of cases. It should be noted that an US EM attending's usage is likely to be higher than that of an EM attending without specialized US training; thus, this number may be an overestimation. In the rest

Table 1. Chief complaints or reasons for referral and vital signs of morbidity and mortality cases reviewed (N = 75).

	POCUS may have prevented M&M	Total cases (N = 75)
Chief complaint		
Chest pain	75% (6/8)	11% (8/75)
Procedural complication	67% (2/3)	4% (3/75)
Shortness of breath	47% (8/17)	23% (17/75)
Trauma	36% (4/11)	15% (11/75)
Altered mental status	29% (2/7)	9% (7/75)
Cardiac arrest	22% (2/9)	12% (9/75)
Abdominal pain	17% (1/6)	8% (6/75)
Other	0% (0/8)	11% (8/75)
Headache	0% (0/4)	5% (4/75)
Medication error	0% (0/3)	3% (2/75)
Vital signs		
Hypoxic	40% (8/20)	26% (20/75)
Tachycardic	30% (11/37)	49% (37/75)
Febrile	29% (2/7)	9% (7/75)
Hypotensive	26% (5/19)	25% (19/75)

POCUS, point-of-care ultrasound; *M&M,* morbidity and mortality.

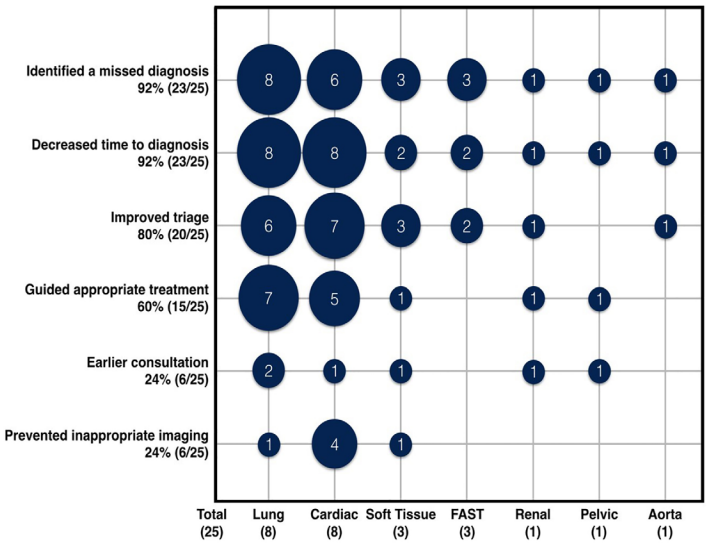

Figure 2. Perceived impact of point-of-care ultrasound: applications versus mechanism by which POCUS may have reduced or prevented morbidity ad mortality (N = 25 cases, multiple mechanisms per case were possible).
FAST, focused assessment with sonography in trauma.

Table 2. Description of cases that POCUS may have contributed to the M&M.

Case	Case description	Ultrasound contribution	Type of error		
			Incorrectly interpreted	Incorrectly performed	Incorrectly integrated
1	Possible septic shock with acute on chronic RV failure.	Severe RV dysfunction correctly identified, however 4L of IVF given causing fluid overload.			X
2	Hemothorax. Liver injury occurred during chest tube placement.	Hemothorax correctly identified but ultrasound not used to guide chest tube placement.		X	X
3	Persistent tachycardia. PE not considered.	RV dilatation correctly identified but not incorporated into care.			X
4	Hemothorax after ultrasound-guided ipsilateral central line placement.	Presumed vascular injury secondary to central venous access attempt. Unclear how procedure was done.		X	
5	Trauma with hypotension.	+FAST correctly identified. No surgery consults until after CT.			X
6	Leg infection treated as cellulitis as outpatient. Returned with necrotizing fasciitis.	Ultrasound correctly identified soft tissue edema, but providers missed subcutaneous air, which was visible.	X		
7	Shortness of breath. Pleural and pericardial effusions identified, admitted.	Pericardial effusion correctly identified, but not read as early tamponade delaying emergent consults.	X		
Total (8 errors/7cases)			25% (2/8)	25% (2/8)	50% (4/8)

M&M, morbidity and mortality; *RV,* right ventricle; *IVF,* intravenous fluid; *PE,* pulmonary embolism; *FAST,* focused assessment with sonography in trauma; *CT,* computed tomography.

of the cases where it was felt that POCUS might have prevented M&M, the US EM attending did not think that he would have performed a POCUS. For many of the cases, the US findings might have been considered to be advanced (ie, endocarditis, focal wall-motion abnormalities) and probably fell outside the scope of standard POCUS in EM. As emergency physicians become more and more facile with POCUS, it is possible that these applications may become more commonplace.

In this study, M&M was used as a surrogate of critically ill patients with significant adverse outcomes as it has been identified in previous literature within EM.[16,17] Our data speak to the importance of POCUS use in the routine care of patients while in the ED, especially in those who are critically ill.

One of the most difficult aspects of POCUS utilization is knowing in which patients to use it. Even when an emergency physician has competence in performing, interpreting, and integrating US, if it is not done then there is no benefit to the patient. Having greater diagnostic accuracy earlier in a patient's work-up could potentially allow for optimization of care during the golden hour with streamlined treatment, better decision-making about imaging, earlier consultation, and more accurate disposition. However, POCUS takes time and so performing it in every patient may not be an efficient use of ED resources or physician time. Our results showed that patients with chief complaints of chest pain, shortness of breath, and trauma made up approximately 80% of the M&Ms where POCUS was thought to be able to help prevent its outcome. This is not surprising as chief complaints of chest pain and shortness of breath comprise a large number of ED visits and are often caused by diagnoses with high mortality.[18] Our data also show that vital sign abnormalities were common in M&M cases where POCUS may have made a difference. Specifically, patients who were tachycardic and/or hypoxic were the most likely to benefit from POCUS. This information can be used to guide physician decision-making with critically ill patients and clinical protocols in EDs.

Additionally, these data can inform ultrasound education in EM residencies and support the idea of advocating for "POCUS first" algorithms in patients presenting with chest pain, shortness of breath, hypoxia, and/or tachycardia. As FAST has been integrated into the Advanced Trauma Life Support algorithm for trauma patients, cardiac POCUS is starting to be incorporated into Advanced Cardiac Life Support for routine cardiac arrest care in the ED.[19] It may be reasonable to develop similar algorithms for patients with hypoxia and/or tachycardia or with chief complaints of chest pain and shortness of breath with the intent of improving patient outcomes. Although it is not reasonable for all patients, highly targeted POCUS for a specific patient population with cardiopulmonary complaints is reasonable. Further, this may help educators teach trainees which patients clinically may have the highest benefit of a POCUS when clinicians must triage multiple sick patients at once. A few studies have attempted to describe their integration;[12,20] however, further research is needed on specific patient outcomes.

Of the 75 cases that were presented to M&M, in 9% (7/75) POCUS may have been one component that negatively impacted the case. To inform educational endeavors, we analyzed the

results by the three components of POCUS: 1) performing the POCUS and acquiring images; 2) interpreting the images; and 3) integrating the findings into clinical care. In half of the errors, the POCUS was both done and interpreted correctly, but the integration of clinical findings was flawed. This knowledge has important implications on POCUS education. POCUS curricula in EM residencies are comprised largely of scan shifts in which acquisition and interpretation of images are heavily emphasized, but integration of findings may not be. These data highlight the importance of also focusing integration of POCUS findings into clinical care needs and emphasize the need for comprehensive POCUS training.

In a quarter of the errors, POCUS was incorrectly performed. Both of the cases were related to procedural guidance. It is not entirely clear how POCUS was or was not involved in these cases as we did not perform image review, but this does speak to the importance of skills training, perhaps in simulation settings. Physicians from non-EM specialties were involved in some of these procedural errors and highlights the need for POCUS education to all services who care for patients in the ED. Finally, interpretation of POCUS was the issue in a quarter of the errors. In both of these cases (necrotizing fasciitis and focal cardiac tamponade), findings extended beyond the traditional questions that POCUS answers. This highlights a vulnerability of POCUS, in that even in these cases we as providers are responsible for images that we acquire and their findings. Identifying examples of these vulnerabilities through review of M&M cases can be one tool that we as educators use to further the education of our physicians. Although POCUS was involved in 9% of adverse cases associated with M&M, it does not suggest that US in and of itself is a dangerous tool. Rather, it underscores the importance of competence in using US and the need for high quality and continuing training.

The notion of POCUS identifying hard-to-make diagnoses is also supported by our study. Mechanisms of how POCUS was perceived to help prevent M&M were noted and quantified. POCUS was perceived to be most potentially useful in its ability to identify missed diagnoses (92% of cases) and decrease the time to diagnosis (92%). Given this ability, the threshold for performance of US in all patients with a questionable diagnosis should be very low. Ultimately, our study supports the idea that US may have a role in decreasing diagnostic and procedural errors, thereby improving patient care. However, it also shows that if US is done it needs to be done well, accurately, and integrated into patient care correctly.

LIMITATIONS

There are several limitations in our study. One limitation was response bias as the results represent the views of the individual respondents. All cases were initially reviewed for patient-related concerns by both the PGY-4 and an EM attending who were not a part of the study, so selection of cases was not biased. However, our surveys were completed by PGY-4 residents only and represent their views of the case. By using PGY-4s it is reasonable to say that they are not expert users of POCUS or experts in medical management, leading to possible inaccurate results. However, an US-trained attending reviewed all the cases and had high agreement with the PGY-4 opinions of the case. Second, all cases that had possible clinical errors were reviewed by an EM attending for agreement.

Another limitation was that the individuals administrating the survey were US faculty. This could have potentially led to some indirect bias on the part of the PGY-4s' responses. Our study was also limited in that we had a relatively low sample size and it was done in academic EDs, potentially leading to limitations regarding the generalizability of our study. However, past studies surrounding M&M process have had similar numbers when reporting.[17,18] Finally, perfect conditions were assumed in cases where POCUS was felt to potentially have a role in preventing an M&M. In reality, it is not the case that images are always correctly obtained, interpreted, and integrated; so the perceived potential benefit of POCUS is a theoretical one. There are many factors related to the patient, provider, and clinical environment that also affect the utility of POCUS and likelihood that it is performed that we could not control for in our model.

CONCLUSION

In our study, the use of POCUS could potentially have positively impacted 33% of departmental M&M cases in which there were concerns about patient care. POCUS would be most likely to prevent M&M in patients with chest pain, shortness of breath, trauma, tachycardia, or hypoxia. Cardiac and lung ultrasound were the applications felt to have the greatest potential to minimize M&M. Clinical integration is an essential component of POCUS competency, and it should be prioritized and taught in appropriate platforms. This information can be useful in guiding POCUS educational curricula and clinical decision-making. A prospective study is needed to determine the actual impact of POCUS on patient-centered outcomes in high-risk patients in the 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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Plastic Surgery Complications: A Review for Emergency Clinicians

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The number of aesthetic surgical procedures performed in the United States is increasing rapidly. Over 1.5 million surgical procedures and over three million nonsurgical procedures were performed in 2015 alone. Of these, the most common procedures included surgeries of the breast and abdominal wall, specifically implants, liposuction, and subcutaneous injections. Emergency clinicians may be tasked with the management of postoperative complications of cosmetic surgeries including postoperative infections, thromboembolic events, skin necrosis, hemorrhage, pulmonary edema, fat embolism syndrome, bowel cavity perforation, intra-abdominal injury, local seroma formation, and local anesthetic systemic toxicity. This review provides several guiding principles for management of acute complications. Understanding these complications and approach to their management is essential to optimizing patient care. [West J Emerg Med. 2020;21(6)179-189.]

INTRODUCTION

The number of aesthetic surgical procedures performed in the United States is increasing rapidly. Over 1.5 million aesthetic surgical procedures were performed in 2015.[1] Breast augmentation and suction-assisted lipectomy (SAL), also known as liposuction, are the most frequently performed cosmetic procedures in the US with over 600,000 performed annually (Figure 1).[2-4] Cosmetic procedures are lucrative, and in the absence of legal restrictions, are increasingly being performed in outpatient settings by non-plastic surgeons and even non-physicians.[5,6] Growing medical tourism has spurred demand for cosmetic surgery in Europe, South America, and Southeast Asia.[6-8] A survey distributed to 2000 active members of the American Society of Plastic Surgeons (ASPS) showed that 51.6% of respondents noted an increasing trend in the number of patients presenting with complications from surgical tourism.[9] Public perception of these surgeries as minor procedures contributes to risks for major complications with potentially fatal consequences, with reported mortality of 1 per 5000 procedures.[5,10-12] Emergency clinicians should be aware of possible complications.

METHODS

This review focuses on the complications of the most common surgical procedures including liposuction, breast augmentation, abdominoplasty, and subcutaneous injections. We describe the expected presentations, evaluation, and emergent care required to manage post-cosmetic surgery complications. We performed a literature search of Medline, PubMed, and Google Scholar for "plastic surgery," "complication," "liposuction," "mammoplasty," "abdominoplasty," "surgical site infection," "dehiscence," "fat embolism," "perforation," "local anesthetic systemic toxicity." The database search was conducted from inception of each database to April 1, 2020. We evaluated case reports and series, retrospective and prospective studies, systematic reviews and meta-analyses, and other narrative reviews. We also reviewed guidelines and supporting citations of included articles. The literature search was restricted to studies published in English, with focus on emergency medicine (EM) and critical care literature.

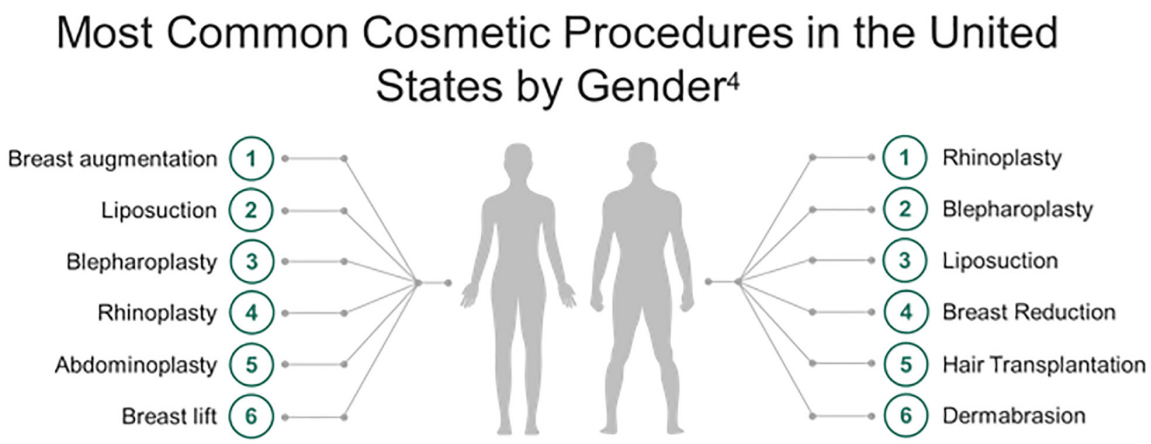

Figure 1. Most common cosmetic procedures in the United States in 2017 by gender. Statistics available at https://www.plasticsurgery.org/documents/News/Statistics/2017/plastic-surgery-statistics-full-report-2017.pdf.

RESULTS

We decided by consensus which studies to include for the review. When available, systematic reviews and meta-analyses were preferentially selected. These were followed sequentially by randomized controlled trials, prospective studies, retrospective studies, case reports, and other narrative reviews when alternate data were not available. There is a notable absence regarding the discussion of plastic surgery complications in the EM and critical care literature. A total of 114 resources were used for the construction of this narrative review.

DISCUSSION

Brief Review of Surgical Techniques

Liposuction

Emerging in the 1970s, SAL is one of the most widespread aesthetic surgeries practiced.[13] Outpatient SAL is typically performed under local anesthesia and is used commonly on the buttocks, back, thighs, face, chest, and abdomen. The predominant technique, *microcannula tumescent liposuction*, consists of suction removal of fat from deep subcutaneous layers via aspiration cannulae introduced through small skin incisions.[14] Several liters of tumescent solution consisting of dilute local anesthetic, epinephrine, and saline are infiltrated into the subcutaneous tissue, percolating through tissue layers prior to aspiration.[15] The saline balloons tissues (tumescence), epinephrine causes vasoconstriction which decreases bleeding, and lidocaine induces local anesthesia.[16] Generally, incisions are left open to drain remaining fluid.[17] Duration of SAL procedures is typically 3-4 hours. The volume of subcutaneous fat that can be extracted is approximately 4-5 liters.[17]

Mammoplasty

Mammoplasty, including breast reduction and augmentation, is a common aesthetic surgical procedure. Mammoplasty typically requires inpatient admission, especially if combined with another procedure such as abdominoplasty.[18] Many surgical techniques exist for breast augmentation. All involve incisions extending caudally between breast and subcutaneous tissue, exposing the pectoral fascia. A rent is then made in the fascia, and fibers of the pectoralis major are split, forming a submuscular pocket into which breast prostheses are placed.[19] Surgical techniques and implant technology evolved over the course of the 20th century. Due to capsular contracture with older prostheses, manufacturers began to design round, smooth-surfaced implants that can move within surgical pockets.[20] Implantation of synthetic and biological matrices such as acellular dermal matrix in surgical breast reconstruction is becoming increasingly common.[21] Implant-based breast reconstruction includes one- or two-stage procedures where expanders or permanent implants are placed to contour breast appearance, with or without use of reinforcing matrices.[21] Breast reduction consists of resection of breast tissue, skin, and parenchyma with formation of a free skin flap. Liposuction may be performed beyond the area of skin resection to shape tissue.[22]

Abdominoplasty

Abdominoplasty is used to reshape body contours by means of excising redundant skin and fat tissue to remodel the abdominal wall. Contemporary techniques use three main characteristics: abdominal flap dissection, plication of the rectus abdominis fascia, and resection of skin and underlying Scarpa fascia-adjacent subdermal tissue. Abdominoplasty is now preceded by or performed concurrently with liposuction in 90% of cases.[23] This practice preserves nerve and blood supply to the abdominal skin and minimizes "dead space," which poses risks for postoperative complications.[24]

Subcutaneous Injections

Subcutaneous injections of dermal "fillers" include a variety of substances injected into the body for soft tissue augmentation. One of the most common sites is the buttocks.[25] Surgical enhancement of buttock volume has been performed

for decades, primarily using silicone or autologous fat injection.[26] The procedural technique for silicone placement is analogous to breast augmentation.

Complications of Cosmetic Surgical Procedures

Physiologic risks of plastic surgery procedures are comparably less than those of other surgical subspecialties. Aesthetic surgical procedures are typically elective and usually performed on an outpatient basis in relatively healthy patient populations. Despite these factors, significant risks exist for postoperative complications. Common complications include infections, local anesthetic systemic toxicity (LAST), electrolyte and hematologic abnormalities, intravascular fluid shifts, and wound complications. Postoperative complications may be immediate, such as LAST, or delayed up to months, as may occur with surgical site hematomas.[2,6] Figure 2 depicts common postoperative complications and clinical findings that may assist in distinguishing etiologies leading to ED presentation.

Post-surgical Complications: Evaluation and Management

Antibiotic Use and Surgical Site Infections (SSI)

The dissected subcutaneous layer created in cosmetic procedures creates an optimal environment for bacterial growth. This presenting risk for infections ranges from cellulitis to life-threatening necrotizing fasciitis (ie, infections invading fascial planes with tissue necrosis). No specific guidelines for perioperative prophylaxis exist for cosmetic surgeries. Prophylactic perioperative antibiotic use is controversial except in breast surgeries, where antibiotic prophylaxis is universally recommended, particularly in surgeries using implants, drains, or mesh.[27-30] Antibiotic prophylaxis should cover both Gram positive and negative bacteria. Of these, the most common culprit for postoperative infection is *Staphylococcus aureus*.[31] Duration of postoperative antibiotic courses range between 24 hours to 14 days, with oral antibiotics frequently continued until surgical drains are removed.[31]

After local fluid collections, postoperative SSIs are the most common local wound complication. SSIs vary by nature of the procedure performed. Breast surgeries have higher associated incidence of wound complications, including infection.[32] Postoperative infections are present in up to 35% of breast surgeries. Most literature suggests an overall incidence of less than 1% in all aesthetic surgeries combined.[27,33-35] Reported SSI incidence following abdominoplasty is variable, ranging from 0.2% to 32.6% of patients in large series.[36-38] Cárdenas et al reported an SSI incidence of 0.09%, with only one infection in 1047 patients who underwent liposuction.[39,40]

The Centers for Disease Control and Prevention (CDC) defines SSI as infections related to an operative procedure occurring at or near surgical incisions within 30 days of the procedure. The CDC categorizes SSI into *superficial* and *deep* presentations.[41] Superficial SSIs are an infection of the dermis and subcutaneous tissue, presenting similarly to cellulitis with imaging findings of fascial thickening, septation of subcutaneous fat, and/or lymph node enlargement.[42] Clinical assessment is imperative, as uncomplicated cellulitis may appear similar to normal postoperative tissue on ultrasound and computed tomography (CT).[42] Symptoms such as fever, local warmth, erythema, and tenderness to palpation should be considered alongside laboratory results when evaluating these patients.[42] Consultation with the operative surgeon is recommended, as he or she may help facilitate outpatient follow-up and appropriate antibiotic choice based on facility antibiogram. Infectious Diseases Society of America guidelines for moderate, non-purulent skin and soft tissue infections recommend penicillin, ceftriaxone, cefazolin, or clindamycin.[43]

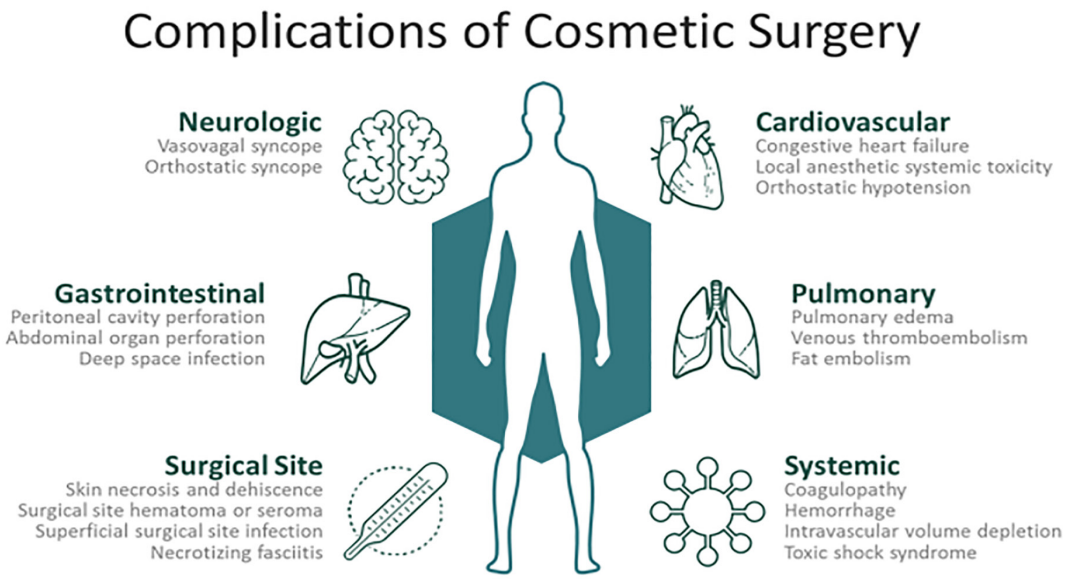

Figure 2. Common postoperative complications of cosmetic surgery.

If the patient has had fat grafting with infection of the graft site or harvest site, a 2-3 day admission with intravenous (IV) antibiotics may be necessary for rapidly progressing infection.[42-44] There is growing concern about chronic, refractory inflammation developing after aesthetic surgeries necessitating admission for IV antibiotics.[44] The etiology underlying these chronic cases is thought to be antibiotic-resistant bacteria and fungi and rapidly growing mycobacteria.[45,46]

Deep SSIs involve the deep soft tissue planes and may extend to fascia and visceral organ structures. Postoperative infection in cosmetic surgery patients poses a diagnostic challenge as edema, color changes, and blistering can result from the initial procedure, thus concealing infectious processes.[47] Constitutional signs and symptoms of infection, including fever, chills, and rigors, should raise suspicion for development of SSI and/or associated sepsis.[43,44,47] Deep infections may also evolve into necrotizing fasciitis, which has been described after cosmetic surgeries, most frequently SAL.[48-50] Necrotizing fasciitis is a surgical emergency necessitating prompt antibiotic treatment, early surgical consultation, and often radical debridement of necrotic tissue.[51] CT with IV contrast is the most sensitive modality for diagnosing necrotizing fasciitis and evaluating the extent of disease. While radiographic findings parallel those of cellulitis, necrotizing fasciitis may be distinguished by gas in the muscle layer.[42,52]

Bacteria are the most common causative agents underlying postoperative SSI. *S. aureus, S. epidermidis*, Streptococci A and B, *Streptococcus pyogenes*, *Klebsiella pneumoniae, Bacillus*, and *Propionibacterium* are most often implicated. Corynebacterium, *Pseudomonas aeruginosa, Escherichia coli*, and *Enterobacteriaceae* are also occasionally implicated.[53-55]

Infection remains the greatest risk of implant-based breast reconstruction, particularly in the setting of mesh implantation. Prosthesis infections can lead to complications ranging from mild SSIs, including superficial cellulitis, to surgical revision for chronic wounds, implant failure, and life-threatening sepsis.[56] In the setting of breast augmentation with mesh use, infection may lead to bacterial biofilm development with subsequent capsular contracture and rib osteomyelitis.[57-61] Approximately two-thirds of postoperative breast infections develop within one month. One report noted 13.3% of patients developed infections three months after surgery, 8.3% after more than six months, and sporadically up to decades following surgery.[57] Risk factors for development of an SSI after breast surgery include older age, female gender, elevated body mass index (BMI), current tobacco smoking, diabetes mellitus, immunosuppressed states, multiple concurrent procedures, and undergoing procedures elsewhere besides the breast or face.[40]

ED management of suspected deep SSI includes early recognition and obtaining appropriate imaging and cultures. Although outside the domain of emergency medicine, deep SSI treatment often requires aggressive surgical debridement. Empiric antibiotic treatment should be broad (eg, vancomycin or linezolid plus piperacillin-tazobactam or a carbapenem, or plus ceftriaxone and metronidazole).[43] The primary surgical team should be consulted, particularly when prosthesis infection is suspected. As culture-directed therapy should be initiated as soon as microbiological analysis is available, early procurement of tissue, wound, and/or blood culture can aid in later antibiotic regimen honing.[43]

Surgical Site Collections

Swelling and tissue edema is normal and anticipated after most cosmetic surgeries. Such findings typically resolve after 1-2 months. However, persistent, organized collections may represent hematoma development.[58] Hematoma occurrence varies depending on the procedure performed and the patient population, ranging from 3% to 15% in lipoabdominoplasty,[32,58] and 0.6% to 5.7% in breast augmentation surgery.[62-65] Risk factors for postoperative hematoma formation include anticoagulant use, older age, male gender, tobacco use, and medical comorbidities such as hypertension or malignancy.[66-68] Hematomas usually occur in the initial 24-hour postoperative period but have been reported months following the initial procedure.[61,69] Clinical presentation of hematomas depends on volume and rate of accumulation. Small hematomas are typically asymptomatic. More sizable hematomas with swelling, localized pain, and ecchymosis can typically be managed supportively.[61] While rare, large hematomas with active bleeding can lead to hemodynamic instability and hemorrhagic shock, necessitating resuscitation and surgical intervention.[61] Hematoma formation in patients with implanted prosthesis is a surgical emergency and should warrant close consultation with the surgical team for evacuation.

Implant rupture, especially in patients with breast augmentation, is an important cause of local fluid collections. The most common cause of implant rupture is age-related weakening of implant material.[70] Signs and symptoms of implant rupture include contour deformity, volume diminution, palpable mass-like lesions, pain, and focal inflammation.[71] Diagnosis of breast implant rupture on physical examination is feasible when presenting with typical features. However, clinical evaluation may fail to detect breast implant rupture that occurs over time without loss of breast volume and contour changes. Ultrasound and mammography are not sufficiently sensitive to rule out intracapsular ruptures, particularly of silicone implants.[72] CT imaging has low sensitivity and is not recommended for evaluation of implant rupture.[73] When feasible, magnetic resonance imaging (MRI) is the preferred study, but this is not required emergently. Sensitivities of clinical diagnosis, ultrasound, and MRI for implant rupture are 42%, 50%, and 83%, respectively, while specificities approach 50%, 90%, and 90%, respectively.[74] Implant rupture is frequently asymptomatic and can be evaluated by MRI on an outpatient basis with surgeon follow-up.

In the subset of patients presenting with silicone injection-based cosmetic buttock enhancement, special attention must be paid to local collections, as foreign material is present in affected tissue. In addition to hematomas and seromas, these patients may

have a foreign body reaction with granuloma formation.[26] Most patients with this complication present with erythema, induration, and plaques (well-circumscribed, elevated, superficial, solid lesions) in the buttocks.[75] Granulomatous reactions to silicone may occur months to years after silicone injection.[25,76] Treatment of silicone granulomas can be challenging. Treatment modalities described in the literature include tetracyclines, steroids, and surgical excision.[25,77]

ED management consists of appropriate laboratory investigations to evaluate for blood loss and infection and imaging to evaluate collection size. In patients presenting with acute pain, other causes of abdominal discomfort should be considered before making a presumptive diagnosis of seroma or hematoma formation.[78] Consultation with the surgical team is recommended to decide whether surgical drainage, needle aspiration, or close outpatient follow-up is appropriate. In hemodynamically unstable patients with evidence of hematoma, further investigation via ultrasound or CT angiography is necessary to search for bleeding sources including intraperitoneal foci.[78,79]

Postoperative Hemorrhage

Contemporary approaches to plastic surgery techniques have resulted in a less than 2% rate of postoperative bleeding.[80] However, postoperative hemorrhage is associated with morbidity and mortality, accounting for roughly 4.5% of postoperative deaths in this population.[81] Quantifying blood loss during cosmetic surgeries such as liposuction is difficult due to the composition of aspirate. However, it is estimated that for every 100 milliliters (mL) of aspirate, the average total body blood loss is 37 mL for females and 23 mL for males when not using tumescent solution, and an average of 0.5 to1.5 mL blood per 100 mL when tumescent technique is used.[82] Most postoperative bleeding from cosmetic surgery is a result of capillary disruption, but cases of organ or vascular perforation with intraperitoneal hemorrhage have been reported.[83] This hemorrhage can be further exacerbated by postoperative coagulopathy, including disseminated intravascular coagulopathy (DIC) secondary to a combination of hemodilution, hypothermia, and liposuction trauma.[58] ED management consists of appropriate laboratory investigations to evaluate for blood loss and coagulation, as well as imaging assessment for hemorrhage via ultrasound or CT angiography.[84] Hemodynamic resuscitation is a priority in the unstable patient.

Skin Necrosis and Wound Dehiscence

Flap compromise in the postoperative period is typically due to insufficient tissue perfusion secondary to disruption of subcutaneous perforating vessels and subdermal plexus. Flap compromise can lead to a variety of acute complications depending on depth of tissue involvement. Epidermolysis is the mildest variant in which only the epidermis suffers ischemia. The natural course of uncomplicated epidermolysis is spontaneous reepithelization without intervention.[61] However, skin necrosis extending to subdermal tissue may involve severe pain and delayed healing. The incidence of skin necrosis varies between 3-4.4%, but less than 1% of these patients require revision.[32] In most cases, necrosis leads to healing by secondary intention, which may require months to heal depending on the affected area size. Clinical features of skin necrosis include tenderness to palpation, ecchymosis, and tissue breakdown.[61] Once detected, treatments include surgical debridement, antibiotics, and/or hyperbaric oxygen therapy.[37]

Wound dehiscence is a rare but important complication of plastic surgery, occurring in approximately 0.75% of patients.[85] Wound dehiscence may occur secondary to infection, local collection, or necrosis. Risk of necrosis is heightened in procedures using autologous fat transfer, in which transplanted fat can cause localized inflammation and destruction of recipient tissues.[86] ED management focuses on pain management and evaluation of any other underlying etiologies, most notably postoperative infection. Close follow-up with the primary surgeon is essential for wound debridement, dressing, and closure.

Venous Thromboembolism (VTE)

VTE is the leading cause of postoperative mortality in cosmetic surgery, accounting for up to 21% of postoperative deaths.[10] Deep vein thrombosis (DVT) and pulmonary embolism (PE) incidence in liposuction is reported at less than 1%, but there is a marked increase in DVT incidence when liposuction is combined with other surgeries, especially abdominoplasty.[32,38,87] Abdominoplasty has the highest incidences of DVT and PE in cosmetic surgery, up to 0.8% and 1.3%, respectively.[32,38,87] These patients are more likely to experience long duration of surgery, impaired drainage of deep veins of the legs and pelvic area due to flexion at the hip during and after surgery, and higher incidence of postoperative inactivity.[88] Risk of VTE increases significantly when cosmetic procedures are combined.[89] There are no differences in imaging or treatment of VTEs in cosmetic surgery patients compared with other patient populations with suspected VTE.

Fat Embolism Syndrome (FES)

It is hypothesized that all patients undergoing liposuction surgery experience some degree of thromboembolic shower due to fat particles being dislodged during surgery, which can result in pulmonary fat embolism syndrome (FES).[90] The underlying pathophysiology involves fat droplets from liposuctioned areas embolizing to the pulmonary circulation. Clinically significant FES carries an overall mortality rate of 10-15% and remains an important complication of cosmetic surgeries, especially SAL.[91] FES is a multisystem disorder; primary clinical manifestations include tachycardia, respiratory distress, focal neurologic symptoms, and petechial rash.[92] Respiratory dysfunction occurs frequently with severity varying from mild dyspnea and/or tachypnea to severe symptoms indistinguishable from acute respiratory distress syndrome.[92] Neurologic

manifestations occur in up to 80% of patients with FES and usually precede development of respiratory symptoms by 6-12 hours.[92] Neurologic symptoms range from mild disorientation to coma.[93] Petechiae on the upper body, primarily the head, neck, anterior chest, subconjunctiva, and axilla, are found in approximately 50% of FES patients.[91] Petechial rash, which usually appears within three days of symptom onset, is believed to be the only pathognomonic feature of FES, However, the absence of a petechial rash should not exclude FES.[91]

Several approaches are suggested for FES diagnosis.[92] CT is not useful for identifying the majority of fat emboli.[94] Ventilation-perfusion scanning detects areas of perfusion mismatch, but cannot differentiate between VTE and FES.[95] MRI is the most sensitive technique for demonstrating diffuse ischemic cerebral changes of FES.[93,96-98] In the acute setting, FES diagnosis is clinical, with imaging as an adjunct to eliminate alternative diagnoses.[92] Treatment considerations include maintenance of fluid and electrolyte balance, administration of supplemental oxygen, and endotracheal intubation with mechanical ventilator support when required.[93] Anticoagulation is not recommended, as fat emboli are a distinct clinical entity from thromboembolism and not amenable to thrombolysis.[93]

Visceral Perforation

Visceral perforation is an important complication requiring aggressive intervention. As cosmetic surgery is routinely performed in an ambulatory setting, patients may not be evaluated by their surgeon until three or four days postoperatively. Therefore, these patients may present to the ED for evaluation.[48,99,100] Bowel wall perforation with visceral injury is the second most common cause of mortality after liposuction, with an incidence of 14 per 100,000 procedures.[101,102] Ileal perforation is most common, followed by perforation of the jejunum, spleen, cecum, and transverse and sigmoid colon.[100] Risks for perforated viscus during liposuction include morbid obesity, previous surgical scars, divarication of recti, and abdominal wall hernias.[58] Patients may present subtly, with pain out of proportion to postoperative course, or in shock.[78] Perforation may extend to surrounding lymphatic, vascular, and intra-abdominal structures, or may occur far from the original surgical site, as in the case of patients with severe chest pain and dyspnea, possibly indicating perforation into the thorax.[78,103]

In the ED, patients with severe abdominal pain after cosmetic surgery should be assessed carefully for visceral perforation. While diagnosis of peritonitis is primarily clinical, plain radiographs of the abdomen or chest in upright position and CT may be useful adjuncts in confirming diagnosis.[100,103] Management of severe peritonitis is complex and requires a multidisciplinary approach consisting of surgical evaluation and aggressive resuscitation with hemodynamic support, broad spectrum antibiotics, and IV fluids.[104]

Local Anesthetic Systemic Toxicity (LAST)

LAST is a potentially devastating complication of local anesthesia administration. The United States Food and Drug Administration recommends a maximum dose of 7 milligrams per kilogram (mg/kg) of lidocaine for local anesthesia.[105] However, when used during tumescent liposuction, this ceiling increases to 35-65 mg/kg.[105,107] This has proven acceptable, as plasma concentrations of lidocaine remain at subtoxic levels despite high infiltrative dosages, affirming that tumescent lidocaine is absorbed slowly from subcutaneous tissues producing lower peak blood levels vs other administration routes.[108] Up to 30% of the anesthetic is suctioned after infiltration, decreasing systemic absorption.[109,110]

Serum lidocaine concentrations peak between 12-16 hours following tumescent infiltration, presumably when the patient is home following office-based procedures.[106,111] Various concentrations of epinephrine are described, typically between 0.65 mg/Liter (L) and 1 mg/L. Maximal doses do not exceed 7 mg/kg.[106,111] Epinephrine use may increase post-SAL cardiac index, delaying potential LAST-associated cardiovascular collapse. Typical tumescent solution lidocaine concentration is one gram (g) per bag, containing 1110 mL or 0.9 g/L (0.09% lidocaine).[108] Sodium bicarbonate is added to reduce the discomfort of large-volume subcutaneous, tumescent infiltration.[108]

Systemic complications of tumescent anesthesia may result from an allergic response or medication toxicity from epinephrine or local anesthetic. Allergic reactions with urticaria, angioedema, and/or anaphylaxis should be treated with antihistamines, intramuscular/IV epinephrine, and airway support as necessary. Medication toxicity may result from direct infiltration into large vessels or impaired drug metabolism (hepatic dysfunction or pseudocholinesterase deficiency for local anesthetics).[112] LAST presentation is variable. Toxicity involves a continuum of adverse central nervous system effects progressing to cardiovascular symptoms at increasing dosages (Figure 3).[112] Typical prodromal

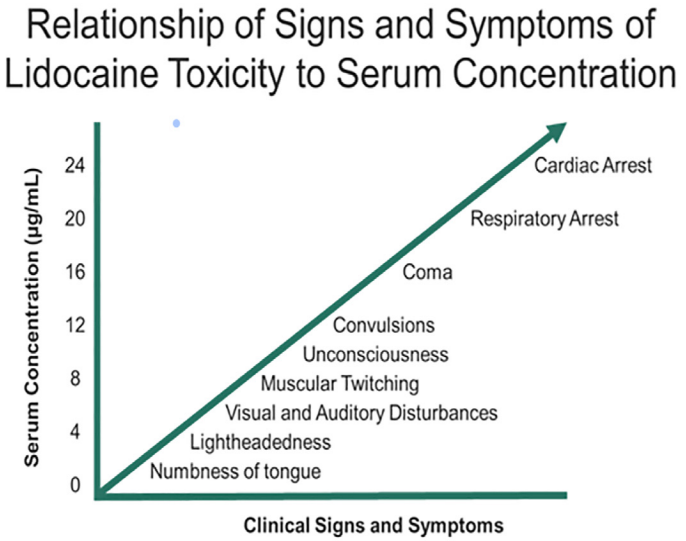

Figure 3. Relationship of signs and symptoms of lidocaine toxicity to serum concentration.

symptoms (eg, circumoral numbness, metallic taste, auditory changes) occur in approximately 18% of patients, although these are decreased in the presence of general anesthesia.[113] In fulminant presentations, these patients may present with seizures and cardiovascular collapse.

The American Society of Regional Anesthesia and Pain Medicine stresses the unique circumstances of resuscitation in patients with LAST (Figure 4).[113] In the peri-arrest period, aggressive airway management to prevent hypoxia and acidosis may slow seizures and cardiovascular collapse. Seizures are managed primarily with benzodiazepines and lipid emulsion therapy.[114] Current lipid emulsion therapy recommendations call for bolus injection of 1.5 mL/kg IV followed by an infusion at 0.25 mL/kg/min.[114] Beyond standard life support measures, providers managing cardiac arrest secondary to LAST should consider amiodarone for ventricular arrhythmias, as further lidocaine use may worsen toxicity. Negative inotropic agents are contraindicated, as they may precipitate or worsen myocardial depression.

LIMITATIONS

This is a narrative review, and thus no pooling of data from individual studies was conducted. We did not assess article quality or risk of bias. Much of the included literature consists of studies conducted in non-emergent settings, and thus generalizing these studies to the ED setting is challenging. Much of the information and resources come from society guidelines.

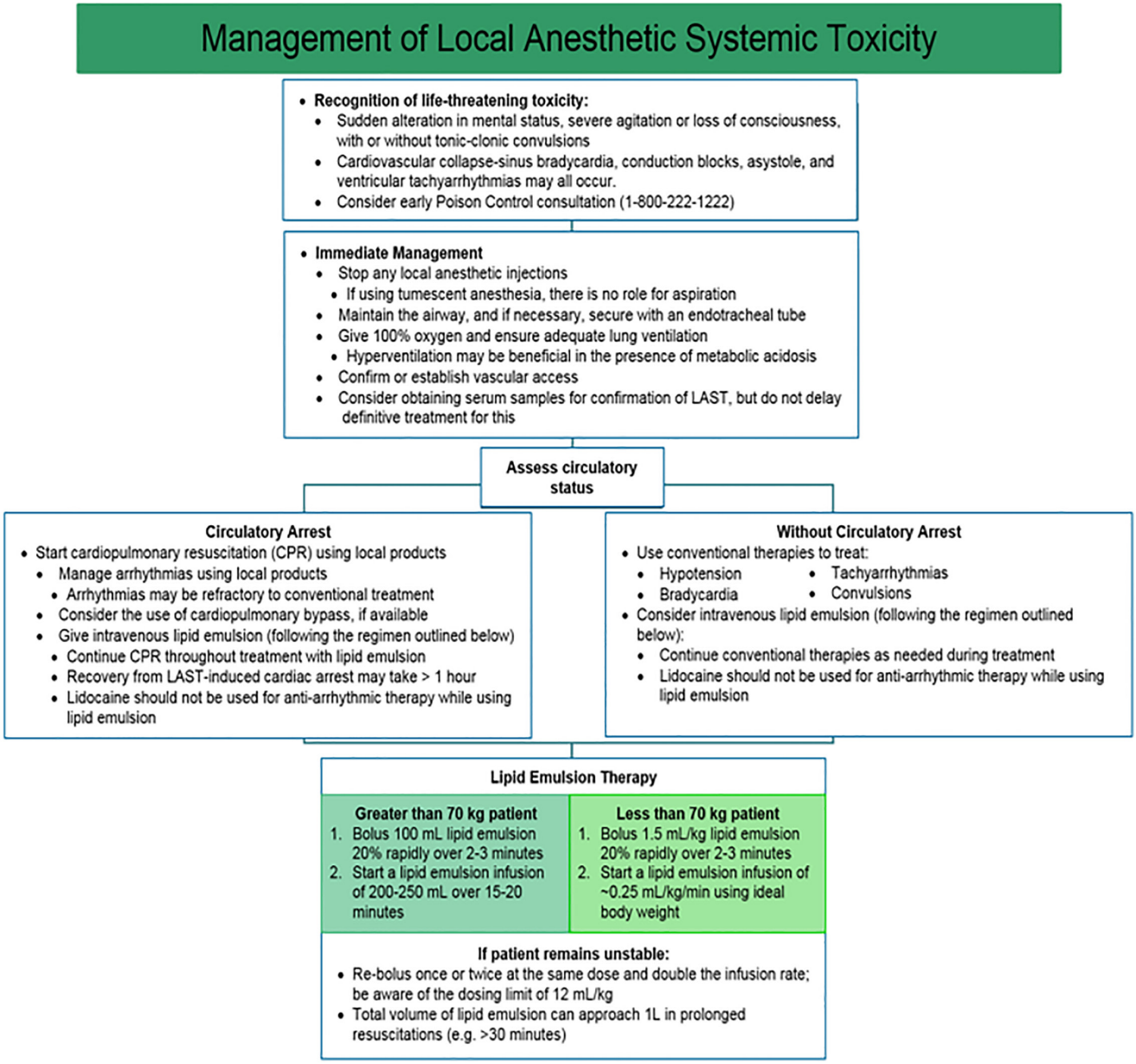

Figure 4. Evaluation and treatment algorithm for local anesthetic systemic toxicity.

CONCLUSIONS

As a result of the increasing number of cosmetic surgeries performed, rising cosmetic tourism, and lack of legal restrictions on who may perform these procedures, post-cosmetic surgery patients may present to the ED with a variety of complications. The most common issues include postoperative wound collections and infections, VTE, hemorrhage, and medication toxicity. These complications are associated with severe morbidity if diagnosis is delayed. Other significant complications include syncope, skin necrosis, and intra-abdominal injury. Critical patients should be evaluated in the resuscitation bay, and consultation with the primary surgical team is essential. Understanding these complications and their management is essential to minimizing the morbidity and mortality accompanying these cosmetic surgical procedures.

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Prevalence of Cigarette Smoking Among Adult Emergency Department Patients in Canada

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Introduction: Tobacco smoking is a priority public health concern, and a leading cause of death and disability globally. While the daily smoking prevalence in Canada is approximately 9.7%, the proportion of smokers among emergency department (ED) patients has been found to be significantly higher. The purpose of this survey study was to determine the smoking prevalence of adult ED patients presenting to three urban Canadian hospitals, and to determine whether there was an increased prevalence compared to the general public.

Methods: A verbal questionnaire was administered to adult patients aged 18 years and older presenting to Royal University Hospital, St. Paul's Hospital, and Saskatoon City Hospital in Saskatoon, Saskatchewan. We compared patients' smoking habits to Fagerström tobacco dependence scores, readiness to quit smoking, chief complaints, Canadian Triage Acuity Scale scores, and willingness to partake in ED-specific cessation interventions.

Results: A total of 1190 eligible patients were approached, and 1078 completed the questionnaire. Adult Saskatoon ED patients demonstrated a cigarette smoking prevalence of 19.6%, which is significantly higher than the adult Saskatchewan public at 14.65% (P<0.0001). Out of the smoking cohort, 51.4% indicated they wanted to quit smoking and would partake in ED-specific cessation counselling, if available. Of the proposed interventions, ED cessation counselling was most popular among patients (62.4%), followed by receiving a pamphlet (56.2%), and referral to a smokers' quit line (49.5%).

Conclusion: The higher smoking prevalence demonstrated among ED patients highlights the need for a targeted intervention program that is feasible for the fast-paced ED environment. Training ED staff to conduct brief cessation counselling and referral to community supports for follow-up could provide an initial point of contact for smokers not otherwise receiving cessation assistance. [West J Emerg Med. 2020;21(6)190-197.]

INTRODUCTION

Cigarette smoking is a global health epidemic which significantly influences the rates of cardiovascular, respiratory, and malignant chronic diseases. The deleterious influence of smoking on these diseases has resulted in cigarette smoking becoming a leading public health concern.[1] Despite persistent

public health campaigns addressing smoking cessation over the past few decades, the daily cigarette smoking prevalence in the Canadian population was estimated at 9.7% in 2018.[1] In Saskatchewan, this rate was estimated to be higher, at 14.65%.[2,3] Saskatchewan has a high proportion of rural-based citizens, and one of the lowest provincial population densities in Canada. This could impact the efficacy of smoking cessation initiatives, and partially explain why the provincial smoking rate is higher. Furthermore, Saskatchewan has a high proportion of indigenous people, who have a higher smoking prevalence than non-indigenous Canadians.[4]

American, Australian, and New Zealand studies have demonstrated a high proportional cigarette smoking prevalence in emergency department (ED) patients.[5-10] Additionally, four of these studies compared the calculated ED smoking prevalence with the public rate, and all demonstrated an increased smoking prevalence among ED patients.[5-8] However, the prevalence of cigarette smoking as well as the associated demographics and characteristics of ED patients has not been studied to a similar extent in Canada. In 2011, a study in northern Ontario found an ED prevalence nearly double the public rate, but patient smoking habits were not further explored.[11] One other Canadian study demonstrated a smoking prevalence of 46%; however, the data was not compared to the public rate.[12] Due to differences in population demographics, government tobacco policy, and healthcare systems, international studies may not be generalizable to a Canadian setting. As a result, additional Canadian studies are needed to address this knowledge gap.

Population Health Research Capsule

What do we already know about this issue?
Previous international research has shown adult emergency department patients have a higher prevalence of cigarette smoking compared to respective community rates.

What was the research question?
Is this data generalizable to three Canadian hospitals, and are patients open to ED based cessation interventions?

What was the major finding of the study?
The ED smoking rate is higher than the provincial. 51% of patients who smoke are open to ED cessation support.

How does this improve population health?
This highlights the ED as a novel location for providing smoking cessation interventions to a population who may not receive cessation support elsewhere.

Traditionally, smoking cessation counselling falls within the primary care provider's scope of practice and is not usually performed in the ED. The Canadian Action Network for the Advancement, Dissemination and Adoption of Practice-informed Tobacco Treatment (CAN-ADAPTT) guidelines, an evidence-based protocol designed by the Centre for Addiction and Mental Health, recommend that all Canadian hospitals should have a system in place to help patients quit smoking.[13] However, these programs are generally introduced at an inpatient level, which precludes their impact among ED patients who are discharged home after treatment. Furthermore, American literature has demonstrated that ED patients who smoke are less likely than non-smokers to have a primary care provider, meaning they may not be receiving cessation support elsewhere.[9] These issues identify the need for ED-specific cessation interventions in departments with an increased smoking prevalence.

The primary objective of this survey study was to determine the smoking prevalence of adult ED patients presenting to three urban Canadian hospitals, and compare this to the prevalence of the general public. Secondary objectives included identifying trends in the actively smoking cohort through demographics, smoking habits, readiness to quit, chief complaint and Canadian Triage Acuity Scale (CTAS) score. We also assessed participant receptiveness to a variety of potential ED smoking-cessation interventions that have been trialed in other studies. These include brief motivational interviewing, distributing cessation materials, providing referrals to a smoker's quit line, or a combination thereof.[14-19] In summary, our goal was to identify whether the prevalence of ED patients who smoke is elevated in a Canadian setting, similar to previous international data. Additionally, we sought to assess whether an ED-specific cessation intervention would be beneficial in these urban hospitals and determine which cessation modalities would be best received by the smoking cohort.

METHODS

A cross-sectional questionnaire was administered to patients at all EDs within Saskatoon, Saskatchewan. In total, the three tertiary EDs (Royal University Hospital, St. Paul's Hospital, and Saskatoon City Hospital) accommodate 130,000 annual patient visits from Saskatoon and the surrounding area; these hospitals provide tertiary care for the entire northern half of the province. Participants were eligible if they were 18 years of age or older and able to independently answer the verbal questionnaire administered by researchers. Patients were excluded if they were confused, actively being tended to by a healthcare professional, medically unstable, unable to verbally communicate due a medical condition, or if they were unable to communicate in English.

We employed verbal administration of the questionnaire to improve accessibility for patients with literacy, visual, or motor deficits. To best represent the ED-user population, patients

were approached by interviewers in both waiting rooms and treatment areas based on convenience. Eligible patients were identified by researchers with assistance from staff physicians and registered nurses to ensure they met inclusion criteria. After obtaining verbal patient consent, researchers verbally administered the questionnaire, using SurveyMonkey (San Mateo, CA) software to electronically record the anonymized responses. Data was collected throughout June–July 2018 at all three EDs during daytime hours. We obtained ethical approval from the University of Saskatchewan research ethics board prior to conducting the questionnaires.

The anonymous questionnaire (Appendix I) consisted of eight demographic questions, including age, gender, ethnicity, nationality, employment status, and whether the individual had a family doctor. If participants responded "yes" to "do you smoke cigarettes now?", they were asked an additional 16 questions. These questions served to further evaluate participants' smoking habits, nicotine dependence, readiness to quit, and receptiveness to potential ED-based smoking cessation interventions. To assess for correlations between smoking status and acuity level, chief complaint, and CTAS scores, these scores were inputted after the survey, but no other personal information was recorded. CTAS is a triaging tool used in EDs across Canada and internationally, which scores patients based on chief complaint, vitals, and other parameters.[20] A scale of 1 (acute life-threatening condition) to 5 (non-urgent presentation) is used.

Questionnaire Development

The questionnaire was developed for the purpose of this study and has not been validated previously. However, many individual survey questions have been validated in previous studies. Smoking status was assessed by asking "do you smoke cigarettes now?", a phrase that has been validated previously, and correlated with breath carbon monoxide tests.[8,9,21] Readiness to quit was determined by asking whether the patient wanted to quit, followed by whether he or she wanted to quit within the next one month or six months. Classifying when a patient wants to quit can predict their current stage of change. Previous literature in New Zealand has demonstrated that participants wanting to quit within a month are more likely to be in a preparation stage than participants who expressed just wanting to quit.[22]

We used the Fagerström Test for Nicotine Dependence (FTND) to stratify individuals' nicotine addiction[23] into categories of minimal, moderate, or high nicotine dependence. This tool is composed of six questions that explore the smoking characteristics of participants. The FTND has been validated as an accurate predictor of nicotine dependence internationally[24,25] and is frequently used to determine nicotine dependence.[7,8] Finally, participants who smoked were asked about willingness to participate in ED smoking cessation interventions including brief cessation counselling in the department, referral to quit smoking hotlines, and/or receiving a pamphlet about quitting. While not previously validated, phrasing of the brief cessation counselling question was identical to an Australian study on ED smoking prevalence.[7] Based on previous literature, the majority of ED smoking cessation studies have also included referrals to smokers' quit lines and pamphlets; thus, we included questions on patient receptiveness to those interventions.[15]

Data Analysis

Data were analyzed using SPSS software (IBM Corp, Armonk, NY) to determine smoking prevalence and compared to Statistics Canada data using chi-square and Cochrane-Armitage trend tests. Statistics Canada is the federally legislated statistics office, which organizes national surveys and a census every five years. We determined the Saskatchewan smoking rate by dividing the number of people aged 18 years or older who smoked daily in Saskatchewan in 2016[2] by 2016 census data of the Saskatchewan population aged 20 and older.[3] Age grouping in these two parameters varied, which made it impossible to compare between 18 years and older populations. Instead we chose to use the number of individuals in the provincial population aged 20 years and older who reported smoking daily, as any error would over-represent the smoking prevalence. Lastly, we used chi-square tests to compare population differences between active smokers wanting to quit and receive ED therapy, and those opposed to quitting and receiving ED therapy.

RESULTS

Of 1190 eligible participants who were approached to participate in the survey 112 declined, leaving a sample size of 1084 participants with 1078 disclosing smoking status. Of the completed questionnaires, 47.5% (n = 514) were completed at Royal University Hospital, 30.6% (n = 331) at St Paul's Hospital, and 22.0% (n = 238) at Saskatoon City Hospital; these proportions are representative of the patient distribution between the three Saskatoon EDs. Across the three sites, 19.6% (n = 211) of ED patients self-reported current cigarette smoking (Table 1). There was no difference in prevalence rates among the three sites ($P = 0.74$). Using Statistics Canada data, we calculated that the prevalence of daily cigarette smokers in Saskatchewan in 2018 was 14.65%.[2,3] Comparing to the prevalence of cigarette smoking in adult ED patients with the calculated Saskatchewan prevalence overall, the proportion of ED patients who currently smoke was significantly higher (95% confidence interval, 17.1-21.8%, $P < 0.0001$). No differences in CTAS score were noted between smoking and non-smoking cohorts, meaning that smoking patients on average did not present more acutely than non-smokers (Figure 1).

Variations between gender and citizenship status were minimal between groups. Interestingly, the 20-34 year age category made up a higher proportion of the smoking cohort (25.6%) compared to non-smokers (14.0%) ($P<0.0001$). Furthermore, 79.6% of ED patients who smoked indicated they had a family doctor, which was significantly lower than the non-smoking cohort at 91.4% ($P<0.0001$). The smoking cohort was also more likely to originate from countries outside of Canada, more likely to be currently employed or unemployed, and less

Table 1. Characteristics of surveyed patients in three Saskatchewan emergency departments.

	Current smokers (n = 211, 19.6%)	Non-smokers (n = 867, 80.4%)	P-value
Age, years, n (%)			
18-19	2 (1.0)	3 (0.3)	<0.0001
20-34	54 (25.6)	120 (13.8)	
35-44	28 (13.3)	83 (9.6)	
45-54	43 (20.4)	106 (12.2)	
55-64	47 (22.3)	127 (14.7)	
≥65	37 (17.5)	428 (49.4)	
Gender, n (%)			
Male	114 (54.0)	429 (49.6)	0.248
Female	97 (46.0)	436 (50.4)	
Citizenship status, n (%)			
Canadian	202 (96.2)	828 (95.5)	0.325
Permanent resident	8 (3.8)	30 (3.5)	
Non-permanent resident	0	9 (1.0)	
Country of origin, n (%)			
Canada	197 (93.8)	753 (86.9)	0.005
Outside of Canada	13 (6.2)	114 (13.1)	
Family physician, n (%)			
Yes	168 (79.6)	792 (91.4)	<0.0001
No	43 (20.4)	75 (8.6)	
Employment status, n (%)			
Employed	91 (43.1)	307 (35.4)	<0.0001
Family caregiver	7 (3.3)	16 (1.9)	
Retired/long-term disability	71 (33.7)	480 (55.4)	
Student	5 (2.4)	16 (1.9)	
Unemployed	37 (17.5)	48 (5.5)	
Hospital, n (%)			
Royal University	104 (49.3)	408 (47.1)	0.736
St. Paul's	65 (30.8)	265 (30.6)	
Saskatoon City	42 (19.9)	193 (22.3)	
CTAS, n (%)			
1	3 (1.4)	9 (1.04)	0.597
2	46 (22.0)	155 (17.9)	
3	89 (42.6)	392 (45.3)	
4	51 (24.4)	207 (23.4)	
5	20 (9.6)	102 (11.8)	

Among all patients surveyed, gender was missing for 2 patients, citizenship status was missing for 1 patient, country of origin was missing for 1 patient, hospital was missing for 1 patient, and CTAS scores were missing for 10 patients. Six patients did not disclose their smoking status. Among smokers, citizenship was missing for 1 patient, country of origin was missing for 1 patient, and CTAS scores were missing for 2 patients.
CTAS, Canadian Triage and Acuity Scale.

likely to be retired or on long-term disability.

The majority of the smoking cohort (88.1%) indicated they had begun smoking before age 20 (Table 2). Additionally, 73.8% reported they were interested in quitting, while 37.1% reported that their current visit to the ED had caused them to consider quitting. Based on Fagerström scores, nearly half of the smoking cohort was classified as having a minimal nicotine dependence. Of the three suggested ED cessation interventions, participants were most receptive to receiving ED cessation counselling (62.4%), followed by receiving a smoking cessation pamphlet (56.2%), and lastly being referred to a smoker's quit line (49.5%).

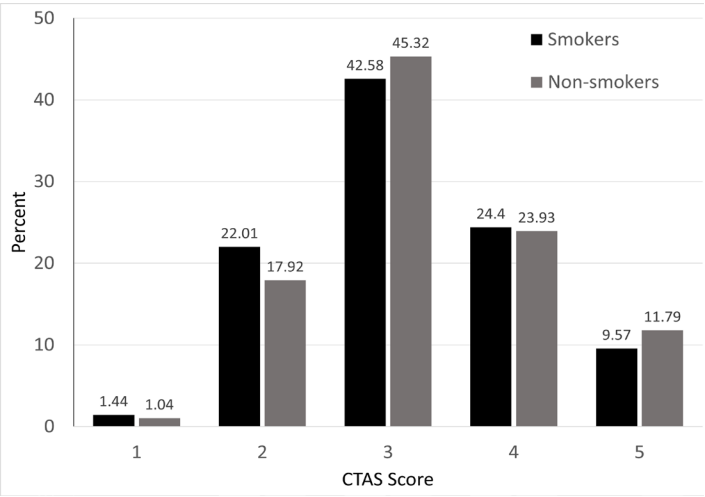

Figure 1. Comparison of Canadian Triage Acuity Scale scores between smoking and non-smoking ED patients.
CTAS, Canadian Triage and Acuity Scale.

Table 2. Smoking-related characteristics of Saskatchewan emergency department patients who reported smoking (N = 211).

	n (%)
Age when smoking started	
18-19 years	185 (88.1)
20-34 years	21 (10.0)
35-44 years	2 (1.0)
45-54 years	2 (1.0)
Believe ED visit related to smoking	43 (20.5)
ED visit has caused quitting consideration	78 (37.1)
Interested in quitting smoking	155 (73.8)
If yes:	
Within 1 month	118/155 (76.1)
Within 6 months	149/155 (96.1)
Nicotine dependency (Fagerström score)	
7-10 (high)	27 (12.8)
4-6 (moderate)	79 (37.4)
<4 (minimal)	105 (49.8)
Would undergo ED cessation counselling, if available	131 (62.4)
Referral to smoker cessation helpline	104 (49.5)
Pamphlet provided	118 (56.2)

ED, emergency department.

As demonstrated in Table 3, 51.4% (n = 211) of the smoking cohort indicated they were both interested in quitting and willing to receive ED-specific counselling. The demographics of smokers interested in quitting and those not interested were fairly homogenous. However, participants in the smoking cohort with less acute CTAS (ie, 4 or 5) scores were generally more receptive compared to those with more severe presentations. Incidentally, the smoking cohort at Royal University Hospital was significantly less receptive to quitting and receiving counselling in the ED than the other two urban hospitals ($P = 0.006$).

DISCUSSION

Based on our findings, the prevalence of cigarette smoking among adult ED patients (19.6%) was significantly higher than the general population prevalence (14.65%).[2,3] Similar to previous international studies assessing ED smoking habits, we also demonstrated an ED smoking prevalence that is significantly higher than the respective region.[5-8] This increased ED smoking prevalence is likely a multifactorial result of government policy, socioeconomic status, and healthcare system structure. ED patients who smoke were found to be younger than the non-smoking cohort, which is consistent with previous studies.[6-8] Additionally, ED patients who smoke also had lower rates of being retired or on long-term disability, and more likely to be either employed or unemployed. Similar employment trends have been previously demonstrated[7] and is likely secondary to the younger age of the cohort. Lastly, a higher proportion of ED patients who smoked were originally from outside Canada, which could be attributable to differences in government tobacco regulation in their countries of origin.

Interest in quitting was also comparable to international studies: 73.8% of the ED smoking cohort expressed interested in quitting, which was similar to Australian and New Zealand studies of 69.7-74.9%.[7,8] Furthermore, 51.4% (n = 108) of the smoking cohort were interested in both quitting and receiving ED-based support. Therefore, a targeted cessation intervention in the ED could potentially benefit a large number of active cigarette smokers. Identifying which patients within the smoking cohort might benefit from an intervention is difficult; however, CTAS 4 or 5 patients may be more interested in quitting than those with more acute CTAS scores. Quit attempts and prolonged abstinence rates have been demonstrated to be more efficacious in individuals with lower FTND scores.[26] As the majority of ED patients who smoke were categorized as having minimal to moderate nicotine dependence (87.2%), ED counselling and interventions could prove beneficial for smoking abstinence.

All three proposed smoking cessation interventions have been previously trialed in other EDs. Cessation counselling while in the ED was considered the most favoured modality among

Table 3. Smokers who expressed interest in quitting and were willing to receive cessation counselling in the emergency department.

	n (% wanting to quit)	P-value*
Age		
18-34 years	27 (49.1)	0.21
35-44 years	13 (46.4)	
45-54 years	25 (58.1)	
55-64 years	29 (61.7)	
≥ 65 years	14 (37.8)	
Age of initiation		
≤ 19 years	95 (51.4)	0.95
≥ 20 years	13 (52.0)	
Gender		
Male	54 (47.8)	0.25
Female	54 (55.7)	
Citizenship status		
Canadian	103 (51.2)	0.72
Permanent resident	5 (62.5)	
Country of origin		
Canada	102 (52.0)	0.68
Outside of Canada	6 (46.2)	
Family physician		
Yes	86 (51.5)	0.97
No	22 (51.2)	
Employment status		
Employed	46 (51.1)	0.69
Retired/Long-term disability	39 (54.9)	
Other	23 (46.9)	
Hospital		
Royal University	42 (40.4)	0.006
St. Paul's	40 (61.5)	
Saskatoon City	26 (63.4)	
Fagerström score		
7-10 (high)	16 (59.3)	0.30
4-6 (moderate)	44 (55.7)	
<4 (minimal)	48 (46.2)	
CTAS Score		
1 or 2	19 (38.8)	0.16†
3	49 (55.1)	
4	27 (52.9)	
5	13 (65.0)	

Comparison of demographic data, nicotine dependence, and CTAS score of smoking cohort interested in quitting and receptive to cessation counselling, with the smoking cohort not interested in quitting. One current smoker was missing information for all above variables; one additional patient was missing citizenship status, one was missing country of origin, and one was missing CTAS.
*P-value by chi-square test/Fisher's exact test; †Cochran-Armitage trend test P = 0.06, suggesting that the proportion of good candidates for cessation counselling may increase with higher CTAS scores.
CTAS, Canadian Triage and Acuity Scale.

patients; however, traditional counselling is limited by time constraints. The Ask-Advise-Refer motivational interviewing model is designed to take under three minutes,[27] and has been previously validated in the ED through training emergency nurses to administer the intervention.[14] Cessation pamphlets were also positively regarded by our ED patients, and could be used to connect them with community-based cessation resources. However, there is little evidence to support pamphlets as a stand-alone intervention.[15] While ED patients were least receptive to receiving a referral to smoking cessation helpline, it could be a feasible method to follow up with patients. Multifaceted interventions with repeated patient interactions improve the likelihood of a successful quit attempt.[28] However, not all ED cessation interventions have correlated to an improvement in patient abstinence rates.[15] This suggests that implementing an ED smoking intervention could be effective for initiating cessation; however, pairing the intervention with community-based supports for follow-up would likely improve cessation rates.

Furthermore, participants within the New Zealand and Australian studies reported interest in quitting at 74.9% and 69.7%, respectively, which is similar to our calculated 73.8%.[7,8] Patients' willingness to undergo brief ED counselling (62.4%) was also comparable (60.3%).[7] Similarly, receptiveness to receiving a smoking cessation pamphlet (56.2%) was comparable to interest in receiving a "quit smoking pack" in a New Zealand study (60.6%).[8] With these similarities in patient receptiveness to ED cessation modalities between countries, it is possible that successful interventions trialed in one country may be generalizable to others. As 88.1% of our ED patients who currently smoke began smoking before the age of 20, it could prove beneficial to further explore the utility of pediatric EDs as a screening location for cigarette use.

Interestingly ED patients who smoked both in our study and in the New Zealand study were less likely than non-smokers to have a family doctor.[8] While Canadian hospitals often have an inpatient-based smoking cessation protocol,[13] this has limited utility for most ED patients who are discharged without admission. As smoking cessation support is traditionally in the scope of the primary care physician, some of our patients who smoke may not be getting cessation support elsewhere.[6]

We encourage our colleagues to assess smoking status in their respective EDs. This will help determine whether our results, and the results of previous studies, are generalizable to the rest of our respective countries. Our next steps will be to develop a smoking cessation intervention that will benefit patients while remaining feasible for the unique and fast-paced environment of the ED.

LIMITATIONS

As we did not objectively measure whether a patient currently smoked, our data is based on self-reported responses, which could impact the validity of the study. Furthermore, our data was collected in 2018, while the most accurate available Statistics Canada data is from 2016, which could further impact validity. Additionally, our provincial prevalence calculation used the general population aged 20 years or older, while our data collected in the ED included people aged 18 years or older. It is possible this discrepancy could overestimate the provincial prevalence, making the ED smoking prevalence more significant. Due to the anonymity of the survey, it is possible that the questionnaire could have been completed more than once by the same participant; however, this is unlikely. As data collection was performed during daytime hours, it is also possible that patients presenting to the ED at night could have had a different smoking prevalence. Finally, the census questionnaire asked if patients smoked cigarettes "daily," while we asked if they smoked cigarettes "now," which could have created subjectivity of responses.

CONCLUSIONS

The prevalence of cigarette smoking in Saskatoon adult ED patients was found to be higher than the respective provincial and national rates, which is consistent with literature from other comparable countries. Over 50% of actively smoking patients indicated they wanted to quit smoking and would be receptive to receiving cessation counselling in the ED. These findings prime the ED as a novel location for initiating a smoking cessation intervention that is feasible, despite the fast-paced environment and limited capacity to provide follow-up support.

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Prompt Outpatient Care For Older Adults Discharged From The Emergency Department Reduces Recidivism

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Introduction: Older adults present unique challenges to both emergency clinicians and health systems. These challenges are especially evident with respect to discharge after an emergency department (ED) visit as older adults are at risk for short-term, negative outcomes including repeat ED visits. The aim of this study was to evaluate characteristics and risk factors associated with repeat ED utilization by older adults.

Methods: ED visits among participants in the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study between 2003-2016 were examined using linked Medicare claims data to identify such visits and resulting disposition. Multilevel proportional hazards models examined associations of age, comorbidity status, race, gender, Medicaid dual eligibility status, social support characteristics (living alone or caregiver support), and use of ambulatory primary and subspecialty care with repeat ED utilization.

Results: Older adults discharged from the ED seen by a primary care provider (hazard ratio [HR] = 0.93, confidence interval [CI], 0.87-0.98, p = 0.01) or subspecialist (HR = 0.91, CI 0.86-0.97, P <0.01) after the ED visit were less likely to return to the ED within 30 days compared to those who did not have such post-ED ambulatory visits. Additionally, comorbidity (HR =1.14, 95% CI ,1.13-1.16, P <0.01) and dual eligibility for Medicare and Medicaid (HR = 1.34, 95% CI, 1.20-1.50, p<0.01) were associated with return to the ED within 30 days. Those who were older (HR = 1.10, 95% CI, 1.05-1.15), had more comorbidities (HR = 1.17, 95% CI 1.15-1.18), Black (HR = 1.23, 95% CI, 1.14-1.33,P <0.01), and dually eligible (HR =1.23, 95% CI, 1.14-1.33, P <0.01) were more likely to return within 31-90 days after their initial presentation. The association of outpatient visits with repeat ED visits was no longer seen beyond 30 days. Patients without a caregiver or who lived alone were no more likely to return to the ED in the time periods evaluated in our study.

Conclusion: Both primary care and subspecialty care visits among older adults who are seen in the ED and discharged are associated with less frequent repeat ED visits within 30 days. [West J Emerg Med. 2020;21(6)198-204.]

INTRODUCTION

The unique characteristics and needs of older adults present numerous challenges to the healthcare system that serves them, particularly in the fast-paced, high-resource setting of the emergency department (ED). Compared to younger patients, geriatric patients use the ED at disproportionally higher rates.[1-3] Older patients seen in the ED are more likely to have extended lengths of stay, higher resource utilizations during their stays, and are more than three times as likely to be admitted to the hospital and five times more likely to be admitted to the intensive care unit, compared to younger patients.[2-6] The increased cost of acute care services is one of the highest drivers of Medicare spending. Shifting this expensive, inpatient care to the post-acute and outpatient setting is one way to reduce healthcare spending; however, discharging older patients after an ED visit is not without risk.

Older patients who are treated in the ED and discharged back to the community have considerably more repeat ED visits that are associated with increased morbidity, mortality, and healthcare costs.[7-9] Factors associated with repeat ED visits have not been thoroughly identified. Despite many emergency clinicians working to establish outpatient appointments prior to discharge, some smaller, single-center studies suggest outpatient follow-up after ED discharge may not reduce future ED utilization and repeat visits.[10,11]

With more than 20 million ED visits by patients over the age of 65 and the continued growth in this segment of the population, it is imperative that the healthcare system implement policies and practice guidelines that establish high-quality, low-cost care for geriatric patients seen in the ED. A shift to ambulatory care settings from the ED and a reduction in ED recidivism is likely to be one mechanism by which to achieve such a goal. As an initial step in helping to identify mechanisms for the delivery of higher value care, emergency clinicians, health system administrators, and policy makers would benefit from further identifying geriatric patients at particularly high risk for unplanned, return ED visits and factors associated with such events.

Population Health Research Capsule

What do we already know about this issue?
Repeat ED visits among older adults are associated with increased morbidity and healthcare costs.

What was the research question?
Do primary care or subspecialty outpatient visits after an index ED visit, reduce recidivism among older adults?

What was the major finding of the study?
Prompt outpatient care after an initial ED visit is associated with lower rates of repeat ED visits within 30 days, but this effect is lost beyond 30 days.

How does this improve population health?
For older adults discharged from the ED, the arrangement of prompt outpatient care prior to discharge may lead to higher value care among this patient demographic.

METHODS

We extracted data from participants enrolled in the national REasons for Geographic and Racial Differences in Stroke (REGARDS) study database. REGARDS is a national cohort study that was designed to identify causes of both regional and racial disparities in stroke incidence. Due to its rich data collection methods, large sample size and linkage to Medicare claims, the REGARDS study has been used to examine numerous medical conditions and procedures beyond stroke. Additional details about the enrollment and data collection procedures in the REGARDS study have been described elsewhere.[12]

Potential participants for the REGARDS study were randomly sampled from a commercially available nationwide list of names with a corresponding telephone number and address. This list was purchased from a telecommunications company (Genesys Inc.. Daly City, CA). Eventual participants were 45 or older at the time of enrollment and of either Black or White race, with oversampling of the "stroke belt" region (Southeastern United States). Those determined to be eligible for enrollment had a baseline telephone interview and in-home visit. Every six months, follow-up telephone interviews were conducted with inquiries about outpatient- and hospital-based medical services. All participants in REGARDS provided written informed consent for researchers to obtain their health records, including electronic records such as Medicare claims files.[13,14]

The REGARDS database offers researchers numerous social (eg, caregiver support, marital status, household income, and education) and medical (eg, chronic medical conditions, surgical history, medication usage, and alcohol/tobacco usage) characteristics of enrolled patients as well as linked Medicare claims for the large proportion of participants enrolled in fee-for-service (FFS) Medicare. Moreover, this database is representative of the US population older than 65 with FFS coverage.[15] All procedures were approved by the institutional review boards of participating institutions.

Medicare claims for ED visits were examined from 2003 to 2016. We identified patients with continuous FFS Medicare coverage in the preceding year and at least one ED visit resulting in discharge. Subsequent ED visits made within 1-30 and 31-90 days after the initial ED visit discharge were also identified for patients who had survived to 30 and 90 days,

respectively, and had FFS Medicare coverage during those time periods. The unit of analysis was the ED visit nested within individual participants. Many participants contributed multiple ED visits to the analysis.

Demographic data including age, race, gender, caregiving availability, marital status, other social support and self-reported health data including disease history and health-related quality of life were obtained from REGARDS from a computer-assisted telephone interview (CATI) conducted at entry into the REGARDS study. Other predictors such as Charlson Comorbidity Index (CCI) and Medicaid dually eligible status were obtained for all patients included from the linked Medicare claims data using procedures previously implemented by our team.[13] We identified outpatient visits by Current Procedural Technology codes specific to outpatient or home service provider care. Primary and subspeciality care was classified based on Centers for Medicare & Medicaid Services' provider speciality codes.

We used descriptive analyses to quantify the prevalence of ED visits and repeat ED visits within the 1-30 day and 31-90 day follow-up periods. We used multilevel Cox proportional hazards analysis, with the ED visit resulting in discharge as the primary unit of analysis, nested within individual participants.[16] A robust sandwich estimate of the covariance matrix was used to account for the clustering of qualifying ED visits within participants.[17] Race, gender, marital status, caregiver availability and living alone – assessed at entry into the REGARDS study – were treated as time-invariant, person-level covariates. We treated age, CCI, and dual eligibility as covariates that are fixed for each visit but may vary across visits. Outpatient care visits were treated as time-varying covariates within each follow-up period.[18]

RESULTS

Figure 1 provides a schematic representation of those patients included in our analysis. A total of 30,239 individual participants were enrolled into the REGARDS study with 19,051 ever having FFS (Medicare Parts A and B) but no health maintenance organization (Medicare Part C) coverage at the same time. For these 19,051 patients, 79,239 ED visits were observed in the Medicare claims for 13,781 patients who had at least one such visit. Of those visits, 49,278 visits (by 11,989 patients) did not result in hospitalization. Of those that did not result in hospitalization, 96% resulted in a discharge home. Those patients who had continuous Medicare coverage in the preceding year accounted for 45,050 total visits by 11,152 patients. Of these patients, 10,858 (who accounted for 43,574 visits) survived at least 30 days and continued to have Medicare FFS coverage during that time. Among these patients, the mean number of ED visits per patient was 4.01 (standard deviation = 5.0) with a median of 2.0 (Q1=1.0, Q3=5.0). Further participant characteristics at the time of the first ED visit are included in Table 1.

In the 30-day follow-up group, 20.9% (n = 9,118) of ED visits were followed by a repeat visit. An additional 19.4% (n = 6,441) of the initial ED visits were followed by a repeat ED visit within 31-90 days. For the entire 90-day period, which includes only those patients who survived from day 1 through day 90, there were 14,898 repeat ED visits of 41,664 initial visits with a return rate of 35.8%. Of older adults seen in the ED for an initial visit and then discharged, those patients with a higher CCI (hazard ratio [HR] =1.14, 95% confidence interval [CI], 1.13-1.16, P <0.01) and who were dually eligible for Medicare and Medicaid (HR = 1.34, 95% CI, 1.20-1.50, P <0.01) were more likely to have returned to the ED within 30 days. With respect to age, gender, race (Black vs White) or marital status, there were no significant differences in return ED visits at 30 days.

Older patients (HR = 1.10, 95% CI, 1.05-1.15), those with more comorbidities (HR = 1.17, 95% CI. 1.15-1.18) as well as dually eligible Medicare and Medicaid beneficiaries (1.49, 95% CI, 1.35-1.64) continued to be more likely to return to the ED within 31-90 days (all P values <0.01). During this follow-up period, however, Black patients were found to be more likely than Whites to return to the ED (HR =1.23, 95% CI, 1.14-1.33, P <0.01). Gender as well as marital status, as in the 30-day follow-up group, were not associated with an increase in return ED visits.

From an outpatient medical resource standpoint, both primary care (HR = 0.93, CI, 0.87-0.98, P = 0.01) and subspecialty care (HR = 0.91, CI, 0.86-0.97, p<0.01) was associated with reduced 30-day repeat ED visits. However, within the 31-90 days follow-up period, this association was no longer seen for either primary care or subspecialty care. For patients who did not return to the ED within 30 days, the average time from ED discharge to primary care visit and subspecialty visit was 10.2 and 11.1 days, respectively. With respect to social support resources, those patients without an available caregiver or who reported living alone, were no more likely to return to the ED than those with such resources for both the 30-day and 31-90 day time periods respectively (Table 2).

DISCUSSION

Within a population of older adults seen in the ED, we found that 20.9% of initial ED visits resulting in discharge were followed by another ED visit within 30 days. For all initial ED visit by patients who survived to 90 days, 35.8% were followed by another ED visit within 90 days. However, older adults who saw a primary care provider (PCP) or subspecialist after the index ED visit were significantly less likely to have a repeat ED visit within 30 days compared to those patients who did not have an ambulatory outpatient visit. These findings were not seen among older adults beyond 30 days, suggesting that prompt outpatient follow-up — that is, follow-up within 10-12 days — is more beneficial than delayed outpatient follow-up. These findings are consistent with similar studies looking at the utility of prompt vs delayed primary care follow-up, albeit in a younger patient population and within the confines of a specific "rapid-access-to-primary-care" program.[19] Other specific characteristics that impact the likelihood of ED recidivism

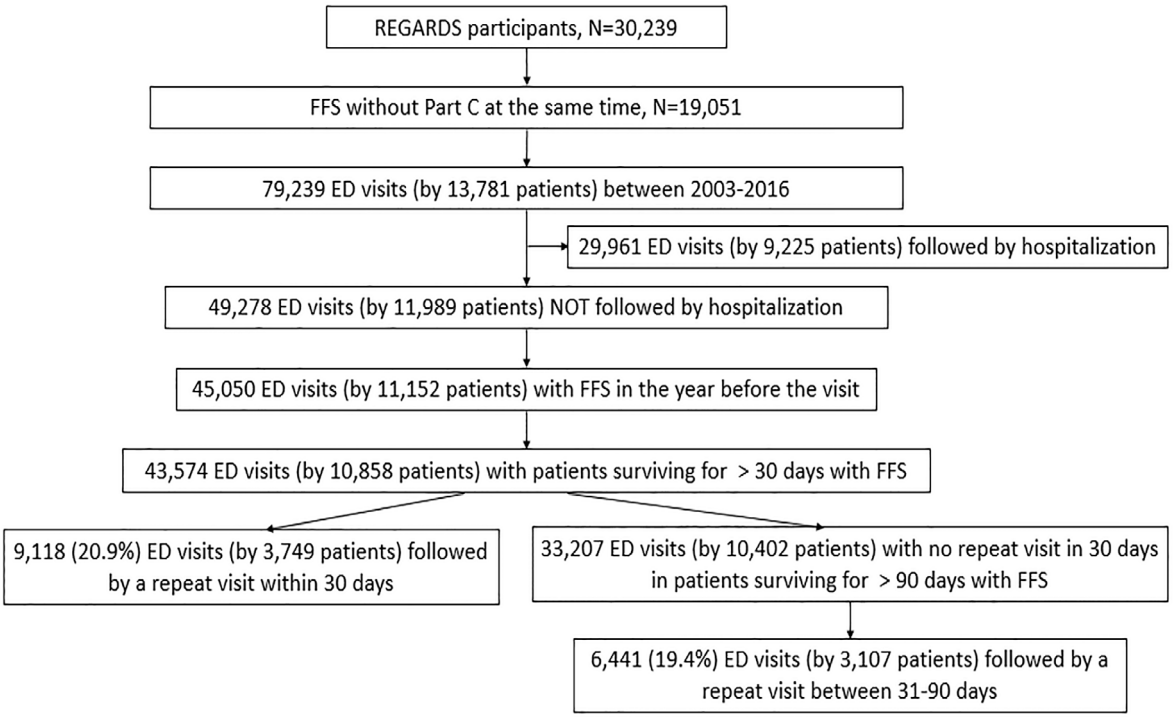

Figure 1. REGARDS participants between 2003-2016 included in analysis.
REGARDS, REasons for Geographic and Racial Differences in Stroke; *ED*, emergency department, *FFS*, Medicare fee for service.

Table 1. Participant characteristics at first ED emergency department visit from REGARDS.*

Variable	N = 10,858
Age at 1st ED visit, mean (SD)	73.36 (7.91)
CCI, mean (SD)	1.43 (1.80)
Female, n (%)	5,857 (53.94)
Black, n (%)	3,993 (36.77)
Dual eligible, n (%)	1,438 (13.24)
Marital status, n (%)	
Married	6,215 (57.24)
Divorced	1,418 (13.06)
Single	423 (3.90)
Widowed	2,558 (23.56)
Other	244 (2.25)
Available caregiver, n (%)	8,714 (80.25)
Living alone, n (%)	3,249 (29.93)

**REGARDS*, REasons for Geographic and Racial Differences in Stroke; *ED*, emergency department; *CCI*, Charlson Comorbidity Index; *SD*, standard deviation.

among older Medicare beneficiaries include advanced age and dual eligibility status, as well as comorbidity status as measured by the CCI.

Some studies have examined the association between social factors and ED recidivism. Specifically, veterans with chronic obstructive pulmonary disease were found to be more likely to return to the ED within two weeks if they were widowed, separated, or divorced.[20] A related study showed older men living alone were more likely to return to the ED within 90 days compared to older men living with someone else.[21] Other social factors such as the role caregivers play in ED usage is well documented in the pediatric literature but less so in older patients. One study that examined ED use after stroke demonstrated an association between caregiver support and a reduction in ED visits.[13] Overall reported poorer health status, lower education level, and lower household income have been associated with an increase in ED use among all patients. However, these associations, specifically among older patients and return ED visits, have not been sufficiently demonstrated.[22]

In our study, social factors such as the lack of an identified caregiver and living alone were not associated with an increase in ED visits at 30 days or between 31-90 days. This may relate to the characteristics of older adults who are receiving help from a caregiver. Specifically, these individuals may have more complicated medical conditions or be more likely to require assistances with self-care activities compared to older adults without such caregiver support.[23,24] This may predict a population that is more likely to require hospital-based services such as emergency care and thus offset any benefit having a caregiver may offer.

Table 2. Multivariable Cox proportional hazard models on time to repeated emergency department visit.

	30 days (n = 10,858, 43,574 ED visits)		30-90 days (n = 10,402, 33,207 ED visits)	
Variable	Hazard ratio (95% CI)	P-value	Hazard ratio (95% CI)	P-value
Age at index ED visit (10-year)	1.04 (0.99, 1.09)	0.16	1.10 (1.05, 1.15)	<0.01
CCI (1 unit)	1.14 (1.13, 1.16)	<0.01	1.17 (1.15, 1.18)	<0.01
Female vs male	0.96 (0.89, 1.04)	0.36	0.98 (0.90, 1.07)	0.68
Black vs White	1.02 (0.94, 1.11)	0.68	1.23 (1.14, 1.33)	<0.01
Dual eligible	1.34 (1.20, 1.50)	<0.01	1.49 (1.35, 1.64)	<0.01
Marital status				
Divorced vs married	1.04 (0.89, 1.21)	0.66	1.06 (0.91, 1.22)	0.46
Other vs married	0.97 (0.78, 1.20)	0.77	1.16 (0.93, 1.45)	0.20
Single vs married	1.01 (0.83, 1.23)	0.89	1.07 (0.88, 1.30)	0.51
Widowed vs married	1.04 (0.91, 1.18)	0.56	1.05 (0.93, 1.18)	0.41
Available caregiver	0.94 (0.85, 1.04)	0.20	0.95 (0.87, 1.04)	0.26
Living alone	1.11 (0.99, 1.24)	0.09	1.06 (0.96, 1.17)	0.28
Primary care visit	0.93 (0.87, 0.98)	0.01	1.05 (0.99, 1.11)	0.13
Subspecialty visit	0.91 (0.86, 0.97)	<0.01	1.04 (0.99, 1.11)	0.14

CI, confidence interval; *ED*, emergency department; *CCI*, Charlson Comorbidity Index.

There is considerable controversy in the literature with respect to the use of the ED by Black patients compared to White patients with some studies suggesting an increased use among Blacks while other studies showing similar use patterns across races.[25-28] As in the previously published literature, our study showed mixed results with no difference in repeat visits within 30 days. However, between the 31- and 90-day follow-up time period, Blacks were more likely to return to the ED compared to White patients.

Although reassuring timely outpatient primary and subspecialty care offers protective benefits for Medicare beneficiaries discharged from the ED, improvements in transitional care between the ED and ambulatory providers must also be made. Currently there are no standardized communication handoff tools used by emergency providers to ensure consistent communication with their primary care or other ambulatory colleagues.[29] This lack of standardized communication gap is appreciated by both emergency clinicians and PCPs alike and is associated with increased ED length of stay as well as consuming time and resources in the primary care setting.[30,31]

To our knowledge, the protective nature of both primary care and subspecialty follow-up visits after an ED discharge in older adults has not been described before with respect to ED recidivism. This has very important pragmatic implications for practicing emergency clinicians. Moreover, the findings are of interest to healthcare administrators and payers in an environment where there is continued pressure to provide lower cost outpatient services in lieu of expensive, hospital-based care.

LIMITATIONS

Limitations of our study include reliance on both claims data as well as on self-reported survey results. With respect to claims data, our analysis looked at the FFS Medicare population and may not be generalizable to all older adults. Additionally, healthcare claims are generated for payment purposes and may not totally capture the specific care a patient received. It is possible, for example, that some patients received outpatient clinical services after an ED visit, which were not reflected in the claims for payment. However, given that a provider's reimbursement for services would be adversely impacted by not filing a claim, we feel the number of outpatient visits that did not generate a claim would be very small.

Additionally, our study primarily looked at community-dwelling older adults who were discharged from the ED, which would exclude those who transitioned to skilled nursing facilities or other short-term rehabilitation units; however, we would anticipate this number to be low and therefore unlikely to change our results. It should further be noted that the residential status and the availability of a caregiver was obtained at the time of REGARDS enrollments, not necessarily at the time of ED visit, and such status could have changed over time.

CONCLUSION

Prompt primary care and subspecialty care for older adults who were seen in the ED and discharged home was associated with lower rates of subsequent, repeat ED visits within 30 days. This protective effect is lost beyond 30 days, suggesting outpatient follow-up should occur within 10-12 days to prevent ED recidivism.

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Reducing Emergency Department Transfers from Skilled Nursing Facilities Through an Emergency Physician Telemedicine Service

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Introduction: Transfers of skilled nursing facility (SNF) residents to emergency departments (ED) are linked to morbidity, mortality and significant cost, especially when transfers result in hospital admissions. This study investigated an alternative approach for emergency care delivery comprised of SNF-based telemedicine services provided by emergency physicians (EP). We compared this on-site emergency care option to traditional ED-based care, evaluating hospital admission rates following care by an EP.

Methods: We conducted a retrospective, observational study of SNF residents who underwent emergency evaluation between January 1, 2017–January 1, 2018. The intervention group was comprised of residents at six urban SNFs in the Northeastern United States, who received an on-demand telemedicine service provided by an EP. The comparison group consisted of residents of SNFs that did not offer on-demand services and were transferred via ambulance to the ED. Using electronic health record data from both the telemedicine and ambulance transfers, our primary outcome was the odds ratio (OR) of a hospital admission. We also conducted a subanalysis examining the same OR for the three most common chronic disease-related presentations found among the telemedicine study population.

Results: A total of 4,606 patients were evaluated in both the SNF-based intervention and ED-based comparison groups (n=2,311 for SNF based group and 2,295 controls). Patients who received the SNF-based acute care were less likely to be admitted to the hospital compared to patients who were transferred to the ED in our primary and subgroup analyses. Overall, only 27% of the intervention group was transported to the ED for additional care and presumed admission, whereas 71% of the comparison group was admitted (OR for admission = 0.15 [9% confidence interval, 0.13-0.17]).

Conclusion: The use of an EP-staffed telemedicine service provided to SNF residents was associated with a significantly lower rate of hospital admissions compared to the usual ED-based care for a similarly aged population of SNF residents. Providing SNF-based care by EPs could decrease costs associated with hospital-based care and risks associated with hospitalization, including cognitive and functional decline, nosocomial infections, and falls. [West J Emerg Med. 2020;21(6)205-209.]

INTRODUCTION

Transfers from skilled nursing facilities (SNF) to the emergency department (ED) account for approximately 14 million ED visits annually, a fifth of which may be avoidable.[1] In many cases, ED visits lead to admission, which in turn conveys risks of cognitive and functional decline, nosocomial infections, and falls.[2,3] Furthermore, for the frailer subpopulation of SNF residents transferred to the ED, up to 78% of their resulting

hospitalizations are potentially avoidable.[4] Several solutions have been proposed to reduce admissions for these patients. One is to improve the quality of ED care for seniors and SNF residents through the development of geriatric-focused emergency care, and improved communication between SNFs and EDs.[5] Incentive programs have also been established to improve longitudinal management of chronic medical conditions by SNFs, reducing transfers for patients with congestive heart failure (CHF) and diabetes mellitus (DM).[6,7]

Few studies have targeted the scenario that often triggers a transfer: when the SNF resident has an acute medical condition such as a fall, a fever, or an exacerbation of a chronic disease. Many SNFs retain on-call medical staff, but most lack the infrastructure to manage acute unscheduled care, particularly after-hours, and SNF healthcare teams often have little recourse other than to call 911 when patients need evaluation.[8-10] One potential intervention to address this scenario is enlisting a physician via telemedicine to evaluate patients with acute care needs at the SNF. Telemedicine consults have been successfully used within EDs for a variety of subspecialties; providing rapid evaluations within the SNF setting could obviate transfers for minor injuries. Prompt evaluations could enable earlier interventions in acute infections and chronic disease exacerbations, potentially preventing the need for ED transfers or facilitating earlier transfers when warranted.

Objectives

Our primary objective was to determine whether a SNF-based telemedicine consultation service staffed by emergency physicians (EP) could reduce hospital admissions of patients requiring acute evaluation, compared to patients who were taken directly to an ED. Our secondary objectives were to compare care escalation for conditions most amenable to on-site acute care in the SNF, and to broadly examine the financial implications of on-site acute care.

METHODS

Study Setting and Design

This was a retrospective, observational study of SNF residents between January 1, 2017–January 1,2018. The intervention group comprised residents of six urban SNF facilities in the Northeastern United States, who underwent an acute telemedicine evaluation.[11] The telemedicine service consists of an on-demand consultation by an EP, facilitated by a clinical care specialist (CCS) who is a paramedic or emergency medical technician on-site at all times. The service is used for acute evaluations when facility staff judged that patients would otherwise require ED transfer. The CCS uses a cart with point-of-care labs, electrocardiograms, telemetry, and ultrasound (Figure 1). Patients can also be directly transported for outpatient imaging (eg, chest radiograph and computed tomography. Order sets and pathways are used to streamline decisions to treat in place or transfer. The CCS monitors SNF residents in accordance with EP orders and can re-initiate consultations. If the patient cannot be definitively managed on-site, or if the patient or family prefers transfer, the EP directs staff to carry out immediate treatments and expedite transport.

The control group consisted of residents of SNFs that did not offer telemedicine evaluations. These residents were transferred via ambulance to the ED of an urban tertiary care hospital with 55,000 visits annually. Patients were broadly matched on age and gender. The study was approved by the institutional review board of the tertiary care hospital.

Protocol

We used electronic health record (EHR) data from the telemedicine service and the tertiary care hospital to abstract age, gender, chief complaint, and disposition. Data were de-identified in accordance with the Health Insurance Portability and Accountability Act-Safe Harbor criteria.

Analysis

Our primary outcome was whether a patient was ultimately admitted to the hospital. For the intervention group, EHR data beyond the telemedicine visit was not available; hence, we could not definitively determine whether the patient was admitted after ED transfer. To address this limitation, we conservatively designated any patient in the intervention group who was transferred to the ED as admitted. This should underestimate the potential benefit of the intervention, as in the general Medicare

Figure 1. Clinical care specialist telemedicine cart in a skilled nursing care facility.

population only about 30% of those treated in the ED are admitted as inpatients.[12] The use of a full calendar-year period was intended to avoid the potential confounding effects of seasonality. The two populations were tested for demographic concordance in terms of age using an independent t-test and gender using a Fisher's exact test, and a logistic regression was conducted with both features relative to the outcome to examine whether they played a role as confounders.

Patients in the control group were evaluated in the ED and designated as either admitted or discharged. Patients were considered discharged from the ED if they did not have an inpatient admission, or if they were directly discharged to their original facility, discharged to acute rehab, or discharged after observation care in the ED. For our primary outcome, we report the odds ratio (OR) of admission with 95% confidence interval (CI). As a significant potential benefit of telemedical care for SNFs is early intervention in chronic disease exacerbations, we conducted a subanalysis examining the OR of admission across the three most common chronic disease-related presentations found among the study population, with strict Bonferroni correction for multiple comparisons.

RESULTS

A total of 2311 patients were evaluated in the SNF-based group, matched with 2295 patients in the control group. The groups had similar distributions by gender (intervention group: 60.2% female; control group 58.1% female; $p = 0.14$), but the control group was slightly older (intervention group: 75.6 [standard deviation (SD) 12.3]; control group 78.9 [SD 8.14]; $p<0.001$). A logistic regression demonstrated no significant association between these factors and admission. The most common reasons for telemedicine activation were exacerbations of CHF, chronic obstructive pulmonary disease (COPD), and DM (Table 1). The mean cost of the telemedicine care delivery in this study was $816 per episode.

Patients who received SNF-based acute care were less likely to have their care escalated. Only 27% of the SNF-based group were transferred to the ED, whereas 71% of the control group were admitted to the hospital from the ED (OR = 0.15 (95% CI, 0.13-0.17), $p < 0.001$, Table 1). These results were directionally consistent across the top three conditions, although rates of presentation for all three were significantly higher in the SNF-based group (Table 1).

DISCUSSION

Telemedicine has been heralded as a panacea to many systemic problems in healthcare; although widespread adoption continues[13] its proven benefits are more modest. Many studies examining telemedicine across settings have failed to find compelling clinical or cost benefits,[14-16] although patients are often satisfied with these services and remain optimistic about their potential.[17,18] The most successful applications of telemedicine have been subspecialty consultations in resource-limited settings. In the ED, this includes tele-neurology for acute stroke, remote radiology,[19-23] and psychiatric evaluations.[24,25] Telemedicine has also shown promise within SNFs for chronic disease management and related hospitalizations.

A pilot study by Dy et al demonstrated that a telemedicine team of an endocrinologist, nurse, and dietician improved glycemic control for SNF residents.[26] Grabowski et al demonstrated a trend toward reducing unnecessary transfers by replacing SNFs' on-call physicians with telemedicine, but had limited utilization of their service.[27] More recently, Gillespie et al showed telemedicine reduced ED utilization for patients with dementia in senior living communities.[28]

The intervention evaluated in our study lies at the intersection of these trends, providing an EP as a specialty consultant. The potential to decrease ED transfer and hospital admission is facilitated by the CCS and expanded diagnostic tools, allowing the EP to conduct much of an ED workup in situ.

Table 1. Care escalation processes for different conditions in telemedicine and control group.

Medical complaint and care escalation	Telemedicine group	Control group	OR (95% CI)	P-value
All conditions, n	2,311	2,295		
Care escalation, n (%)	623 (27)*	1,629 (71)†	OR 0.15 (0.13-0.17)§	< 0.001
CHF, n (% all visits)	576 (25)	314 (14)		
Care escalation, n (%)	156 (26)*	257 (82)†	OR 0.08 (0.06-0.11)§	< 0.001
COPD, n (% all visits)	607 (26)	363 (16)		
Care escalation, n (%)	158 (26)*	265 (73)†	OR 0.13 (0.10-0.18)§	< 0.001
DM, n (% all visits)	761 (33)	234 (10)		
Care escalation, n (%)	213 (28)*	152 (65)†	OR 0.21 (0.15-0.29)§	< 0.001

*Denotes transfer to the emergency department (ED)

†Denotes admission to the hospital.

§For the purposes of this analysis it was assumed all telemedicine patients transferred to the ED were admitted; lower odds ratio indicating lower odds of admission in the telemedicine group.

OR, odds ratio; *CI,* confidence interval; *CHF,* congestive heart failure; *COPD,* chronic obstructive pulmonary disease; *DM,* diabetes mellitus.

Furthermore, the ability of the CCS to fulfill medication orders and re-initiate consultation effectively allows for observation care at the SNF.

While rigorous cost-effectiveness studies of telemedicine are lacking,[15,16,29] the complexity of the interventions in this study invariably comes at increased cost. The average cost of the telemedicine service in this study was $816 per episode, compared to the flat rate of $30,000 per facility per year charged by Grabowski et al. Amortized across 2311 consultations in six SNFs over a one-year period, this represents a more than tenfold increase. Conversely, the average Medicare payment for a SNF-based rehospitalization is over $10,000.[30] Considering the added expenses of ambulance transportation and EP fees, this enhanced telemedicine service would be cost-effective if it averted 10% of hospitalizations. The data from this program suggests an 80% reduction in care escalation, suggesting this is a worthwhile investment, irrespective of the clinical benefits from avoiding unnecessary admissions.

LIMITATIONS

This study has several significant limitations. It is possible that the telemedicine program was activated for conditions where the staff would not automatically initiate transport to the ED, and SNFs may have substantial differences in their threshold for transferring patients; however, a similar reduction was seen in patients with COPD and CHF exacerbations, conditions where ED transfer is typically required. The lack of follow-up information for the intervention group obscures patients' disposition after ED transfer, which we addressed by conservatively assuming these patients were admitted when many may have been observed or discharged directly. Seasonality is also a potential confounding factor, as during flu season facilities without the capacity to test or cohort patients may be more inclined to transfer patients. Finally, as a pilot study our analysis does not include specific markers of disease severity, such as oxygen saturation during COPD and CHF exacerbations, which could substantially affect the effects of the intervention. More robust matching of the groups (eg, propensity-score matching on age and comorbid conditions) would improve the generalizability of our results.

CONCLUSION

In this pilot study, emergency physician-staffed telemedicine acute evaluations of SNF residents were associated with lower rates of hospital admissions than typical ED care, including in exacerbations of chronic diseases such as COPD and CHF, which represented a substantial portion of overall evaluations in the intervention group. The COVID-19 pandemic has broadly increased the tempo and urgency of telemedicine use; however, more in-depth studies are needed to determine whether these interventions result in longer-term reductions in chronic disease exacerbations and hospitalization rates among SNF residents. While comprehensive cost data for admitted patients was not available in this study, the reduced likelihood of hospital transport and admission for SNF residents may justify the increased upfront costs of a comprehensive telemedicine evaluation.

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Predictors of Mortality in Elderly and Very Elderly Emergency Patients with Sepsis: A Retrospective Study

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Introduction: Elderly patients are at increased risk of developing sepsis and its adverse outcomes. Diagnosing and prognosing sepsis is particularly challenging in older patients, especially early at emergency department (ED) arrival. We aimed to study and compare the characteristics of elderly and very elderly ED patients with sepsis and determine baseline factors associated with in-hospital mortality. We also compared prognostic accuracy of the criteria for systemic inflammatory response syndrome, quick sequential organ failure assessment (qSOFA), and the National Early Warning Score in predicting mortality.

Methods: We conducted a retrospective study at the ED of Siriraj Hospital Mahidol University in Bangkok, Thailand. Patients over 18 years old who were diagnosed and treated for sepsis in the ED between August 2018–July 2019 were included. We categorized patients into non-elderly (aged <65 years), elderly (aged 65-79 years), and the very elderly (aged >80 years) groups. The primary outcome was in-hospital mortality. Baseline demographics, comorbidities, source and etiology of sepsis, including physiologic variables, were compared and analyzed to identify predictors of mortality. We calculated and compared the area under the receiver operator characteristics curves (AUROC) of early warning scores.

Results: Of 1616 ED patients with sepsis, 668 (41.3%) were very elderly, 512 (31.7%) were elderly, and 436 (27.0%) were non-elderly. The mortality rate was highest in the very elderly, followed by the elderly and the non-elderly groups (32.3%, 25.8%, and 24.8%, respectively). Factors associated with mortality in the very elderly included the following: age; do-not-resuscitate (DNR) status; history of recent admission <3 months; respiratory tract infection; systolic blood pressure <100 millimeters mercury (SBP<100); oxygen saturation; and Glasgow Coma Scale (GCS) score. Factors associated with mortality in the elderly were DNR status, body temperature, and GCS score. qSOFA had the highest AUROC in predicting in-hospital mortality in both very elderly and elderly patients (AUROC 0.60 [95% confidence interval {CI}, 0.55-0.65] and 0.55 [95% CI, 0.49-0.61, respectively]).

Conclusion: The mortality rate in the very elderly was higher than in the younger populations. Age, DNR status, recent admission, respiratory tract infection, SBP<100, oxygen saturation. and GCS score independently predicted hospital mortality in very elderly patients. The qSOFA score had better but only moderate accuracy in predicting mortality in elderly and very elderly sepsis patients. [West J Emerg Med. 2020;21(6)210-218.]

INTRODUCTION

The elderly population is increasing worldwide due to an increase in life expectancy and a decrease in birth rate. It is estimated that this population will grow the most rapidly and will surpass that of the younger population by 2050.[1] The use of healthcare resources is thereby increasing, as more than half of patients requiring intensive care unit (ICU) admissions are elderly (aged over 65 years).[2-4] As for the emergency department (ED), the mean age of ED patients is also increasing. Elderly patients have become "frequent users" of the ED.[5-6]

Sepsis is a state of organ dysfunction caused by dysregulated host response to infection.[7-8] It is a critical condition leading to a high rate of mortality and is considered a significant health problem worldwide. The incidence of sepsis increases with age, especially in very elderly patients (age ≥80 years), and mortality is also significantly higher in this population.[9-10] This high incidence and mortality could be explained by various reasons, such as multiple pre-existing comorbidities, reduced functional reserve, and abnormal immune system.[11] Diagnosing sepsis is also more difficult, given elderly patients' vague symptoms and atypical clinical presentations. This poses an extreme challenge for emergency physicians to recognize such patients early, especially those at greater risk of adverse outcomes.

Various diagnostic and prognostic tools have been developed and/or validated to help predict poor prognosis in suspected sepsis patients early at presentation to the ED. These tools include criteria developed especially for sepsis, such as systemic inflammatory response syndrome (SIRS),[12] and the quick sequential organ failure assessment (qSOFA).[7] Criteria such as the National Early Warning Score (NEWS) have been developed for other purposes but validated to predict outcomes of sepsis.[13] These scoring systems consist of physiologic variables, such as vital signs and mental status. They have been frequently used tools to predict mortality secondary to sepsis in the ED.[14-16] However, with distinctive clinical presentations in the elderly, the accuracy of these criteria may be different. To date, no studies have validated or compared these scoring systems in the ED in this specific population.

Although the mortality rate from sepsis is exceptionally high in geriatric patients, little is known about the predictive factors of this adverse outcome, especially in the very elderly group. Therefore, we conducted this study to examine the characteristics and determine factors associated with in-hospital mortality in elderly and very elderly patients who presented to the ED with sepsis. We also aimed to study the accuracy of SIRS, qSOFA, and NEWS in predicting mortality in these patients.

Population Health Research Capsule

What do we already know about this issue?
Elderly patients are at increased risk of developing sepsis and its adverse outcomes. Diagnosing and prognosing sepsis in the elderly is particularly challenging.

What was the research question?
We sought to determine baseline factors associated with in-hospital mortality of elderly ED patients with sepsis.

What was the major finding of the study?
Age was associated with mortality only in the very elderly. qSOFA had the best prognostic utility in these patients.

How does this improve population health?
If the factors associated with sepsis in elderly patients are better understood, more appropriate care can be guided toward high-risk patients.

METHODS

Study Design and Setting

We conducted a retrospective study at the ED of Siriraj Hospital, Mahidol University in Bangkok, Thailand. Siriraj Hospital is the largest tertiary university hospital in Thailand, with over 20,000 ED visits per year. Siriraj Institutional Review Board approved the study (certificate of approval Si 510/2019). Patients' informed consent was waived.

Patients

We assessed ED patients retrospectively and consecutively for eligibility between August 1, 2018–July 31, 2019. Adult patients aged >18 years were eligible if they were suspected of having sepsis, were treated accordingly in the ED and were discharged from the hospital with sepsis-related diagnoses (ie, sepsis, sepsis-induced hypotension, and septic shock) based on Sepsis-3.[7] The attending emergency physicians suspected sepsis based on SIRS or qSOFA, together with clinical judgment. This suspicion of sepsis was defined by having ordered a hemoculture followed by having prescribed intravenous antibiotics, or vice versa. All patients received antibiotics within one hour after sepsis suspicion. The diagnosis of sepsis was confirmed during admission by internal medicine or ICU attending physicians. Patients with prescribed empirical antibiotics who were not considered to have sepsis and later had antibiotics ceased were excluded. After inclusion, we categorized patients by their age according to the most-often referred term into the non-elderly (aged >18 and <65 years), elderly (aged at ≥65 and <80 years), and very elderly (aged ≥80 years) patients.

Data Variables

When patients visit the ED, they are assessed by triage nurses who record their initial vital signs in the standing triage form, before being assessed by emergency physicians. Afterward, patients' vitals were routinely recorded every two hours. We extracted the following data from their medical records: age; gender; body temperature; heart rate; respiratory rate; blood pressure; oxygen saturation measured by pulse oximetry; mental status reported as Glasgow Coma Scale (GCS) score; baseline functional status; and comorbidities. We also collected laboratory results, management in the ED, diagnosis, disposition, outcomes, and any other relevant data. An emergency medicine resident (PM), trained by the attending emergency physician researchers (CL and OR), was the data abstractor. Another physician (OR) randomly audited the recorded data for its completeness and reliability. Interobserver agreement measured by weighted kappa on mortality status and early warning score values were 1.0 and 0.98, respectively. Respiratory rate ≥22 breaths per minute and systolic blood pressure ≤100 milligrams mercury (SBP≤100) were cut-points chosen to be analyzed according to qSOFA. Infection was deemed to be hospital-associated if patients had been admitted within the prior three months, or healthcare-associated if patients were in healthcare facilities. Otherwise, they were considered to be community acquired. The primary outcome was in-hospital mortality. For scoring systems calculation, we imputed components of each risk score from the standing ED admission triage form recorded at the patient's ED arrival or records closest to the time that sepsis was suspected, defined as the time of culture or antibiotics, whichever came first.

SIRS is a four-item score (0-4 points) consisting of pulse rate, respiratory rate, body temperature. and white blood cell count. qSOFA contains three items (0-3 points): respiratory rate; mental status; and systolic blood pressure. NEWS (0-20 points) is an aggregated, weighted scoring system based on pulse rate, respiratory rate, body temperature, systolic blood pressure, oxygen saturation, and need for oxygen supplement.

Statistical Analysis

We reported patients' characteristics as frequency (percentage) and compared them using chi-squared or Fisher's exact test for categorical variables. Continuous variables were reported as mean (standard deviation) or median (interquartile range) and compared using Student's t-test or Mann-Whitney U test, as appropriate. We compared characteristics between two groups based on patients' ages: 1) between the elderly and the very elderly, and 2) between the very elderly and all others (aged <80 years). Univariate logistic regression analyses were performed to evaluate factors associated with hospital mortality in each age group, and results were presented as odds ratio (95% CI) and *p*-value. We only analyzed baseline variables that could be retrieved early after ED arrival because we aimed to categorize patients at high risk early after ED primary triage. Variables, which were statistically significant or considered clinically significant in the univariate analyses, were selected for the multivariate analyses. We subsequently analyzed multivariate logistic regressions in each age group. Furthermore, we performed subgroup analyses of patients without do-not-resuscitate (DNR) status to adjust for potential bias that the status might have caused. We decided to include patients with DNR status in the primary analysis because, unlike the younger population, a significant number of elderly and very elderly patients had this status. We believed that analyzing the results both before and after its stratification could help us to better understand this distinctive population. As for scoring systems, we calculated their prognostic accuracy performances and presented them as sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ration (LR-), negative predictive value (NPV), positive predictive value (PPV), and area under the curve of the receiver operator characteristics curves (AUROC). The accuracy at recommended cut-points from previous literature (SIRS ≥2, qSOFA ≥2 and NEWS ≥5) were computed and reported. We performed analyses using SPSS 18.0 (IBM Corp., Chicago, IL), and we calculated (95% CI) for sensitivity and specificity, LR+, LR-, NPV and PPV using MedCalc statistical software for Windows version 19 (MedCalc Software Ltd, Ostend, Belgium).

RESULTS

Characteristics of Patients

A total of 15,830 patients visited the ED August 1, 2018–July 31, 2019. Of these, 1927 (12.2%) patients were in the ED due to suspected sepsis; 311 received empirical treatment and were not diagnosed as sepsis at discharge. There were no exclusions due to missing mortality status or incomplete early warning score values. Consequently, we analyzed 1616 patients. When stratified by age, 668 (41.3%) were in the very elderly group, 512 (31.7%) were in the elderly group, and 436 (27.0%) were non-elderly patients. The very elderly group had the highest mortality rate (32.3%), followed by the elderly (25.8%) and non-elderly (24.8%) groups (Figure1).

Characteristics compared between the very elderly and the elderly patients are presented in Table 1. More of the very elderly group were female compared to the elderly group ($p<0.0001$). The very elderly group had significantly higher rates of underlying hypertension, debilitating neurologic diseases (ie, stroke, dementia), and bedridden and DNR status. Initial vital signs were similar between the two groups, except for a slightly higher systolic blood pressure in the very elderly group ($p = 0.03$). The very elderly group had significantly lower band form counts ($p = 0.02$), as well as a lower rate of positive hemoculture ($p = 0.03$). They also received fewer inotropic drugs ($p = 0.02$), and had fewer ICU admissions ($p = 0.003$) compared to the elderly group. When compared with other patients aged less than 80 years, the very elderly had significantly more underlying diseases. Moreover, more of them

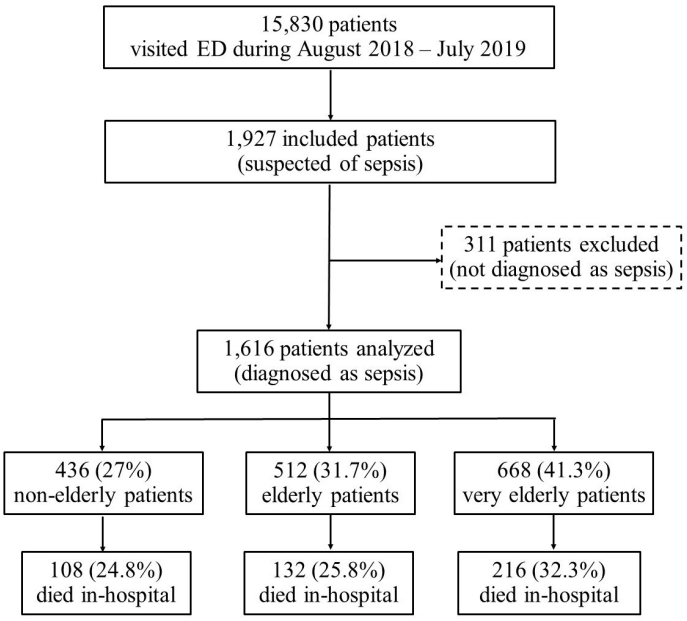

Figure 1. Flow diagram of the study participants.
ED, emergency department.

had sepsis due to respiratory and urinary tract infections. They also had higher mean systolic blood pressure and lower mean heart rate at presentation than younger patients (Table S1).

Predictive Factors for In-Hospital Mortality

Table S2 presents characteristics of the very elderly comparing those who had and did not have in-hospital mortality. Table 1 reports results from univariate analyses of factors in predicting in-hospital mortality in the elderly and the very elderly group. In very elderly patients, factors chosen to be included in the multivariate model were age, underlying cancer, bedridden status, DNR status, recent hospital admission within the prior three months, suspected primary infection site, etiology of infection, SBP≤100, oxygen saturation, and GCS score. In the elderly, results were similar to the very elderly group, except that body temperature was a significant predictive factor for mortality.

From multivariate analyses, age ($p = 0.03$), DNR status ($p<0.0001$), history of recent admission ($p = 0.02$), respiratory tract infection ($p = 0.03$), SBP≤100 ($p = 0.001$), oxygen saturation ($p = 0.002$), and GCS score ($p<0.0001$) were independent factors associated with in-hospital mortality in the very elderly group. In the elderly group, factors that remained significant from multivariate analyses were DNR status ($p<0.0001$), body temperature ($p = 0.006$), and GCS score ($p<0.0001$) (Table 2). In the non-elderly group, factors associated with mortality were DNR status, oxygen saturation, and GCS score (Table S3). In the subgroup of patients without DNR status, the significant factor in predicting hospital mortality among all age group was GCS score. Body temperature remained a significant factor in the elderly group. In the very elderly patients, underlying hypertension, respiratory tract infection, and SBP≤100 were also predictive factors of mortality (Table S4).

Performance of Early Warning Scores

SIRS, qSOFA and NEWS yielded higher AUROC in the very elderly compared to the elderly group (Table 3). AUROCs of SIRS and qSOFA increased with age. In the very elderly patients, qSOFA had the highest AUROC (0.60 [95% CI, 0.55-0.65]), followed by SIRS (0.55 [95% CI, 0.49-0.59]) and NEWS (0.54 [95% CI, 0.49-0.59]). NEWS≥5 had the highest sensitivity (89.8%) but lowest specificity (18.4%), whereas qSOFA≥2 yielded the highest specificity (71.0%) but lowest sensitivity (49.1%). Similar results were seen in the elderly group, except that SIRS≥2 could provide the highest sensitivity. Nonetheless, NEWS performed the best in the non-elderly group.

DISCUSSION

This retrospective study found that the mortality rate of patients with sepsis increases with age. Patients aged 80 years and older had the highest mortality rate compared to patients aged 65-79 years and non-elderly patients. Moreover, age is found to be an independent predictive factor for in-hospital mortality in this very elderly group, but not in the other two younger cohorts. Initial vital signs may not be good predictors for mortality, unlike baseline mental status, which was shown to be predictive across all age groups. Furthermore, qSOFA was the best scoring system with the highest specificity and AUROC in predicting mortality in the elderly and the very elderly group.

The world population is experiencing an unprecedented demographic change. According to the 2019 world population prospects, the ratio of people aged over 65 will increase from 1/11 in 2019 to 1/6 in 2050. Additionally, people aged 80 or over will be tripled by the same time.[17] These older adults are at increased risk of contracting infection due to declining physical and functional status. They are also at higher risk for developing sepsis and its adverse outcomes.[18] In our study, we found that 73% of all patients with sepsis were aged 65 years or older, and the mortality rate increased with age. These findings were similar to previous studies conducted in ICUs[19-22]; however, the mortality rate in our study was relatively lower because it was conducted in the ED, not in the ICU where the severity and hence mortality rates of patients are usually higher. Besides, we found that over 40% of all patients were very elderly patients aged 80 years or older, which was higher than any previous studies conducted in ICU but similar to a study conducted in the ED.[23] This might have been because ICU physicians usually consider ICU admissions for younger patients rather than very elderly patients with limited, life-sustaining treatment demand. We found that the ICU admission rate was significantly lower in the very elderly group compared to younger patients in our study.

Table 1. Characteristics and factors predicting in-hospital mortality in elderly and very elderly patients.

Characteristics	Elderly (n=512)	OR (95%CI), P-value	Very elderly (n=668)	OR (95%CI), P-value	P-value of difference
Age	72.6+4.5	1.0 (0.9-1.00), 0.07	86.1+4.8	1.0 (1.0-1.1), 0.03	<0.0001
Gender (female)	238 (46.5)	1.1 (0.7-1.6), 0.78	386 (57.8)	0.9 (0.6-1.2), 0.48	<0.0001
Underlying conditions					
Diabetes mellitus	190 (37.1)	1.0 (0.6-1.4), 0.84	222 (33.2)	1.1 (0.8-1.5), 0.69	0.17
Hypertension	304 (59.4)	0.9 (0.6-1.3), 0.49	444 (66.5)	0.8 (0.6-1.2), 0.30	0.01
Dyslipidemia	187 (36.5)	1.2 (0.8-1.8), 0.43	257 (38.5)	1.1 (0.8-1.6), 0.51	0.49
CKD or ESRD	89 (17.4)	1.3 (0.8-2.2), 0.28	144 (21.6)	0.8 (0.6-1.2), 0.36	0.07
Coronary artery disease	63 (12.3)	0.9 (0.5-1.6), 0.70	110 (16.5)	0.8 (0.5-1.2), 0.21	0.05
Debilitating neurologic diseases	137 (26.8)	0.8 (0.5-1.3), 0.33	267 (40.0)	0.8 (0.6-1.1), 0.16	<0.0001
Cancer	136 (26.6)	2.4 (1.6-3.7), <0.0001	94 (14.1)	1.9 (1.2-2.9), 0.006	<0.0001
Bedridden status	306 (59.8)	1.9 (1.2-2.9), 0.004	563 (84.3)	1.6 (1.0-2.7), 0.04	<0.0001
Do-not-resuscitate status	192 (37.5)	4.8 (3.2-7.4), <0.0001	386 (57.8)	3.6 (2.5-5.2), <0.0001	<0.0001
Recent admission < 3 months	210 (41.0)	1.8 (1.2-2.7), 0.004	313 (46.9)	1.6 (1.2-2.2), 0.005	0.05
Suspected primary infection site					
Urinary tract	63 (12.3)	Ref, 0.09	100 (15.0)	Ref, 0.21	0.09
Respiratory tract	301 (58.8)	2.1 (1.0-4.4), 0.04	419 (62.7)	1.7 (1.0-2.8), 0.04	
Other known sites	50 (9.8)	0.8 (0.2-3.0), 0.69	42 (6.3)	1.3 (0.5-3.2), 0.62	
Unknown site	98 (19.1)	1.9 (0.9-4.2), 0.10	107 (16.0)	1.5 (0.8-2.6), 0.22	
Etiology of infection					
Community-acquired	278 (54.3)	Ref, 0.005	337 (50.4)	Ref, 0.04	0.08
Healthcare-associated	32 (6.3)	1.1 (0.4-2.6), 0.86	29 (4.3)	0.5 (0.2-1.3), 0.16	
Hospital-associated	202 (39.5)	2.0 (1.3-3.0), 0.001	302 (45.2)	1.4 (1.0-1.9), 0.06	
Vital signs and mental status at time of sepsis suspicion					
Body temperature (o^C)	37.1 (36.8,37.9)	0.7 (0.6-0.9), 0.009	37.1 (36.8,37.9)	1.0 (1.0-1.0), 0.34	0.65
Respiratory rate (breaths/min)	30.9+8.4	1.0 (1.0-1.0), 0.67	31.2+8.2	1.0 (1.0-1.0), 0.95	0.47
Pulse rate (times/min)	102.9+41.9	1.4 (0.7-3.0), 0.33	97.8+42.3	1.5 (0.8-2.9), 0.21	0.07
Systolic blood pressure (mmHg)	125+36.1	1.6 (1.1-2.5), 0.03	129.9+40.5	1.8 (1.2-2.6), 0.004	0.03
Diastolic blood pressure (mmHg)	70.9+18.7	0.97 (0.95-0.99), 0.008	69.9+18.3	0.96 (0.94-0.98), <0.0001	0.34
Mean arterial pressure (mmHg)	89+23.1	0.8 (0.7-0.8), <0.0001	89.9+22.8	0.8 (0.7-0.8), <0.0001	0.49
Oxygen saturation (%)	94 (88,97)	0.7 (0.6-0.9), 0.009	94 (89,97)	1.0 (1.0-1.0), 0.34	0.48
Glasgow Coma Scale score	12.5+2.5	1.0 (1.0-1.0), 0.67	12.5+2.5	1.0 (1.0-1.0), 0.95	0.49
Laboratory results					
White blood cells (cells/mm^3)	13,440+11,444	-	12,281+8,411	-	0.05
Band form (%)	3.3+15.1	-	1.8+5.8	-	0.02
Positive hemoculture	98 (19.1)	-	97 (14.5)	-	0.03
ED management					
Time to hemoculture (min)	28 (15,56)	-	30 (15,50)	-	0.34
Time to antibiotics (min)	107 (64,169)	-	99 (60,147)	-	0.23

Table 1. Continued.

Characteristics	Elderly (n=512)	OR (95%CI), P-value	Very elderly (n=668)	OR (95%CI), P-value	P-value of difference
Inotropic drugs	115 (22.5)	-	113 (16.9)	-	0.02
ED disposition					
ICU admission	33 (6.4)	-	19 (2.8)	-	0.003
Outcome					
Length of stay (days)	6 (2,11)	-	6 (2,11)	-	0.96
In-hospital mortality	132 (25.8)	-	216 (32.3)	-	0.01

Note: data presented as n (%), mean+ standard deviation or median (interquartile range).
OR, odds ratio; *CI*, confidence interval; *CKD*, chronic kidney disease; *ESRD*, end-stage renal disease; *Ref*, reference variable; *ED*, emergency department; *ICU*, intensive care unit; *mmHg*, millimeters of mercury; *mm^3*, cubic millimeters.

Table 2. Multivariate analyses of factors associated with in-hospital mortality between elderly and very elderly patients.

Factors	Elderly (n=512)	P-value	Very elderly (n=668)	P-value
Age	1.0 (0.9-1.0)	0.43	1.0 (1.0-1.1)	0.03
Underlying conditions				
Cancer	1.4 (0.8-2.3)	0.26	1.4 (0.8-2.3)	0.20
Bedridden status	0.8 (0.5-1.4)	0.49	0.9 (0.5-1.6)	0.65
Do-not-resuscitate status	4.5 (2.6-7.6)	<0.0001	3.1 (2.0-4.8)	<0.0001
Recent admission < 3 months	0.6 (0.1-2.3)	0.42	3.5 (1.2-10.3)	0.02
Suspected primary infection site				
Urinary tract	Ref	0.20	Ref	0.13
Respiratory tract	1.6 (0.7-3.7)	0.25	1.9 (1.1-3.4)	0.03
Other known sites	0.6 (0.1-2.8)	0.53	1.1 (0.4-3.2)	0.88
Unknown site	1.0 (0.9-1.0)	0.43	1.5 (0.8-2.9)	0.26
Etiology of infection				
Community-acquired	Ref	0.35	Ref	0.11
Healthcare-associated	0.6 (0.2-1.6)	0.33	0.5 (0.2-1.3)	0.12
Hospital-associated	1.9 (0.5-8.0)	0.37	0.4 (0.1-1.1)	0.07
Vital signs and mental status at time of sepsis suspicion				
Body temperature (o^C)	0.7 (0.5-0.9)	0.006	-	-
Systolic blood pressure<100 mmHg	1.3 (0.8-2.2)	0.36	2.2 (1.4-3.4)	0.001
Oxygen saturation (%)	1.0 (0.9-1.0)	0.13	0.97 (0.95-0.99)	0.002
Glasgow Coma Scale scores	0.7 (0.7-0.8)	<0.0001	0.8 (0.7-0.8)	<0.0001

Note: data presented as odds ratio (95% confidence interval).
Ref, reference variable; *mmHg*, millimeters mercury.

Early identification of patients at high risk for developing adverse outcome from sepsis may aid clinicians to give appropriate treatment and may possibly lead to improved patient outcomes. For emergency physicians, vital signs and clinical characteristics at arrival are of utmost importance in order to early recognize patients at high risk. In fact, almost all components of early warning scores were based on this information. It is known that older patients usually present with atypical presentation and may not present with the abnormal vital signs usually seen in septic patients. Our study results showed supportive evidence.

First, the very elderly group had significantly lower heart rate compared to patients aged <80 years, and higher systolic blood pressure compared to both the elderly and all other patients aged <80 years. Although we found that SBP≤100 could significantly predict hospital mortality only in the very

Table 3. Performances of early warning scores in predicting in-hospital mortality between non-elderly, elderly and very elderly patients.

Early warning scores	AUROC (95% CI)	Cut-point	Sensitivity	Specificity	LR+	LR-	PPV	NPV
				SIRS				
Non-elderly	0.51 (0.45-0.57)	>2	88.1 (80.5-93.5)	14.4 (10.8-18.7)	1.0 (1.0-1.1)	0.8 (0.5-1.5)	25.2 (23.7-26.8)	78.7 (67.5-86.8)
Elderly	0.53 (0.47-0.58)		87.9 (81.1-92.9)	17.11 (13.5-21.3)	1.1 (1.0-1.2)	0.7 (0.4-1.2)	26.9 (25.4-28.5)	80.3 (70.9-87.1)
Very elderly	0.55 (0.49-0.59)		82.87 (77.2-87.6)	26.1 (22.1-30.4)	1.1 (1.0-1.2)	0.7 (0.5-0.9)	34.9 (33.1-36.8)	76.1 (69.6-81.6)
				qSOFA				
Non-elderly	0.54 (0.48-0.61)	>2	40.4 (31.1-50.2)	68.5 (63.2-73.4)	1.3 (1.0-1.7)	0.9 (0.7-1.0)	29.5 (24.1-35.6)	77.8 (74.7-80.6)
Elderly	0.55 (0.49-0.61)		43.2 (34.6-52.1)	67.1 (62.1-71.8)	1.3 (1.0-1.7)	0.9 (0.7-1.0)	31.3 (26.4-36.8)	77.3 (74.3-80.0)
Very elderly	0.60 (0.55-0.65)		49.1 (42.2-55.9)	71.0 (66.6-75.2)	1.7 (1.4-2.0)	0.7 (0.6-0.8)	44.7 (39.9-49.7)	74.5 (71.7-77.1)
				NEWS				
Non-elderly	0.55 (0.49-0.61)	>2	91.7 (84.9-96.2)	18.9 (14.9-23.6)	1.1 (1.1-1.2)	0.4 (0.2-0.9)	27.0 (25.5-28.6)	87.5 (78.3-93.2)
Elderly	0.52 (0.46-0.58)		87.1 (80.2-92.3)	16.8 (13.2-21.0)	1.1 (1.0-1.1)	0.8 (0.5-1.3)	26.7 (25.2-28.3)	79.0 (69.6-39.3)
Very elderly	0.54 (0.49-0.59)		89.8 (85.0-93.5)	18.4 (14.9-22.3)	1.1 (1.0-1.2)	0.6 (0.4-0.9)	34.5 (33.1-35.9)	79.1 (70.8-85.4)

Note: data presented as values (95%CI).
AUROC, area under receiver operating characteristic curve; *CI*, confidence interval; *LR+*, positive likelihood ratio; *LR-*, negative likelihood ratio; *PPV*, positive predictive value; *NPV*, negative predictive value; *SIRS*, systemic inflammatory response score; *qSOFA*, quick sequential organ failure assessment score; *NEWS*, National Early Warning Score.

elderly group, this might have been because of the greater severity of disease in the very elderly compared to the other two groups. Second, we found that unlike in the elderly, body temperature was not an independent predictive factor of mortality in the very elderly. This was concordant with a previous report stating that the older the patients, the lower the body's baseline temperature.[24] Thus, fever may not be seen in geriatric patients with infection. However, we found that oxygen saturation is a significant factor in predicting mortality in the very elderly, but not in the elderly, which might have been due to the higher rate of respiratory tract infection in very elderly patients, similar to previous studies.[19,23] Nonetheless, apart from all vital signs, the GCS may be a reliable tool to predict adverse outcome since it was a significant predictor across all age groups. This was also evident in the subgroup of patients without DNR status.

Of the commonly used early warning scores, qSOFA had the highest specificity and yielded the highest accuracy in predicting in-hospital mortality in the elderly and the very elderly, despite respiratory rate greater than 22 not being an independent predictive factor for mortality. This came as no surprise since qSOFA has always been known for its high specificity.[25-26] It was proposed by Sepsis-3 as a tool to early identify patients with sepsis in the ED.[7] However, recent studies in the general ED population have shown that newly-developed early warning scores, such as NEWS, may have better predictive performance than qSOFA and SIRS.[14-16] We demonstrated similar findings in the non-elderly group, but not in the elderly and the very elderly groups. Interestingly, we found that AUROC of both qSOFA and SIRS increased in older patients, unlike NEWS. This might have been explained by the fewer number of components in qSOFA and SIRS.

Our data showed that many baseline variables in these scoring systems did not accurately predict mortality in older patients; therefore, the scoring systems with fewer variables could have yielded higher accuracy than those with more components. The qSOFA score only consists of three components, two of which are SBP≤100 and mental status that were found to be predictive of mortality. As a consequence, it could provide the highest accuracy in the very elderly patients. However, it is important to note that the prognostic accuracy performances based on sensitivity, specificity, and AUROC of all the early warning scores in this study were generally less robust than previous studies.[14-16,25-26] This may have also been due to the advancing age and subsequently higher severity of patients' baseline risk for mortality in this study population.

A modification of the currently available scores or an "age" factor may be required to obtain better diagnostic and prognostic performances, as reported in previous studies.[27-28] Nonetheless, further studies should still be conducted to derive and validate appropriate early warning scores for this particular population.

LIMITATIONS

The study had several limitations. First, it was conducted in a single, tertiary, university hospital situated at the city center with moderate volume of visiting patients. This may limit the generalizability of the study findings. Second, we only included patients suspected of sepsis in the ED and not patients whom we did not suspect but later went on to be diagnosed with sepsis during hospital admission. This may have been reasonable since these patients could have had a hospital-acquired infection that occurred after ED disposition. However, we might have missed some patients with sepsis who presented with atypical presentation leading to non-sepsis-related diagnoses such as delirium. And although we included patients with DNR status who could have biased the study results in the primary analysis, we performed a subgroup analysis excluding them to obtain strong predictive factors that remained significant regardless of the patient's palliative status. Nevertheless, some of the factors might have failed to meet statistical significance due to small sample sizes in the subgroup analyses.

Another limitation is that we used in-hospital mortality, which is all-cause mortality rather than sepsis-related mortality as the primary outcome. This might have overestimated the actual mortality due to sepsis since the elderly could have died from many other concurrent causes. Nonetheless, our mortality rate was similar to other previous studies in geriatric patients. Additionally, as per our clinical practice, we used the older definitions of hospital-acquired and healthcare-associated infection in the study. Finally, we did not have records of some essential factors in critical septic patients such as serum lactate, compliance with the sepsis bundle of care, or the severity of sepsis assessed by appropriate tools such as Sequential Organ Failure Assessment or Acute Physiology And Chronic Health Evaluation II (APACHE II) score. This was because of the retrospective nature of our study, which limited the completeness of laboratory data and the availability of variables needed for the score calculation. There might have also been other limitations associated with a retrospective study design such as potential selection bias.

CONCLUSION

Very elderly patients with sepsis in the ED had higher in-hospital mortality than elderly and non-elderly patients. Factors associated with mortality in the very elderly were age, DNR status, history of recent admission, respiratory tract infection, SBP≤100, oxygen saturation, and GCS score. Factors associated with mortality in the elderly were DNR status, body temperature, and GCS score. qSOFA had the highest but only moderate accuracy in predicting in-hospital mortality in elderly and very elderly patients compared to SIRS and NEWS.

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The Association of Sleep Hygiene and Drowsiness with Adverse Driving Events in Emergency Medicine Residents

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Introduction: Prior research shows that physicians in training are at risk for drowsy driving following their clinical duties, which may put them in danger of experiencing adverse driving events. This study explores the relationship between sleepiness, overall sleep hygiene, level of training, and adverse driving events following an overnight shift in emergency medicine (EM) residents.

Methods: Throughout the 2018-2019 academic year, 50 EM residents from postgraduate years 1–4 completed self-administered surveys regarding their sleepiness before and after their drive home following an overnight shift, any adverse driving events that occurred during their drive home, and their overall sleep hygiene.

Results: Fifty out of a possible 57 residents completed the survey for a response rate of 87.7%. Sleepiness was significantly associated with adverse driving events (beta = 0.31; P < .001). Residents with high sleepiness levels reported significantly more adverse driving events. Residents reported significantly higher sleepiness levels after completing their drive home (mean = 7.04, standard deviation [SD] = 1.41) compared to sleepiness levels before driving home (mean = 5.58, SD = 1.81). Residency training level was significantly associated with adverse driving events (beta = -0.59, P < .01). Senior residents reported significantly fewer adverse driving events compared to junior residents.

Conclusion: Emergency physicians in training are at risk for drowsy driving-related motor vehicle crashes following overnight work shifts. Trainees of all levels underestimated their true degree of sleepiness prior to initiating their drive home, while junior residents were at higher risk for adverse driving events. [West J Emerg Med. 2020;21(6)219-224.]

INTRODUCTION

The dangers of sleep deprivation are featured by the negative effects on multiple facets of neurocognitive function, including higher level executive function and working memory.[1] One of the most severe consequences of sleep deprivation is drowsy driving that may result in property damage, injury, and fatal crashes. Between 2011–2015, drowsy driving was implicated in 4121 fatalities related to motor vehicle-related crashes.[2] Drowsy driving is well known to compromise not only decision-making while driving, but also the driver's ability to control the vehicle.[3] In simulated driving studies, drivers who are sleep deprived show poorer performance on driving tasks

compared to individuals who consumed a moderate amount of alcohol.[3-5] However, relatively little media attention and research are focused on advancing this special area of impaired driving (ie, compared to alcohol or drug-impaired driving) that has important implications for the public's health.

The trend of motor vehicle crashes (MVC) due to daytime drowsiness continues to rise and has led to an increased interest in sleep hygiene – an assessment of an individual's sleeping habits that influence his or her sleep experience.[6] Research shows a strong positive relationship between an individual's sleep hygiene and the quality of his or her sleep.[6,7] That is, individuals with worse sleep hygiene are expected to experience poorer sleep quality (ie, less restful sleep). Certain individuals with poor sleep hygiene, such as night shift workers, are more likely to develop and accumulate sleep deprivation, in turn putting them in danger of experiencing adverse events on the job or outside of the workplace, including drowsy driving-related crashes.

Medical professionals have a particularly increased risk of sleep deprivation and poor sleep hygiene due to the rigor of their work (eg, physical, emotional, cognitive) and systematic requirements to work extended hours and overnight shifts. Young physicians in training are especially vulnerable to drowsy driving and subsequent MVCs as they often work shifts that last longer than 24 hours or frequently transition between day and overnight work shifts.[8-10] Recent regulations that limit resident physician duty hours have focused on improving patient safety,[11] but these regulations also resulted in a greater need to transition frequently from day to overnight work shifts, a pattern that may further detrimental and worsen sleep deprivation.

Among medical trainees, emergency medicine (EM) residents may be at higher risk for both poor sleep hygiene and drowsy driving with subsequent adverse driving events (eg, drifting out of the roadway lane; unexpectedly braking hard to avoid rear-ending a vehicle; running a stop sign). Due to the nature and contextual setting of their work, they regularly have a high number of sporadic overnight shifts, leading to more opportunities for cumulative sleep deprivation and drowsy driving. In fact, one study found that 80% of near-crashes and nearly 75% of MVCs involving emergency physicians in training occurred while driving home after an overnight shift.[12] Higher levels of self-reported drowsiness prior to driving home have been shown to be associated with subsequent adverse driving events.[8]

In a broader context, a foundational principle of any EM training program relies on the concept of trainees becoming more competent and proficient, clinically and procedurally, as they advance in their training and gain experience year by year. This raises the question as to whether in the setting of medical training EM residents adapt their sleep hygiene year to year, so that they experience less drowsiness after their shift work and, more importantly, experience fewer drowsy-driving adverse events. In other words, "Is there adaptation that occurs over years of training that may be protective to the more senior EM residents compared to junior residents?"

Population Health Research Capsule

What do we already know about this issue?
Drowsy driving is a leading cause of injury and fatal crashes. Long work hours and overnight shifts put physicians in training at risk for drowsy driving-related crashes.

What was the research question?
What is the relationship between sleepiness, sleep hygiene, training level, and adverse driving events after overnight shifts?

What was the major finding of the study?
Higher sleepiness levels were reported after driving home. Resident training level was associated with adverse driving events.

How does this improve population health?
Our findings have implications for the well-being of emergency physicians in training as well as injury prevention programs focused on their safety.

While the question may be intriguing, there remains a paucity of research assessing this important and highly relevant physician safety concern. It is possible that work experience could ameliorate overall sleep hygiene or, to some extent, the degree of drowsiness experienced after a night shift. Furthermore, it is unclear how EM residents manage sleep hygiene in general, and whether sleep hygiene is correlated with the degree of drowsiness experienced after a night shift. To fill this knowledge gap we aimed to examine the association between subjective sleepiness, level of training, overall sleep hygiene, and adverse driving events in EM residents after completion of an overnight shift.

METHODS

Recruitment and Design

We conducted a cross-sectional, self-administered online survey study. EM residents ranging in training levels from postgraduate years (PGY) 1-4 at a single, large, urban-based EM residency participated in the study throughout the 2018-2019 academic year. This study was approved by the university's institutional review research board. All participants provided written informed consent.

Residents at this training program spend three months of the academic year working at a community hospital site 20 miles away from the main hospital. All residents have variability in working overnight shifts at this site at the discretion of

the training program faculty scheduler. All overnight shifts are scheduled from 10 PM-7AM requiring residents to travel approximately 20 miles home following their overnight shifts. Residents were sent a scheduled email the morning after an overnight shift at this community hospital with instructions to complete the online questionnaire after their drive home.

Participants

A total of 50 EM residents completed the survey. Of these, three residents obtained a ride home and did not provide information regarding adverse driving events.

Questionnaires and Measures

We used web-based survey software (Qualtrics XM, Provo, UT) to conduct the survey.[13] Within the questionnaire, participants were asked to complete the Karolinska Sleepiness Scale,[14] a validated measure of sleepiness. They rated their subjective level of sleepiness both before and after their drive home. The summed sleepiness scores (ie, before and after the drive home) were used for the linear regression analyses. Residents also completed the Sleep Hygiene Index,[6] a validated instrument used to measure one's stable sleep hygiene behaviors. Additionally, based on the investigator-developed Adverse Driving Events Questionnaire, participants were asked to evaluate their drive home after the overnight shift by answering "yes" or "no" to 15 questions that defined and quantified adverse/dangerous driving events. (See Appendix for all questionnaires used.)

Statistical Analysis

We conducted a descriptive analysis of self-reported adverse driving events with baseline characteristics of EM residents. Thereafter, we performed a bivariate linear regression analysis to evaluate the association between subjective sleepiness and adverse driving events. These analyses were also used to assess the association of sleep hygiene with adverse driving events and sleepiness. A paired t-test was performed to compare the average level of sleepiness before and after driving home following an overnight shift. Finally, we conducted adjusted linear regressions to evaluate the relationship between sleepiness and adverse driving events while controlling for levels of residency training. Standardized Cronbach's alpha of the Adverse Driving Events Questionnaire was calculated. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).[15] All levels of significance for the two-tailed tests of this analysis were set a priori as 0.05.

RESULTS

Fifty out of a possible 57 residents completed the survey for a response rate of 87.7%. Table 1 shows the proportions and distribution of self-reported adverse driving events with baseline demographic characteristics of the EM residents. The PGY 1 + PGY 2 training levels were combined to reflect overall junior vs senior training levels (ie, PGY 3 and PGY 4). Among junior residents, 88% reported adverse driving events and the average number of reported driving events was 2.79 (SD = 1.89). Of the 14 residents at PGY 3 level, 79% reported adverse driving events and the average number of reported driving events was 2.57 (SD = 1.83). Of the 12 residents at PGY 4 level, 75% reported adverse events and the average number of reported driving events was 1.33 (SD = 0.98). Overall, the summed sleepiness score among the residents who reported adverse driving events was 13.37 (SD = 2.35). The standardized Cronbach's alpha for the Adverse Driving Events Questionnaire was 0.97, suggesting that the items of this questionnaire have high internal consistency.

Table 1. Proportion and distribution of self-reported adverse driving events with baseline characteristics of emergency medicine residents.

		Adverse driving			Adverse driving events[$]	
	Overall, n	Yes, n (%)	No, n (%)	P-value	Mean±SD	P-value
Levels of residency training						
Junior (PGY 1 + PGY 2)	24	21(88)	3(12)	0.64[a]	2.79±1.89	0.05[c]
Senior – PGY 3	14	11(79)	3(21)		2.57±1.83	
Senior – PGY 4	12	9(75)	3(25)		1.33±0.98	
Gender						
Male	32	28(88)	4(12)	0.25[a]	2.31±1.64	0.72[b]
Female	18	13(72)	5(28)		2.50±2.04	
Continuous independent variables	Overall, n	Yes, n (mean±SD)	No, n (mean±SD)	P-value	Coefficient, ß	P-value
Subjective sleepiness	50	41(13.37±2.35)	9(9.22±1.99)	0.00[b]	0.31	0.00[d]
Sleep hygiene	49	40(34.33±5.59)	9(34.11±5.11)	0.92[b]	0.06	0.20[d]

[$]Adverse driving events were calculated by summing up each binary response (yes vs. no) from adverse driving event questions; [a]Chi-square test (Note: the Fisher's exact test was performed when 50% of the cells had counts less than 5); [b]T test; [c]Analysis of variance test; [d]bivariate linear regression.
SD, standard deviation.

Table 2 shows the bivariate linear regression results. Sleepiness was significantly associated with adverse driving events (beta = 0.31; $P < .001$). Neither subjective sleepiness nor reporting of adverse driving events was found to be significantly related to sleep hygiene scores.

Table 3 shows the average level of sleepiness before and after driving home following an overnight shift. Residents reported significantly higher sleepiness levels after completing their drive home (mean = 7.04, standard deviation [SD] = 1.41) compared to sleepiness levels before driving home (mean = 5.58, SD =1.81).

Table 4 shows the results of the adjusted linear regression of adverse driving events on sleepiness, controlling for residency training levels. Both subjective sleepiness (beta = 0.30, $P < .001$) and residency training levels (beta = -0.59, $P < .01$) were significantly associated with adverse driving events. Residents with high sleepiness levels reported significantly more adverse driving events. Senior residents reported significantly fewer adverse driving events compared to junior residents. No interaction was found between training levels and level of sleepiness.

DISCUSSION

We explored the relationships between subjective sleepiness, level of training, and overall sleep hygiene on adverse driving events after completion of an overnight shift in EM residents. The results show that high levels of subjective sleepiness were significantly associated with increased self-reported adverse driving events. Further, there was a significant increase in the level of sleepiness reported after completing the drive home compared to the level of sleepiness prior to driving home. Senior residents reported a lower number of adverse driving events compared to junior residents.

Table 2. Bivariate linear regression analyzing the relationship between sleepiness, sleep hygiene, and adverse driving events.

	Beta	P-value
Sleepiness - Sleep hygiene	0.06	0.40
Adverse driving events - Sleep hygiene	0.06	0.20
Adverse driving events - Sleepiness	0.31	<0.001

Our findings highlight the dangers of drowsy driving in an understudied and at-risk group, EM residents. Physicians in training are crucial to patient care at hospitals across the country. Interventions that improve sleep deprivation have been shown to reduce patient care errors made by these physicians.[16] However, recognizing the effect of sleep deprivation on the safety and health of the physicians themselves needs to be brought to the forefront of our attention.

Research has shown that drowsy driving-related MVCs were more likely to involve individuals who average fewer hours of sleep per night, work overnight shifts, or have unusual work schedules.[17] Working rotating shifts has been shown to result in higher levels of sleepiness compared to working overnight shifts exclusively.[18] Based on these demographics, EM residents are inherently at high risk for sleep-related adverse driving events. The findings of our study support this hypothesis as 82% of participants reported experiencing an adverse driving event. This is concerning, and the results point to a very tangible injury risk for drowsy driving-related MVCs in this unique and vulnerable population.

Our results show that after working an overnight shift, EM residents reported significantly increased sleepiness after completing their drive compared to their sleepiness prior to initiating their drive home. The implications of this finding are of paramount importance. Immediately after completing an overnight shift, a resident may not recognize his or her true level of sleepiness and may feel safe to drive home. The increased degree of sleepiness after completion of the drive likely represents the true level of sleepiness. This suggests that emergency physicians in training may underestimate their degree of sleepiness immediately prior to initiating their drive home, putting them at risk for drowsy driving-related MVCs.

Our results also suggest that the subjective burden of sleep deprivation increases after performing a focused task (i.e., driving) particularly when coupled with working an overnight shift. A prior study conducted in the state of New York points to individual demographic characteristics as well as sleep, work, and driving patterns as key contributors to increasing drowsy driving.[19] Moreover, other studies show that adverse driving events occur after a longer duration of driving.[20] Awareness of these facts is crucial. Understanding that the driver's level of sleepiness upon completion of an overnight shift will increase throughout the duration of the drive is necessary in order to take meaningful

Table 3. Average level of sleepiness before and after driving home following an overnight shift.

	Sleepiness			
	Before (mean±SD)	After (mean±SD)	Difference[$] mean (95%CI)	P-value[#]
Levels of subjective sleepiness	5.58±1.81	7.04±1.41	-1.46 (-1.93, -0.99)	<0.001

[$]Difference = Average of level of sleepiness before minus average of level of sleepiness after driving home; [#]A paired t test was used to compare the levels of subjective sleepiness before and after driving home.
SD, standard deviation; *CI,* confidence interval.

Table 4. Linear regression of adverse driving events on sleepiness adjusted for levels of residency training.

	Adverse driving events	
	Beta	P-value
Levels of subjective sleepiness	0.30	<.001
Levels of residency training	-0.59	0.003

corrective and preventive action to avoid drowsy driving.

Further, our results confirm that increased sleepiness is associated with a significantly greater number of adverse driving events. Past research shows that the best predictor of near-crash events is a prior episode of severe sleepiness at the wheel.[21] Drowsy driving-related near-crash events are a strong predictive risk factor for future crashes.[22] On average, the participants in our study reported that they felt "sleepy" at the end of their drive home. This alone puts these physician trainees at needless risk for future drowsy driving-related crashes.

These findings have important implications for residency training programs of all specialties and suggest that a multifaceted approach may be needed to address the problem and potential dangers of drowsy driving. First, recognition of this issue is the pivotal step toward enacting change. Our results show that junior residents reported more adverse driving events. It's unlikely that new physicians have faced the regularity of drowsy driving at prior stages in their training. Upon entering residency, first-year residents should be intentionally educated about the dangers of drowsy driving. Second, residency training programs may need to adapt their culture to consider safer alternatives to drowsy driving for physician trainees of all levels.

Encouraging car pooling, creating call rooms for sleeping after an overnight shift, or identifying alternate methods of transportation home for residents are all possible solutions. Considering a consistent night-float system, as opposed to sporadic overnight shifts, is another possible avenue to explore. In this system, residents would work overnight shifts for an entire month at a time, allowing them to have more consistency in their sleep schedule. This would eliminate sporadic overnight shifts in other months. Resident physicians should be educated about their risk for drowsy driving and that their assessment of their level of sleepiness at the start of their drive may dangerously misrepresent their sleepiness at the end of their drive. Initiating a dialogue to promote wellness in this area is the feasible and viable first step to prevention. Graduate medical education departments across the country need to mandate better training for their residency programs in this area. To take the best care of patients throughout their careers, we must instill good habits in physicians at an early stage and implore residents to first take good care of themselves.

LIMITATIONS

We realize that our study has a number of limitations. First, the participants were derived from a single training program. Although we were able to obtain a favorable distribution of residents across different training levels, the overall sample size was restricted by the total number of EM trainees within our program. Second, our study design relied on self-reported data and this approach could have inherently introduced social desirability and recall bias. As a result, some participants may have been both hesitant to report adverse driving events and may have incorrectly remembered whether they experienced an adverse driving event or not.

Third, it would be reasonable to consider that the recall bias could have been accentuated as a result of potentially greater drowsiness at the end of the drive. In turn, this might also affect the extent of social desirability bias if a participant realized he or she had a high (ie, more than expected) number of reported adverse driving events and chose to minimize some of their reporting. Nevertheless, prior research has shown that the subjective Karolinska Sleepiness Scale is positively correlated with objective measures of drowsiness.[23] Future studies should consider building off our findings to obtain more objective data using high-fidelity driving simulation or a naturalistic driving research approach with a larger number of participants from several training programs.

CONCLUSION

In EM residents driving home after completing an overnight shift, higher levels of subjective sleepiness were significantly associated with increased self-reported adverse driving events. Increased levels of sleepiness were reported after completing the drive home compared to the level of sleepiness reported prior to initiating the drive. Senior residents reported a lower number of adverse driving events compared to junior residents. Our findings emphasize the need to explore this relationship further to determine whether improvement in sleep hygiene or improved tolerance of sleepiness leads to fewer reported adverse events. Overall, these findings have important implications for the health and safety of physicians in training as well as the overall safety of the public.

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Cross-Sectional Survey of Former International Emergency Medicine Fellows 2010-19

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Introduction: International emergency medicine is a new subspecialty within emergency medicine. International emergency medicine (EM) fellowships have been in existence for more than 10 years, but data is limited on the experiences of the fellows. Our goal in this study was to understand the fellowship experience.

Methods: The study employed a cross-sectional survey in which participants were asked about their demographics, fellowship program, and advanced degree. Participants consisted of former fellows who completed the fellowship between 2010-19. The survey consisted of both closed and open-ended questions to allow for further explanation of former fellows' experience. Descriptive analysis was conducted on the quantitative survey data while content analysis was conducted to ascertain salient themes from the open-ended questions.

Results: We contacted 71 former fellows, of whom 40 started and 36 completed surveys, for a 51% response rate (55.6% women). Two-year fellowships predominated, with 69.4% of respondents. Prior to fellowship, a subset of fellows spoke the native languages of their service sites: French, Spanish, Haitian Creole, Mandarin, or Kiswahili. Half the respondents spent 26-50% of their fellowship in field work, with 83.3% of institutions providing direct funding for this component. Many respondents stated a need for further institutional support (money or infrastructure) for fieldwork and mentoring. Non-governmental organizations comprised 29.7% of respondents' work partners, while 28.6% were with academic institutions in country, focused mostly on education, health systems development, and research. The vast majority (92%) of respondents continued working in global EM, with the majority based in American academic institutions. Those who did not cited finances and lack of institutional support as main reasons.

Conclusion: This study describes the fellow experience in international EM. The majority of fellows completed a two-year fellowship with 26-50% of their time spent in fieldwork with 83.3% of institutions providing funding. The challenges in pursuing a long-term career in global EM included the cost of international work, inadequate mentorship, and departmental funding. [West J Emerg Med. 2020;21(6)225-230.]

INTRODUCTION

Emergency medicine (EM) is a relatively new specialty with a variety of subspecialties, which have been growing in number and popularity. The international EM fellowship (IEMF) emerged over 10 years ago as a subspecialty providing public health training, experiences in resource-limited settings, and research and education in international health.[1] IEMFs are aimed at EM trainees focused on emergency care provision and development in resource-limited settings such as low-and-middle-income countries (LMIC). While fellowship goals, objectives, and skills have been outlined previously,[1-4] this information has not always been easily available to those applying.[5]

The fellowship attracts individuals interested in working with LMICs and in resource-constrained areas through direct service provision, as well as through research, EM education, health systems development, and humanitarian and disaster response. Over 20 academic institutions across the United States now offer IEMFs with projects throughout North and South America, Africa, the Middle East, and Asia. These fellowships are governed by the IEMF Consortium. Many offer an advanced degree in public health, global sciences, tropical medicine, or education. Each fellowship offers slightly different foci based on the goals of the fellowship and institution, faculty expertise, and existing country partnerships. The programs are not accredited by the Accreditation Council for Graduate Medical Education, and consequently there is a dearth of information on the fellowships themselves and experiences of the fellows. Now that IEMFs have graduated fellows for 10 years, this is an opportune time to describe the fellowship experience.

Aims

Our goal was to describe and map the experiences of the IEMF fellows both domestically and abroad. We provide data that can be used to improve IEM training.

Population Health Research Capsule

What do we already know about this issue?
Information is limited on the experiences of international emergency medicine fellows (IEMF), whose focus is public health and who often become leaders in global health.

What was the research question?
What motivates IEMFs to enter fellowship and what do they experience during fellowship and post-fellowship careers?

What was the major finding of the study?
Most became IEMFs to professionalize their interest in global EM. Those who left the field cited finances.

How does this improve population health?
IEMFs work in global and population health after fellowship. Learning from their experiences can help create an even more effective cadre of professionals.

METHODS

Study Design and Population

We employed an electronic cross-sectional survey of all fellows who graduated from an IEMF at a US institution from 2010-2019. Current IEMFs were identified through the IEMF Consortium, which provided the fellowship directors' email addresses. All current, active IEMFs are part of this consortium, but fellowships that have since closed or are inactive are not included. The consortium, in its role as oversight body for IEMFs, provided the most direct way of contacting fellows. Fellowship directors had the option to provide us with the emails of the former fellows or directly email the former fellows an anonymous link with consent to participate in the study. Institutional review board approval for the study was obtained by each author's affiliated institution prior to study conduction.

Survey Content and Administration

Survey participants were asked about their demographics, motivation for entering fellowship, fellowship program content and outcomes, advanced degree, if obtained, and post-fellowship activities. The survey consisted of a mix of closed and open-ended questions to allow for further elaboration. The survey was distributed using Qualtrics (Provo, UT) from April 29–May 15, 2019. Two additional follow-up emails were sent to the fellowship directors to ensure that as many former fellows as possible would be included in the study.

Data Analysis

Quantitative data were collected via an anonymous online survey through the Qualtrics software. We conducted descriptive analyses on the data including geo-mapping of field sites. We analyzed qualitative data using content analysis. Themes were derived from the data by two independent, separate coders, and the derived themes were compared and agreed upon for the final analysis.

RESULTS

Demographics

Response rate was 51% (36/71). Respondents included slightly more women than men, with most between the ages of 35-44 (Table 1). Only 36.1 of respondents had an additional advanced degree (besides a medical or osteopathic

Table 1. Demographics of survey respondents regarding their experiences in an international emergency medicine fellowship.

Variable	N(%)
Gender	
Male	16(44.4)
Female	20(55.6)
Age	
25-34	14(38.9)
35-44	20(55.6)
45-54	2(5.6)
>55	0(0.0)
Degree before fellowship	
MD	34
MPH	9
PhD	0
MS	1
DO	1
Other (MBA, MA Bioethics)	2
Languages spoken before fellowship	
French	8(12.5)
Spanish	17(26.6)
Other (Haitian Creole, Mandarin, Kiswahili)	3(4.7)

MD, doctor of medicine; *MPH*, master of public health; *PhD*, doctor of philosophy; *MS*, master in science; *DO*, doctor of osteopathic medicine; *MBA*, master of business administration; *MA*, master of arts.

degree) prior to starting the fellowship with the majority attending a two-year fellowship (69.4%). With regard to languages spoken, 43.8% reported the ability to speak another language besides English prior to starting the fellowship, which did not have a significant impact on where their fieldwork was conducted.

Fellowship Demographics Results

Most respondents went to a two-year program (69.4%) earning a master of public health degree (69.5%) during fellowship (Table 2).

Motivations and Perceptions of Training

Fellows reported that they decided to enter the fellowship to develop a humanitarian aid career, enter academic international EM, have dedicated field time, develop research skills, and obtain mentorship. One respondent stated he wanted to enter an IEMF to "*professionalize [his] interest in global health."* Respondents elaborated and stated the most valuable components of the degree were learning public health methodology (specifically epidemiology, biostatistics, population health, monitoring, and evaluation), becoming subject matter experts, and having the opportunity to network during fellowship. The least valuable components commonly reported were limited statistics and classes aimed at non-clinicians.

Respondents worked an average of 719 hours per year clinically (interquartile range of 161.5 hours) at the fellowship institution with 88.8% having a faculty appointment during fellowship; 88.9% of respondents' fellowships had existing field sites with over 80.6% working at those sites. Respondents stated that institutional support was in the form of pre-existing fieldwork/sites, funding for travel, clinical scheduling flexibility, and research support. Respondents stated that further institutional support could be provided through *"more autonomy and reduction of barriers to fieldwork";* research and scholarly mentorship; *"more cross-institution mentorship on how to prepare for a further career in international EM;, more mentoring for early faculty development (not specific to international EM); flexibility in clinical schedules; and increased travel funds."*

Most respondents worked in EM education followed by health systems development and research with the fewest respondents involved in direct clinical care and humanitarian response during their fellowship fieldwork (Figure 1).

More than half of respondents worked with either non-governmental organizations or academic institutions (Figure 2).

During their fellowship, some level of funding was provided for 88.3% of the respondents for fieldwork. The amount of funding given to fellows is shown in Figure 3. Funding came from the fellow's institution (75.0%), grants (16.7%), private partners (16.7%), and other sources (2.8%).

The geographic distribution of field sites is shown in the map below (Figure 4). The majority of respondents worked in India followed by sub-Saharan Africa with the least number of respondents working in the Americas.

Of those who responded, 80.6% reported they would complete the fellowship again. Overall the most valuable components of the fellowship were felt to be the advanced degree followed by developing contacts and networking. One respondent succinctly described the fellowship as an opportunity to *"form professional networks, greatly increase confidence as a researcher and gain experience teaching in LMICs*." The biggest challenges faced during fellowship were the *"overwhelming burden of clinical duties which detracted from getting the most out of field opportunities and advanced degree,"* lack of IEM mentorship and no clear career path development, and lack of fieldwork opportunities.

Post-Fellowship Results

The majority, 91.7%, of respondents, continue to work in global EM with 67.4% working in academics, 16.3% in community settings, and 11.6% in unspecified international settings. Respondents stated that the advanced degree they received during fellowship had provided skills to conduct research and obtain funding, further adding to their academic profile. Summation of the respondents' use of their advanced degree was that "*[the degree] adds to my academic profile*

Table 2. Descriptive analysis of international emergency medicine fellowships.

Variable	N(%)
Length of fellowship	
1 year	11(30.6)
2 years	25(69.4)
Degree obtained during fellowship	
Yes	23(63.9)
No	13(36.1)
Degree earned during fellowship	
Master of public health	16(44.4)
Doctor of philosophy	0(0)
Master of science	3(8.3)
Master of academic medicine	1(2.8)
Diploma of tropical medicine	4(11.1)
Diploma in humanitarian assistance	1(2.8)
Faculty appointment during fellowship	
Yes	31(88.5)
No	4(11.1)
No answer	1
Percentage of fieldwork during fellowship	
0-25%	16(44.)
26-50%	18(50.0)
51-75%	2(5.6)
>75%	0
Allocated fieldwork funding	
Yes	30(83.3)
No	6(16.7)
Existing field sites	
Yes	32(88.9)
No	4(11.1)
Participation in existing field sites	
Yes	29(80.6)
No	3(8.3)
No answer	4 (11.1%)
Fieldwork deliverables	
Formal research	14(38.9)
Educational curricula	12(33.3)
Quality improvement / Quality assurance	6(16.7)
Field report	17(47.2)
Other	1(2.8)
None	9(25.0)

[1]Existing field sites are sites that the fellow's institution had an agreement with to place fellows for fieldwork.
[2]Fellows who worked in institutions' existing field sites vs creating a new field site or working with an organization outside the institution's fieldwork sites.
[3]Some fellowships had multiple deliverables; therefore, one respondent could have multiple deliverables.

Figure 1. Project types during international emergency medicine fellowship.

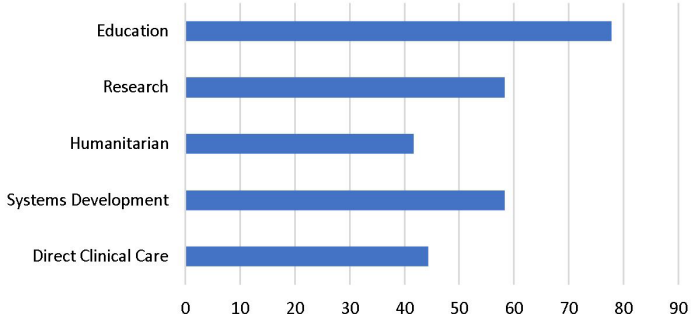


Figure 2. Type of fieldwork organizations with which the fellows worked.

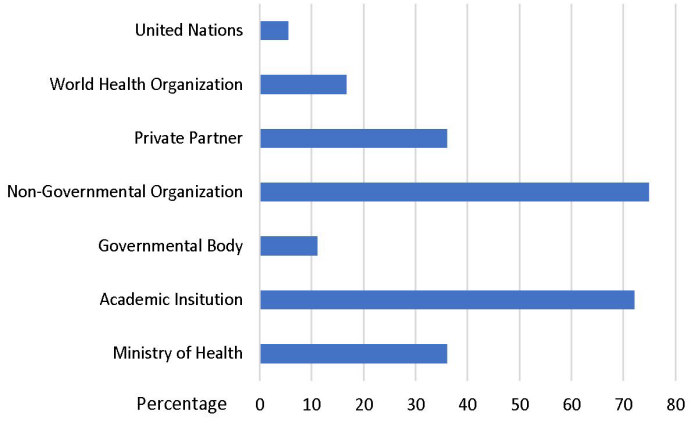
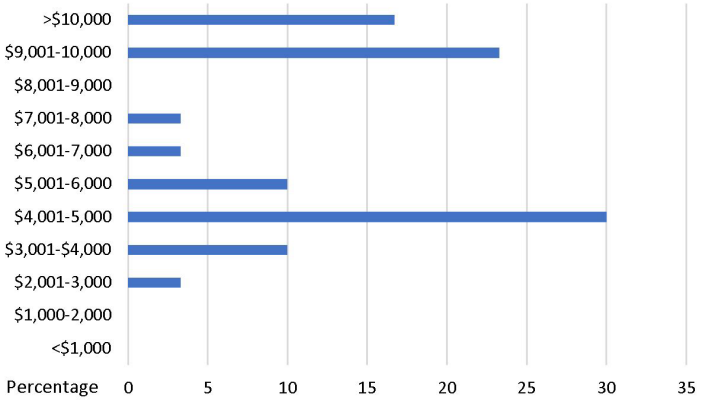


Figure 3. Amount of fellowship funding.[4]



[4]Fellows received funding from a variety of sources used for educational pursuits such as master-level courses, conferences, publication fees, and travel associated with fieldwork.

in my current department/faculty position, allows me to approach global health in a more comprehensive manner and to lend a public health perspective and approach to EM."

Those who have continued working in IEM work as part of the institutional division of international EM, IEM fellowship director, mentoring/teaching residents and medical students, international research, lecturing/planning international conferences, humanitarian work, education and training in international EM training programs, capacity development, and health system development. Those who did not continue international work cited lack of institutional support. Reasons for why they did not continue in IEM included the following: *"[F]inancial opportunity costs are too high given debt load*"; work-life balance; and limited academic positions domestically in international EM.

DISCUSSION

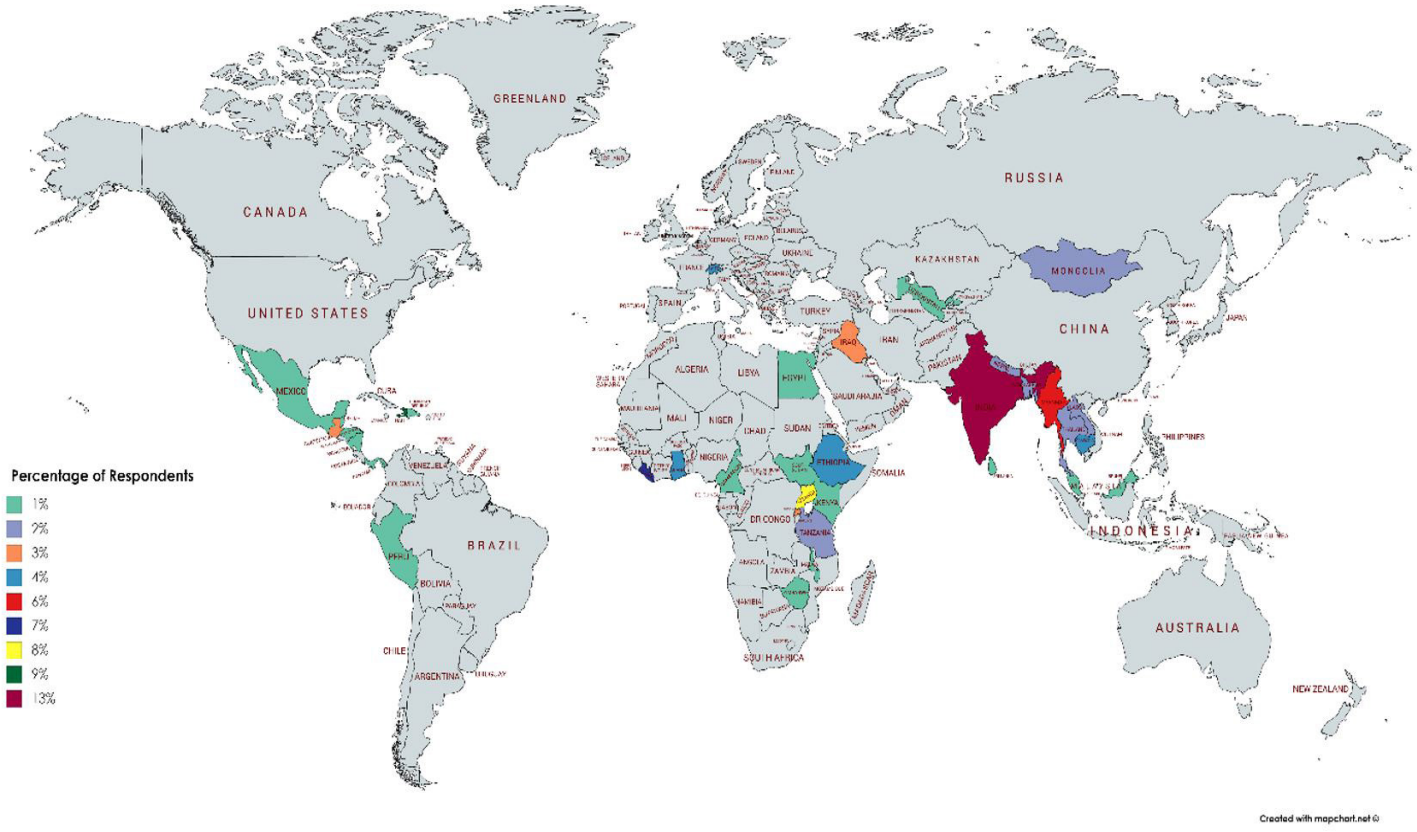
Understanding why IEM fellows become fellows, where they do their fieldwork, their institutional experience, and postgraduate roles provide information for both fellowship directors and future fellows. These data can then be used for fellowship development and aligning future fellows' expectations and goals with what is offered by the training programs. Our survey shows that most fellows choose a two-year fellowship and pursue an advanced degree, which many found to be the most valuable part of their fellowship. The data also suggest fellowship decision-makers should focus on providing opportunities and time to pursue advanced degrees with a focus on epidemiology and biostatics as many respondents felt that these were gaps in the master's degree programs.

Balancing clinical hours and field time was a constant challenge for fellowship directors and significantly impacted the fellows' experience. Acquiring protected fieldwork time for fellows is traditionally tied to the overall support of the home institution and requires active negotiations between fellowship and departmental leadership. The IEMF Consortium could play a more active role in developing advocacy tools for fellowship directors to assist in these negotiations.

Most fellowship activities took place in India and sub-Saharan Africa. Although it can be difficult to build global partnerships, the network of current and past fellows' projects might be a resource to build future partnerships and networking opportunities in areas not currently linked to IEM programs.

Almost 20% of respondents reported that they would not complete the fellowship again mainly because of financial concerns. Financial concerns occurred both during the fellowship and post-fellowship periods. Both the monetary value of fieldwork and the opportunity costs of only receiving a fellowship salary out of residency were cited as key factors. Funding for fieldwork was seen as inadequate as the funding

Figure 4. Geographic distribution of field sites (percentage per site 1-13%).



provided to fellows is used for travel expenses related to fieldwork but also to cover educational activities, such as conferences and potentially master-level courses, publication fees, and costs related to fieldwork projects. Fellowship directors and departmental leadership should consider these concerns when developing the fellow's salary and procuring travel funds in order to keep the fellowship competitive. Post-fellowship, most fellows continued to pursue global health work; those who did not left IEM due to the high cost burden relative to the benefits of continuing international work. To help those who train in this new field continue as part of the IEM community post fellowship, mentorship and funding opportunities should be shared and developed.

LIMITATIONS

The primary limitation of this study was the limited response rate. This may have skewed results to those who have continued to pursue global health. Another limitation was the potential for recall bias given that some fellows had graduated almost a decade prior. The sampling technique was limited by the completeness of fellowship directors' responses. Additionally, not all fellowships were included in this study as only active fellowships within the IEMF Consortium were contacted. This may have resulted in missed respondents from inactive or former fellowships limiting the sample size. It was assumed that fellowship directors had emails to previous IEM fellows, but lack of email addresses by the fellowship directors could have also posed a problem in generating an accurate sampling of fellows.

CONCLUSION

This study provides much needed information on the experience of international emergency medicine fellows and the international EM fellowship. IEM fellows traditionally have completed more two-year fellowships with a slight minority entering fellowship with a second language. These fellows spent 26-50% of their time in the field with 83.3% of institutions providing funding. Financial cost of continuing international work was cited as the main challenge in pursuing an IEM fellowship, which may be mitigated with novel approaches to funding global health work and improved departmental support. IEMFs should prioritize field preparation training, funded fieldwork, and integrated master-level qualifications to support the further development of this subspecialty.

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Evolving from Morbidity and Mortality to a Case-based Error Reduction Conference: Evidence-based Best Practices from the Council of Emergency Medicine Residency Directors

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Morbidity and mortality conferences are common among emergency medicine residency programs and are an important part of quality improvement initiatives. Here we review the key components of running an effective morbidity and mortality conference with a focus on goals and objectives, case identification and selection, session structure, and case presentation. [West J Emerg Med. 2020;21(6)231-241.]

BACKGROUND

Learning from medical errors and near-misses based on retrospective, single-case outcomes is an ubiquitous part of medical training, so much so that morbidity and mortality (M&M) conferences are a required component of graduate medical education in the United States and have been since 1983.[1] Despite widespread use of the M&M conference, its format remains heterogenous with significant variation between programs.[1,2]

The origin of the M&M conference can be traced to the early 20th century when Ernest Codman, a surgeon and outspoken reformer at Massachusetts General Hospital, introduced the end-results system, which employed end-result cards to publicly document individual surgeon's outcomes.[2] While this system of blame assignment was met with intense opposition at the time, it largely informed the initial iteration of the M&M conference.[2] Despite over a century of shared experience with M&M conferences among medical centers, many of the limitations of the primitive M&M conference still exist today. These include haphazard retrospective collection of data, focus on isolated and anecdotal events without consideration of previous similar events, recall bias, lack of meaningful audit, narrow focus on individual performance, lack of systems-based thinking, and lack of multidisciplinary involvement.[3–5]

Recently, there has been a shift toward incorporation of quality assurance (QA) and quality improvement (QI) goals and objectives within the framework of the traditional M&M conference.[2] In this paper, we perform a narrative review of the literature and provide best practice recommendations for goals and objectives, case identification and selection, and the structure and case presentation of M&M conferences. Using the available evidence, these recommendations redefine the conference's purpose and revise the outdated elements of the traditional M&M conference, including the proposal for a new title to better reflect the goals of the session – case-based error reduction conference (CBERC).

Critical Appraisal Of The Literature

This article is the fifth in a series of evidence-based best practice reviews from the Council of Residency Directors in Emergency Medicine (CORD) Best Practices Subcommittee.[6–10] A literature search was performed by a medical librarian of databases including ERIC, Embase, CINAHL, Medline, and Web of Science for articles published from inception through February 7, 2019, using combinations of keywords including education level (graduate, medical, internship, house staff, PGY,

and residency), conference (or didactics or lecture), and "morbidity and mortality." Two authors independently screened the resulting papers for relevant articles addressing M&M conference. Additionally, bibliographies were reviewed for applicable references not included in the initial literature search.

The literature search yielded 1199 articles, of which 51 were deemed relevant for inclusion. When there was a paucity of supporting data, recommendations were made based on our consensus opinion and experience. We used the Oxford Centre for Evidence-Based Medicine criteria to provide level and grade of evidence for each statement (Tables 1 and 2).[11] Prior to submission, the manuscript was reviewed by the entire CORD Best Practices Subcommittee and then posted to the CORD website for two weeks for general feedback and review from the entire CORD community.

DISCUSSION

Goals and Objectives

The objectives of M&M conferences vary widely across residency training programs.[1,2,12,13] Without any established best-practice recommendations and a limited body of robust literature, many conferences operate based on local institutional experience and the potentially limited knowledge of the educators administering the conference. QA is the process of using monitoring systems and retrospective performance analysis to determine whether expected standards are being met. QI is the application of data, including data gathered from QA activities, to improve systems and individual performance. The goal of the application of QA/QI activities is to prevent the occurrence or recurrence of errors through system and process improvement in the interest of delivering better patient care.

The goal of a conference-based or a classroom-setting interaction with medical staff is generally focused on education and information transfer. Historically, M&M conference has sought to improve patient care through education using a case-based format. However, the attempt to combine the QA/QI goals with those of medical education has been a more recent development.[2] In fact, Gerstein et al noted that the "typical [M&M conference] format has many shortcomings, including lack of understanding of human factors and systems thinking, a narrow focus on individual performance to the exclusion of the contributory team and larger social issues, hindsight bias, and a lack of multidisciplinary integration into a system-wide safety culture."[4] In short, traditional M&M conferences lack standardization, structure, and clear objectives. In the era of increased focus on patient safety, individual departments, institutions, and professional organizations have begun to deconstruct the M&M conference with the goal of transforming it into a mechanism to improve healthcare through education and process improvement.[14]

The traditional title, "morbidity and mortality," implies that the occurrence of an adverse patient outcome is a necessary trigger. This implication contradicts the evolution of QA/QI best practice, which incorporates near-miss error reporting and analysis as the highest yield source of error prevention events.[15] This ideology is founded on recognizing the importance of learning from errors before they reach the patient.

The foundational objectives of M&M conference reform are twofold. The system-based goal is to review cases to identify process failures and either create new or modify existing department processes to support both patients and clinicians to prevent error recurrence. The individual-based goal is to teach the healthcare team how to identify the individual and environmental factors leading to cognitive errors and address knowledge gaps. Standardized and comprehensive error discussions have not been effectively performed in programs using traditional M&M conference models.[16,17] If done effectively, working towards these goals could help departments standardize care by reducing practice variability. Additionally, a department-wide conference, including nurses, advanced practice providers, and students in addition to faculty and residents, with a system-based error focus would give the care team and individual providers an opportunity to learn from

Table 1. Oxford Centre for Evidence-Based Medicine criteria.[11]

Level of evidence	
1a.	Systematic review of homogenous RCTs
1b.	Individual RCT
2a.	Systematic review of homogenous cohort studies
2b.	Individual cohort study or a low-quality RCT*
3a.	Systematic review of homogenous case-control studies
3b.	Individual case-control study**
4.	Case series or low-quality cohort or case-control study***
5.	Expert opinion

RCT, randomized controlled trial.
*Defined as <80% follow up; ** includes survey studies;
***defined as studies without clearly defined study groups.

Table 2. Oxford Centre for Evidence-Based Medicine grades of recommendation.[11]

Grades of recommendation	
A.	Consistent level 1 studies
B.	Consistent level 2 or 3 studies or extrapolations* from level 1 studies
C.	Level 4 studies or extrapolations* from level 2 or 3 studies
D.	Level 5 evidence or troublingly inconsistent or inconclusive studies of any level

*Extrapolations refer to data used in a situation that has potentially clinically important differences than the original study situation.

errors, which are most commonly multifactorial, without having to repeat them. Redesigning the traditional M&M conference, in which the providers are exposed and vulnerable when presenting their own cases, to an anonymous shared experience model may improve information transfer while avoiding a punitive or divisive atmosphere.[18]

To avoid the negative emphasis often associated with M&M conference, we propose that M&M conference be renamed to reflect the two goals of classroom-based education and QA/QI as well as the deliberate move away from the perceptions of "shame and blame" associated with them. For the purposes of this article, the term case-based error reduction conference or CBERC will be used to refer to this transition.

BEST PRACTICE RECOMMENDATIONS - GOALS AND OBJECTIVES:

1. Emergency departments should hold regular case-based error reduction conferences (CBERCs) with a system focus to help standardize care (Level 3a, Grade C).
2. Programs should ensure that their CBERCs reflect sound educational goals and move away from the perceptions of "shame and blame" associated with the traditional M&M conference (Level 5, Grade D).

Case Identification and Selection

A. Incident Identification

An incident is generally defined as any variance that may ultimately represent a potential or experienced error after complete analysis.[19] The existing literature is sparse with regard to clearly defined processes to identify these potential errors and determine whether they have educational or QA/QI value. Incident identification is understandably the cornerstone of any effective QA/QI process. Given that the healthcare system lacks real-time, third-party oversight, it is dependent on other retroactive mechanisms for identifying errors that result in discernible harm or near-misses. Without a comprehensive incident identification mechanism, determining error prevalence is not possible. Consequently, the QA community must heavily rely upon voluntary reporting and retrospective medical record screening. Voluntary reporting sources include department physicians, nurses, students, and other employees, as well as external referrals from other services, administration, and patients.

The number and completeness of reports are limited by a variety of barriers. These barriers may include lack of clear departmental expectations for reporting; lack of a convenient mechanism for reporting; lack of anonymity for the reporter; feelings of sympathy for or a perceived need to protect colleagues; fear of litigation; fear of retaliation toward the reporter; and a lack of trust in administrative handling of the report.[19,20] A survey of medical and surgical residents suggested that residents find reporting time-consuming and cumbersome, and some expressed fear of repercussions.[21] All of these factors can lead to the development of an anti-reporting mindset and a departmental culture of non-participation and ineffectual identification of incident-based improvement opportunities. Therefore, it is essential to have departmental and institutional support to create a culture of safety with an emphasis on improvement over blame. One group described a web-based reporting tool used to identify high-yield cases to facilitate reporting and allow for anonymity if desired.[19,22]

Generally, the process for incident identification consists of the following three components: 1) standard medical record review of pre-defined screening parameters; 2) provider reporting efforts; and 3) referrals from other service lines. Several emergency departments (ED) employ institutional screens for predefined events that may identify an opportunity for improvement. Examples of screening categories are listed in Table 3.

Most hospitals have the ability to track these events and provide a list of cases for review. Modern electronic health records may also be able to assist with identifying cases. Departmental leadership or a case review committee should review the health records of each screening-identified patient encounter to search for medical errors. The case analysis process for error identification varies widely between institutions. It may be tasked to a single individual or a QA/QI committee. Regardless of who performs the reviews, the reviewers should have ongoing training in QA/QI, so they can continuously apply best practices with a sophisticated understanding of the science and psychology of QA.

It is important these reviews be separate from traditional peer-review committees, as the emphasis is on process failures, as opposed to individual performance. This separation from peer review committees is critical for two reasons. First, prematurely focusing on individual performance may distract the reviewers from subtle system defects that contributed to the issues associated with the identified case. Second, premature critique of individuals can erode the trust of faculty and residents in the overall QA process and further undermine subsequent reporting. In the case that an incident has both process and individual performance concerns, it is incumbent on the QA committee and departmental leadership to ensure they are addressed separately. Interjecting peer-review elements into CBERC will undermine the goals of QA/QI centered conference by distracting from the focus on systems issues and introducing tension and anxiety regarding individual performance.

Predefined screening-based reviews may only identify a small number of the errors within a given department. Thus, other reporting mechanisms should be sought to identify as many potential cases as possible. Table 4 includes a list of other potential sources for case identification.

Ideally, reporting should be anonymous and confidential; however, anonymous reports can be problematic if the report is incomplete or requires further clarification in order for the investigator to sufficiently assess the case for errors. The

Table 3. Examples of screening categories for potential medical error.

Return to ED within 48-72 hours with admission
Death in the ED
Death within 3 days of hospitalization
Rapid Response Team activation with escalation of care within 12 hours of hospital admission

ED, emergency department.

Table 4. Potential sources for case identification with regard to medical error incidents.

Institutional or departmental reporting registries
Feedback from other services
Solicitation from department leadership
Self-reporting
Institution-based standard quality reviews
Patient complaints
Medical staff reporting

ability to communicate with the reporter may be invaluable. Therefore, while anonymity should be offered to increase reporting, an emphasis should be placed on providing the reporter's name to better understand the case components.

B. Case-based Evidence Review Conference Case Review and Selection

Several methods of standardized case review may be used and will largely depend on the number of cases and staffing available to investigate.[23] Berenholtz et al describe using a "defect tool" in their new M&M conference format stating "... to learn from medical incidents and improve patient safety and quality of care, caregivers need to do the following: 1) elicit input from all staff involved in the incident[12]; 2) use a structured framework to investigate all underlying contributing factors; and (3) assign responsibility for management [of process changes] and follow-up on recommendations."[24] The exact details of the technique used may be less important than the general incorporation of a standardized methodology as many programs reported perceived improvement with a wide variety of standardized tools. One study found that participants in a surgical program believed that group peer review was substantially less heterogeneous than that of a single individual.[25] Error analysis by group consensus is likely to yield less concern for variability and misclassification of cases.

Cases should be carefully selected for their value in achieving the goals of process and performance improvement. Selected cases should have a broad educational value such that a meaningful proportion of providers may benefit from the error prevention strategies discussed. Cases that do not have a clear value to the audience-at-large should be avoided and referred to other venues for remediation (eg, peer review committee). Some cases may have broad educational or process improvement value, in addition to isolated concerns for provider competence or professionalism. It is critical to handle these cases in such a way as to accentuate the educational or process improvement points while preventing the other, more personal elements from distracting the participants.

Cases selected should be analyzed diligently to determine the nature of the error and the impact on the patient. Several case analysis tools are available from the QA/QI literature that can be used as part of a standard review process (Table 5).[23,24,26–28] Gathering accurate information regarding the case details may require iterative feedback from the care team involved in the case in order to generate an accurate description of case details. Feedback should be sought early and in sufficient detail to ensure a high-quality review, as the health record may not fully or accurately reflect the care episode and delays in discussing the case may result in substantial recall bias.[5] This two-way communication will also improve the ability to provide early feedback to the involved providers and give them an opportunity to clarify events. Subsequently, involved providers should be informed of the committee consensus and plans for anonymous presentation with the opportunity to clarify events at the CBERC if they desire. In addition to improving the quality of case reviews, two-way communication supports the care team members, so that they do not feel attacked or misrepresented. The process should be inclusive, transparent, and conducted with sensitivity, respecting both the patient and family, as well as the care team members.

BEST PRACTICE RECOMMENDATIONS – CASE IDENTIFICATION AND SELECTION

1. Incident identification should occur via web-based reporting and/or institutional screens for predetermined events (Level 4, Grade C).
2. Case analysis should be separate from peer review so as not to distract from the focus on system issues (Level 5, Grade D).
3. Error analysis should be performed by group review using a standardized methodology (Level 3a, Grade B).
4. Feedback from involved providers should be sought early and in detail as the health record may not accurately reflect the care episode and to avoid recall bias (Level 3b, Grade C).
5. Cases should be carefully selected for their value in achieving the goals of process and performance improvement (Level 5, Grade D).

Structure and Case Presentation

Programs that instituted standardized, structured approaches to CBERC with a focus on system-based errors found that the

Table 5. Select case analysis tools.

Tool	Components	Advantages	Limitations
Defect tool[24]	• Identify a clinical or operational event that should "never happen again"	• Elicits input from all staff involved • Incorporates structured framework to investigate all underlying contributing factors • Assigns responsibility for management and follow-up	• Difficult to find experienced mentors • Difficult to curtail enthusiasm regarding widespread system issues and limit project "scope-creep"(ie, shifting the focus from the primary process to a different, partially related process) • Difficult to evaluate efficacy of interventions for "rare" errors
Ishikawa (fishbone) diagram[23,26]	• Include people, procedures, equipment, environment, policy, and other	• Uses an approach similar to root-cause analysis • Uses a standardized process improvement tool	• May need to add a category reflecting "cognitive errors" • Usually only one element of a larger analysis
Mayo Clinic 6-step audit[27]	• Interview all parties and use a QI tool (eg, fishbone, mind map) for root-cause analysis • Determine overall cost and system issue contributing to outcome • Propose system level intervention and prioritization	• Meaningfully contributes to institutional QI initiative • Creates a change in the culture of M&M conference away from "shame and blame"	• Requires larger institutional buy-in • May involve larger audiences/groups
Mind map[23,28]	• Use diagram in which the central box represents the adverse outcome or problem • Extend links outward in all directions as contributing factors	• Cross-links factors on periphery that may have interactions and associations	• May need more contextual institutional data • Can become large and difficult to interpret for linear thinkers
Vanderbilt Structured Morbidity and Mortality Improvement (MMI) conference[26]	• Include all deaths, patient injuries with prolonged or permanent damage, and near-miss (selected by MMI Task Force)	• Selects cases with the potential for issues that are system-wide, multi-departmental, or involve more than one patient care population • Has a fixed format, reports on progress from prior conferences • Includes ACGME Core Competencies	• Requires larger institutional buy-in • May involve larger audiences/groups

ACGME, Accreditation Council for Graduate Medical Education; *QI,* quality improvement; *M&M,* morbidity and mortality.

resident perceptions of the conference were consistently more positive than prior to the structured apporach.[28–31] Although there is not yet a consensus on the ideal format for achieving the objectives of CBERC, several elements and models have been described that have demonstrated improvement in the experience and the ability to translate error analysis to meaningful QA/QI initiatives.[32–34] Studies have consistently demonstrated that the perceptions regarding standardizing error analysis are positive when compared to previous less structured conferences within a given department.[18,31,34–38]

Table 6 includes a list of elements associated with a successful CBERC based upon a study by Mitchell et al. This intervention was associated with increased faculty satisfaction, improved presentations, and greater retention of learning points by the residents.[32] In addition to those listed in Table 6, the situation, background, assessment/analysis, and review of literature with recommendations (SBAR) format has also been proposed as a useful format.[32,39]

The case presentation should have a standard format to organize the content in a way that is easy to follow and

Table 6. Key elements of successful morbidity and mortality conferences.

Making resident and faculty attendance mandatory
Decreasing defensiveness and blame
Improving the efficacy of the case presentations
Using slides
Using radiographic images
Focusing on analysis of error
Integrating evidence-based literature into the case discussion
Providing educational points related to the complication
Encouraging audience participation in the process
Allowing for a consensus to be met with respect to analysis of the cases presented
Having a moderator facilitate the conference
Fostering multidisciplinary involvement

Adapted from Mitchell et al 2013.[32]

comprehend.[40,41] The error description and classification should be based on a standard taxonomy. Additionally, the presentation should include best practice educational elements that optimize information delivery and retention for the audience.

In a survey of 33 residency training programs, the majority of residents stated that they believed that M&M conference should be non-punitive (72%), educational (87%), and contribute to a culture of safety (78%); however, almost half reported no feedback from cases discussed in the M&M conference, and three-quarters reported no debriefing.[42] Incorporating structured feedback into an organized process will likely further enhance information transfer and participant satisfaction.[42,43] Therefore, it is important to ensure that there are clear goals and take-home points.

A. Anonymity and Immunity

Any CBERC should be conducted under the guidelines and protection of the institution's QA/QI umbrella. The Healthcare Improvement Act of 1986 (Title 42 of the United States Code, Sections 11101 - 11152) extended state-level immunity for quality assurance and "performance appraisal" activities to the federal law. Unfortunately, these laws do not pertain to medical boards and other licensing organizations, which may request QA/QI records to inform a given investigation. In addition to national and local legal protections, it is critical to clearly and overtly establish that all participants in a departmental CBERC process are protected from retaliation from the department leadership, as well as other members of the medical staff and care team. The CBERC leaders should make every effort to preserve anonymity within the structure of the case presentation to reduce fear of reporting and erosion of trust.[12,20]

B. Moderators, Statement of CBERC Objectives and Rules of Conduct

The evolution of retrospective, case outcomes analysis for the purpose of QA/QI has resulted in the transformation of a traditionally provider- or institution-centered effort to one that is patient centered. For this reason, the objectives and guidelines for conduct should be explicitly stated at the outset of each CBERC, reminding the participants of the expectations for a collegial and productive learning environment. In addition to the opening guidance, the assigned moderator should ensure that the tone and content of discourse throughout the presentation continues to meet with the expressed goals and rules of conduct.

Many of the participants in a structured CBERC as described here may not have had any substantial QA/QI training. Orienting new participants on an annual basis to the philosophy and design of CBERC may help prepare participants to understand the goals and offer insights and reminders around the principle of a culture of safety. Patel and colleagues surveyed residents after an introductory lecture series on morbidity and mortality concepts. They demonstrated that residents improved their knowledge of M&M conference and felt more comfortable presenting after the training.[44,45] Additionally, both faculty and resident moderators should be trained to present the case findings in a fair-minded, objective manner and to facilitate discussion while preventing participants from deviating from the stated goals to focus on more personal agendas.

Given the general emotional impact of some inevitable performance critique in the context of errors and patient harm, it is important to not take a judgmental, overly prescriptive, or authoritarian tone. Such an approach risks reinforcing negative experiences or perceptions with CBERC and medical errors. In addition, it may be helpful to reinforce available local support resources like employee assistance programs. Every effort should be made to engage the audience in both the error analysis discussion, as well as the error remediation or prevention components of the presentation. The moderators should also be trained to use nonjudgmental language reinforcing positive themes such as patient-centered focus, teamwork, collegiality, and improving together. Ending the conference on a positive note may also help relieve tension and promote engagement. For example, ending the meeting by recognizing outstanding resident performances may help alleviate concerns of focusing solely on a handful of mistakes rather than the excellent care that constitutes the majority of care encounters.

C. Case Presentation

The core of the presentation will be the series of clinical events from the case in question. A standardized format should be employed, and the level of detail and timeline should be consistent with the error identified and the preceding contributing events. The moderators should have access to all

the clinical data if the discourse raises unanticipated questions, but the presentation itself should be succinct. The CBERC organizers should attempt to find a balance between excessive brevity and an exhaustive inclusion of every clinical detail. The following three elements leading up to the error should be included: 1) clinical data; 2) ancillary data; and 3) timeline.

Accurately recounting the case in a classroom format may not perfectly capture all of the dynamics encountered in the actual clinical environment, but it may be enhanced in several ways. First, by recreating the clinical experience of the providers involved in the case, with pauses for audience participation, the audience can appreciate the challenges the providers faced, as well as assess their own knowledge anonymously. This encourages empathy rather than allowing assumptions regarding the likelihood of making the same or similar error.

Audience-response poll questions could provide an important, low-pressure, self-assessment opportunity for participants. For example, a question requiring interpretation of an electrocardiogram may provide information regarding a knowledge gap that can be addressed by the participant, as well as the education leadership. Second, visualizing real-time data from audience members may help the CBERC organizers gain insight into process or knowledge gaps. For example, a question regarding an existing department policy may provide valuable information regarding what proportion of the audience is familiar with the policy. This practice of interpolating questions promotes retrieval, a critically important task for learning,[46,47] and has been shown to increase learners' ability to sustain attention, encourage task-relevant notetaking, and improve learning and enjoyment.[48–50]

Another method of increasing engagement is the use of simulation. Vozenilik described the use of previously recorded simulations based on M&M conference cases in which audience participants view the recording and make decisions within the context of a patient encounter.[44] This would allow participants to experience the scenario in real time and identify additional areas for improvement.

D. Discussion and Error Classification

Once the outcome of the case is disclosed to the audience, the error should be categorized based on the impact to the patient. If the error reached the patient and contributed to a poor outcome, then the degree of patient harm is classified as either minor or major depending on the outcome. The harm can be further classified as physical, psycho-emotional, patient inconvenience, or financial. If the error made no discernible impact on outcome, then it can be classified as a near-miss. In addition to patient impact, the error can be classified by the impact to the department or institution including resource stewardship. For example, an error resulting in an avoidable increased length of stay represents a resource loss in the form of monopolizing a bed, which may impact ED throughput.

Historically, M&M conference has focused on the most serious outcomes rather than minor events or near- misses as is evidenced by the traditional name of the conference. Special effort should be made to explain the value of errors that result in near-misses or have a minor impact on the patient if these cases add educational or process value.[15,51] As departments transition from the traditional morbidity and mortality model to a more QA/QI-focused process, there may be a reluctance to include cases without any discernible patient harm, as the participants have been habitualized to discussing cases with the most severe outcomes. The participants should understand that the greatest improvement value in retrospective error analysis lies in near-miss and minor harm cases because they represent the vast majority of potential cases.

Through the use an existing taxonomy, the error should be classified by type. Using standard language in assessing the error will help the CBERC organizers create a consistent, uniform approach, which can facilitate tracking and trending of the errors in a department error registry or database. Reviewing the various taxonomies available is beyond the scope of this article, but one such taxonomy that has been used successfully by the authors is shown in Table 7.

In discussing and classifying errors, there is a natural tendency to divert focus from patient care to medicolegal risk for the provider or the institution. Although CBERC may lend itself to risk management-centered teaching, the CBERC organizers and moderators should be careful to maintain a patient-centered focus. It is certainly reasonable to capitalize on risk-management teaching moments as they arise naturally, but the dominant theme should not stray from patient care to legal risks as this may erode the foundational paradigms surrounding QA/QI. Other settings like a "mock trial" format may serve as a better mechanism for the "teaching to the tort" model.[53]

E. Case Closure and Error Reduction Strategies

Aaronson et al found that despite having process improvement objectives, many programs have no feedback or follow-up process by which to effect changes.[12] Siegel et al performed a national survey with similar results.[13,54] By describing the errors, the sequence of events, and contributing factors that led to the error, the presenter will be able to make recommendations regarding error prevention. Once the contributing factors and root causes have been dichotomized into remediable vs non-remediable, the moderators and CBERC organizers can suggest mechanisms to improve the remediable factors. It is critical to engage the audience in this process in order to take advantage of brainstorming in a group. This will facilitate a greater understanding of the issues, broaden list of potential solutions, and increase support for proposed solutions.

In the interest of high-quality information transfer and retention, the core lessons for each case should be reinforced at least twice during the presentation. Examples of techniques include clearly declaring a "take home message" both verbally and visually or rapid question-answer sequences that test the audience recall. Meenakshisundaram et al reported consistent improvement in knowledge using pre- and post- M&M

conference questions following case presentations, with knowledge retention maintained at three months.[55] Table 8 provides an overview of a CBERC presentation.

F. Post-case-based error reduction conference debrief to generate consensus on error reduction strategies and QI projects

Incorporating and applying QA/QI principles will create a natural transition from error identification to error reduction in the form of QI projects intended to change processes.[29] A group of organizers, along with the moderators, should convene to review the cases and make sure there is consensus regarding the error types and the care improvement strategies generated in the conference. As previously mentioned, vetting cases in a group dynamic is more likely to be viewed as fair and transparent.[25] Maintaining databases for both error types and reduction strategies can help identify departmental trends,

Table 7. Example of an error taxonomy system.[52]

System/process error	Non-remediable factors	Cognitive factors
Equipment failure	Atypical presentation	Faulty data gathering
High workload	Complicated medical history	Faulty information processing
Inadequate handoff	Language barrier	Faulty information verification
Inefficient process	Limited ability to provide history	Faulty knowledge
Insufficient resources	Patient body habitus	Other
Interruptions	Patient non-adherence	
Non-handoff communication error	Psychiatric issues	
Poor equipment usability	Rare disease	
Supervision failure	Other	
Other		

Table 8. Proposed order of case-based error reduction conference presentation.

CBERC order of presentation	Comments or examples
1. Statement of objectives and guidelines for conduct	Example: "The information discussed in CBERC is protected and should not be discussed in forums outside hospital-designated QA activities. The objectives of CBERC are intended to improve patient care through the identification, analysis and remediation of medical errors in a collegial, non-punitive forum. Participants are asked to refrain from unprofessional conduct including the use of any accusatory or inflammatory language that may be construed as targeting, intimidation or shaming."
2. Case presentation	Provide only data available to the provider at specific timeline intervals.
3. Audience response poll	It is often helpful to poll the audience when a critical juncture in the case presentation is reached. For example, after displaying laboratory values revealing hyponatremia for a patient in status epilepticus, a multiple-choice question regarding the next most appropriate step in management may help identify knowledge gaps.
4. Outcome	Reveal the case outcome.
5. Discussion and error classification	Allow for audience discussion, classify the error, and summarize the core lesson. Repeat steps 2 through 5 until all selected cases have been presented.
6. Kudos	We suggest ending the conference on a positive note to relieve tension. This can be achieved by recognizing outstanding performance at the end of every CBERC.

CBERC, case-based error reduction conference; *QA*, quality assurance.

as well as provide ideas for future QI work.[29,56] There should also be a feedback mechanism regarding what went well and what areas need improvement with regard to the presentation style or content.

BEST PRACTICE RECOMMENDATIONS – STRUCTURE AND CASE PRESENTATION:

1. Programs should institute a standardized, structured, and systems-based approach to case presentation (Level 3a, Grade B).
2. Error classification should be based on standard error taxonomy (Level 5, Grade D).
3. CBERC should make every effort to preserve anonymity within the structure of case presentation to reduce fear of reporting and erosion of trust (Level 3a, Grade B).
4. The educational and safety-promoting focus should be clearly and consistently reinforced at the onset of each CBERC (Level 4, Grade C).
5. The periodic use of polling response systems can provide a simulated environment to stimulate learning (Level 2a, Grade B).
6. CBERC moderators should engage the audience in the process of error prevention for errors that are remediable to take advantage of the group dynamic (Level 5, Grade D).
7. A group of organizers should convene post-CBERC to gain consensus on error types and improvement strategies generated in the conference, facilitating the formation of QI projects (Level 3b, Grade C).

LIMITATIONS

There are several limitations to consider with regard to this review. First, it is possible that we may have missed some relevant articles. However, an experienced medical librarian conducted the search using a broad search strategy across multiple databases. We also reviewed the bibliographies of all included articles, contacted topic experts, and underwent pre-submission peer review by the entire CORD community. Additionally, some areas did not have EM-specific data available. In these cases, relevant data from other specialties and fields was incorporated where appropriate. When limited evidence was available, recommendations were based upon expert consensus.

CONCLUSION

As quality- and safety-related programs evolve, there is an increasing recognition of the importance of analyzing near-misses in healthcare error reduction. The classic M&M conference model implies that a bad outcome is necessary prior to error analysis and remediation. The vast majority of errors relate to near-misses and therefore represent the greatest opportunity to improve processes. Additionally, the M&M conference title is fraught with potential for negativity and apprehension due to the often punitive and trial-like nature of traditional conferences. Therefore, we recommend a new title – case-based error reduction conference. We recommend building a culture of safety in which leaders create a non-punitive structure that focuses on systems issues and avoids individual "blame and shame" tactics.

Other structural elements likely to be successful include transparent incident reporting, multidisciplinary involvement, anonymity whenever possible, case selection for broad educational value, audience participation, and quality improvement. To maximize the educational value of CBERC, audience members should actively participate, central concepts should be recapitulated, and learners should be encouraged to debrief on error reduction strategies and QI projects. This should be conducted in a carefully guarded educational safe space designed to protect patients and providers.

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A Social Network Analysis of the *Western Journal of Emergency Medicine* Special Issue in Educational Research and Practice

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Introduction: Scholarship and academic networking are essential for promotion and productivity. To develop education scholarship, the Council of Emergency Medicine Directors (CORD) and Clerkship Directors of Emergency Medicine (CDEM) created an annual Special Issue in Educational Research and Practice of the Western Journal of Emergency Medicine. The objective of this study was to evaluate the network created by the special Issue, and explore changes within the network over time.

Methods: Researchers used bibliometric data from Web of Science to create a social network analysis of institutions publishing in the first four years of the special issue using UCINET software. We analyzed whole-network and node-level metrics to describe variations and changes within the network.

Results: One hundred and three (56%) Accreditation Council for Graduate Medical Education-accredited emergency medicine programs were involved in 136 articles. The majority of institutions published in one or two issues. Nearly 25% published in three or four issues. The network analysis demonstrated that the mean number of connections per institution increased over the four years (mean of 5.34; standard deviation [SD] 1.27). Mean degree centralization was low at 0.28 (SD 0.05). Network density was low (mean of 0.09; SD 0.01) with little change across four issues. Five institutions scored consistently high in betweenness centrality, demonstrating a role as connectors between institutions within the network and the potential to connect new members to the network.

Conclusion: Network-wide metrics describe a consistently low-density network with decreasing degree centralization over four years. A small number of institutions within the network were persistently key players in the network. These data indicate that, aside from core institutions that publish together, the network is not widely connected. There is evidence that new institutions are coming into the network, but they are not necessarily connected to the core publishing groups. There may be opportunities to intentionally increase connections across the network and create new connections between traditionally high-performing institutions and newer members of the network. Through informal discussions with authors from high-performing institutions, there are specific behaviors that departments may use to promote education scholarship and forge these new connections. [West J Emerg Med. 2020;21(6)242-248.]

INTRODUCTION

For educators, publication is important for both the dissemination of educational innovation and academic promotion. Research collaboration between institutions improves circulation and generalizability, reflecting a growing trend for joint research among academic scholars and institutions.[1] For any research community the knowledge-creation process depends on researchers' collective ability to combine and integrate the findings from previous studies to advance new incremental knowledge in that area. Education research and scholarship are essential for the dissemination of innovative educational practices. In the recent past there has been an emphasis among academic institutions to focus on educational requirements of certifying organizations and financial outcomes with less emphasis on such things as scholarly teaching and research.[2–4] The *Western Journal of Emergency Medicine* (WestJEM), Council of Emergency Medicine Directors (CORD), and the Clerkship Directors of Emergency Medicine (CDEM) came together in 2015 to create a Special Issue in Educational Research and Practice. This special issue provides the opportunity for EM researchers to collaborate and disseminate educational innovations.

In this study we sought to understand the network of authors' institutions publishing in the special issue through social network analysis (SNA), a strategy used to investigate the social structures of groups or individuals.[5] SNA conceptualizes a network using the ties (edges) that connect its members (nodes) by focusing on attributes of the relationship.[6] SNA has been used in medical education to analyze research topics and trends, the dissemination of educational innovations, communities of practice, and scholarship networks.[7,8] This tool captures quantitative aspects of the patterns of relationships, which allows for comparisons between different groups and network structures. When compared over time, SNA can show changes in relationships between members of a network.

Co-authorship networks are a type of social network that may help to explain the latent structure of particular scientific inquiry or the status of individual authors of research. These networks also have the potential to identify high productivity institutions, aiding in the discovery and dissemination of best practices strategies for promoting educational scholarship. The objective of this study was to evaluate and map this network of education scholars publishing in the special issue and measure characteristics of the network to assist faculty in establishing robust publishing connections.

Population Health Research Capsule

What do we already know about this issue?
The ability of the WestJEM Special Issue in Educational Research and Practice to encourage and connect scholars across institutions is not yet known.

What was the research question?
What are the characteristics of the social network of institutions created by the special issue?

What was the major finding of the study?
An increasingly diverse group of institutions is represented in the network with a core of schools publishing in consistent groups.

How does this improve population health?
There is opportunity to increase education research collaboration by intentionally expanding the network to include new institutions and encouraging new groupings of institutions on publications.

METHODS

Data Collection

To assess social connectivity among authors and institutions published in the first four CORD/CDEM special issues we collected and analyzed bibliometric data as described previously.[9] Publication data were exported from Web of Science, and the authors' institutional affiliations were collapsed so that multiple names for one institution were grouped into a single identifier. We used institutional identifiers to calculate the number of articles with authors from more than one institution. The following data were abstracted for all articles appearing in the 2015, 2017, 2018 and 2019 WestJEM special issues: author(s); article title; year of publication; digital object identifier; and the times cited within the Web of Science (Clarivate Analytics, clarivate.com); authors' affiliations; article type (original research, commentary, education innovation, etc); number of institutions represented by authors; and whether or not data were gathered from one or multiple institutions.

Data Analysis

We used the institution and co-authorship data to analyze the social network associated with each year of the Special Issue in Educational Research and Practice as well as all four years combined. The software UCINET (Analytic Technologies, analytictech.com) was used to conduct a SNA of the *WestJEM* Special Issues. UCINET allows the analysis of a social network through whole-network and node-level metrics as well as visual representation of the network. Whole-network and node-level metrics are used to describe variations in the network in each of the four years and across all years while the sociogram depicts the extent of the network created by all of the special issues. Institutional review board approval was not required as this is based on publicly available data and not considered to be human subjects research. Specific metrics of interest at the network and node (institution) levels are included in Table 1.

Table 1. Definitions of selected social network metrics included in this study assessing connectivity among authors and institutions.

Network level metrics	
Average degrees	The average number of connections for a member of the network. This helps describe how connected an average (typical) institution is across the special issue network.
Network density	The proportion of actual connections to all possible connections across the entire special issue network (range: 0-1). In the context of this study, a denser network (higher value, closer to 1) would mean the authors' institutions are more directly connected to each other, while a less dense network (closer to 0) would mean fewer direct connections between author institutions making up the special issue network.[10]
Degree centralization	Measures the concentration of power or influence within a network or the variance in the distribution of centrality in a network. This is a normalized value of the importance of single players within the given network. In our case, high degree centralization would suggest that the network is characterized by few centralized institutions whereas a low centralization score would suggest that institutions are more evenly distributed across the special issue network.
Node level metrics	
Degree centrality	The number of connections between one institution and the other institutions within the network. In this study, a network node is represented by a single institution and the degree would count the number of connections to other institutions making up the special issue network.[11]
Betweenness centrality	Measure of how often a node (institution) is connected to other nodes (institutions) that are not then connected to each other. As such, the measure serves as an indicator of which institutions serve as key bridges or connectors within the special issue network.[10,11]

RESULTS

Over four years of the *West*JEM CORD/CDEM special issues, authors from 122 institutions contributed to 136 articles that were included in this analysis; a description of this dataset is published elsewhere.[9] Of the 122 institutions that published in a special issue, 41.8% (51) published in a single year, 33.6% (41) published in two years (consecutive or not), 13.9% (17) published in three years, and 10.6% (13) published in all four years. Fifty-six percent (76) of the publications in the special issues included authors from more than one institution with a low of 42% (14) in 2015 and a high of 69% (25) in 2017. In analyzing the network created by the special issues, Figure 1 represents the relationship between institutions across all four years.

Network-wide metrics

Density

Network density is a ratio measure that compares the number of actual connections between institutions in the network to the total possible *potential* institutional connections that make up the network of scholarship. The resulting score can range from 0-1. In each of the four years analyzed, and in the cumulative analysis, network density remained fairly constant across the special issues, ranging from 0.08-0.1 (mean score of 0.09). (For whole-network metrics, see Table 2.) Given that the network density score remained about .08 across all publications and years, this would imply that there was no observed expansion in collaboration between the different institutions making up the scholarship network.

Degree Centralization

Degree centralization measures to what extent there are a small number of highly centralized nodes (institutions) that make up the global network of special issue publications (answering the question: how centralized is the network?). The score is a ratio that compares the actual sum differences between the individual institution's degree centrality score and the maximum degree centrality score in the network. As such, the resulting measure can range from 0-1 in the global network, where a score closer to 0 would represent a global network where all institutions are on more equal footing, whereas a larger score would indicate a network where fewer institutions were more central to the network. Overall, it appears that degree centralization was low in each of the years of the special issues (average 0.28 across four issues). However, as noted in Table 2, in the 2018 and 2019 issues, there was greater participation by a more diverse set of institutions than was seen in the earlier issues.

Node-level Metrics

Degree Centrality

Degree centrality for a particular institution represents the importance of a particular institution in the network (ie, which institutions are in the center). For each institution, we calculated the degree centrality score for that institution, which is simply the sum total of the number of connections that a particular institution has to other institutions making up the network of scholarship. Three institutions placed in the top three in terms of degree centrality within the network most years (Michigan, Mt. Sinai, and Ohio State). There was considerable variation within degree centrality each year for each institution (see Table 3). With the exception of 2018, a year in which Yale did not publish in the special issue, the average degree of the network nodes increased between the initial issue and the most recent (eg, 3.48 in 2015 to 6.17 in 2019, mean 5.34).

Betweenness Centrality

Betweenness is another measure of centrality importance based on where a particular institution stands as a crossover point for shortest paths between all the other nodes in the entire network. The betweenness centrality score for an institution, therefore, is the number of the shortest paths that pass through that institution in the network of scholarship. The top five institutions based on betweenness scores for all four years combined were Michigan, Mt. Sinai, Ohio State, University of Washington, and Yale (see Table 3). These institutions also had authors publish in either three or four years of the special issues. While the node with the highest betweenness score varied from year to year, the same group of five institutions remained important actors in the network across the four years.

DISCUSSION

Social network analysis serves as a useful method for investigating characteristics of the *West*JEM Special Issue in Education and Research and Practice network as it highlights key players within the network and trends within each year and across multiple years. SNA allows observation and mapping of the characteristics, connections, and frequency of interactions in the author network. This study found that the special issues represent a diverse network of authors and institutions. The network was diverse in the individual institutions represented in the issues and new institutions being introduced to the network as well as some variability of the authorship groups. In other words, often papers included different authors from different institutions and a different group of authors for other papers. Still, there were a small number of institutions that published in consistent author groups, without introducing new members to that group, and were more highly connected to the rest of the network.

Social network analysis focuses on the interactions between the members of the network.[12] The analysis provides information about how members interact with one another and what is the level of connectedness.[13] In the network, every network member, is not tied to every other node. There may be clusters of densely knit connections, while other members may only be connected from the periphery through a central member. The relationships reflect a flow of interactions and opportunities. It is these varying degrees of closeness, or connectedness, that determine the influence that node may have on others. Social network analysis has been widely applied across other fields and in a few studies on medical networks to describe the relationships of the members.[7,8,14,15]

As indicated in Table 2 by the network density remained

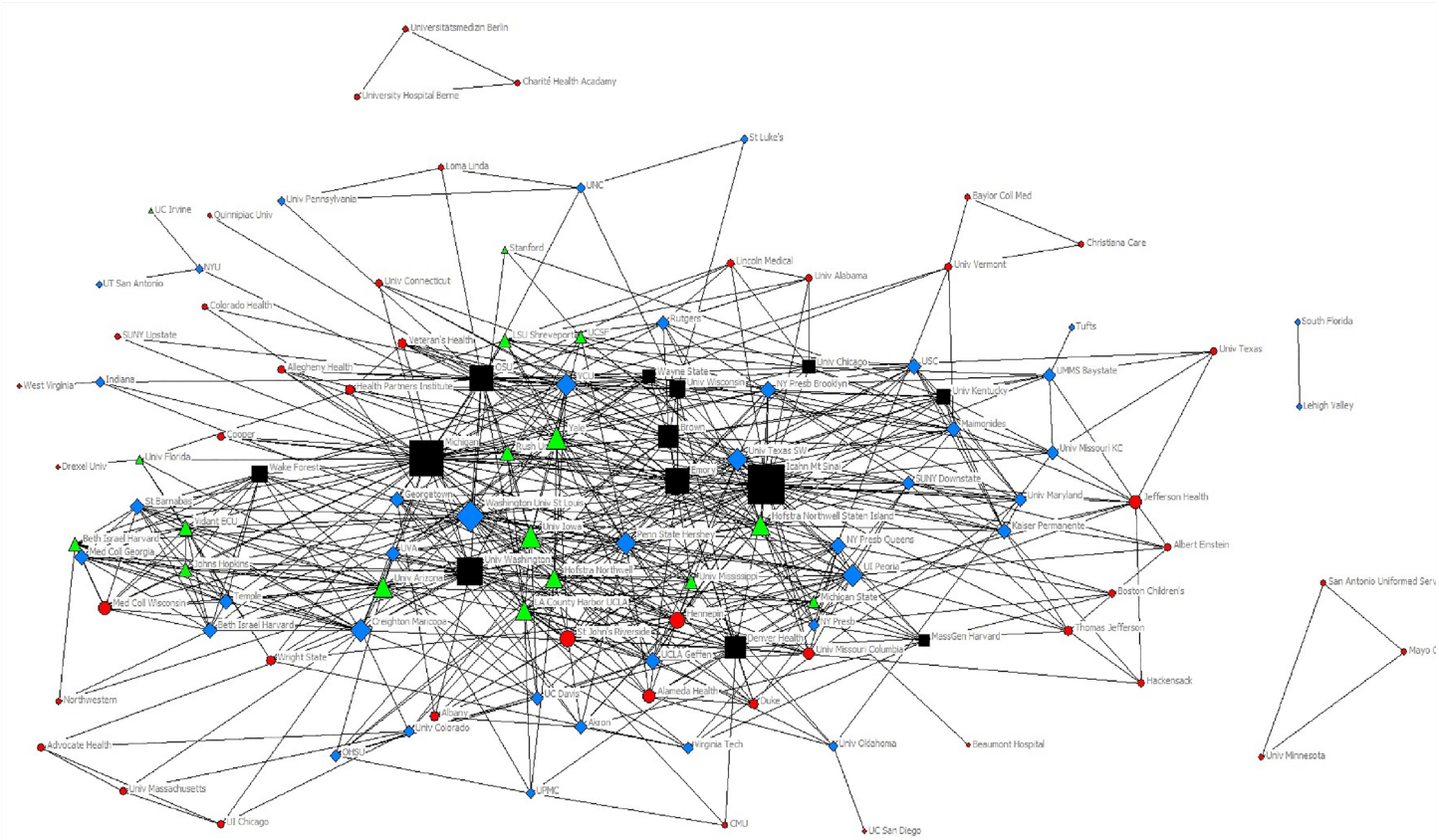

Figure 1. Sociogram of networked institutions from the first four years of the *West*JEM Special Issue in Educational Research and Practice. Circles represent institutions that published in a single issue. Diamonds represent institutions that published in two issues. Triangles represent institutions that published in three issues. Squares represent institutions that published in all four issues. The node size is weighted by the number of connections (degree) per node (reported for select institutions in Table 3 in the "All Years" column).

Table 2. Whole-network metrics for each year of the Special Issue in Educational Research and Practice and all years combined.

Network metrics	2015	2017	2018	2019	All years
Density	0.08	0.1	0.09	0.1	0.08
Average degree	3.48	6.1	5.61	6.17	9.66
Degree centralization	0.31	0.33	0.23	0.24	0.32
Authors from two+ institutions (%)	42.42	69.44	55.56	54.84	55.88

Table 3. Degree centrality and betweenness metrics for select institutions in each year and cumulatively.

	Degree centrality (rank)							
	2015	2017	2018	2019	All years	# Publications[1]	NIH rank[2]	Program length (years)
Average degree centrality	3.48	6.1	5.61	6.17	9.66			
Michigan	17 (1st)	20 (2nd)	24 (1st)	11 (11th)	73	24	1st	4
Mt. Sinai	8 (2nd-tie)	16 (3rd)	19 (4th)	23 (1st)	66	12	4th	4
Ohio State	3 (24th)	8 (19th-tie)	20 (2nd-tie)	9 (18th-tie)	41	17	15th	3
University of Washington	8 (2nd-tie)	1 (53rd-tie)	10 (10th-tie)	8 (25th-tie)	32	6	Not ranked	4
Yale	8 (2nd-tie)	5 (30th-tie)	n/a	16 (6th)	29	6	3rd	4
	Betweenness (rank)							
Michigan	0.30 (1st)	0.12 (3rd)	0.14 (1st)	0.02 (12th)	0.12	24	1st	4
Mt. Sinai	0.03 (6th)	0.16 (2nd)	0.06 (4th)	0.06 (2nd)	0.12	12	4th	4
Ohio State	0.03 (7th)	0.02 (14th)	0.06 (5th)	0.06 (3rd)	0.08	17	15th	3
University of Washington	0.15 (2nd)	0 (27th-tie)	0 (13th-tie)	0 (16th-tie)	0.06	6	Not ranked	4
Yale	0.03 (9th)	0 (27th-tie)	n/a	0.09 (1st)	0.05	6	3rd	4

[1]This is the number of publications in the dataset for Social network analysis.
[2] NIH (National Institutes of Health) research rankings provides a benchmark for other research in the department (http://www.brimr.org/NIH_Awards/2018/NIH_Awards_2018.htm).

low and did not change significantly over four years. One would expect that if the same people are in a network and developing new relationships over time, then density would increase as more connections are made. Rather, there was no change in density reflected here, which suggests that relationships are stable and that the same institutions continue to publish together with little change to the institutions represented in certain author groups. There is some data to suggest that while the central players in the network, described in part by betweenness scores in Table 3, did not vary greatly across the four issues and continued to published in similar author groups, that some of these institutions formed additional authorship groups with new or existing members of the network. However, these new connections were not brought into the more established authorship groups.

The creation of new authorship groups mentioned above is supported by the fact that the average number of connections per institution increased between the initial and most recent special issue. At the same time, measures of power concentration within the network decreased over the four-year period. This suggests that, aside from traditional key players reaching out to form new groups, new institutions are entering the network with each subsequent year with novel authorship groups. Some of the new connections observed in the network may be due to reasons as various as individuals moving to new institutions, a trainee obtaining a new faculty positions, or novel authors joining the network. One might also hypothesize that the expansion of the network is due to both formal connections generated by work on task forces, work groups, committees, and educational scholarship programs, as well as by informal connections such as colleagues not attached to a specific working group.

To understand the network dynamics better, we informally contacted the authors at institutions with the highest consistent metrics in degree centrality and betweenness to provide insights on a departmental approach to creating successful educational

scholarship in an attempt to identify common themes. By contacting these representative institutions, we sought to provide insight on approaches and key strategies in building productive multi-institutional collaborations for educational scholarship.

Based on discussions among the authors regarding the content of these discussions, there were some common threads for collaboration success. The first approach to scholarship was participation in working groups, task forces and longitudinal educational scholarship programs at a national level, such as Medical Education Research Certification at CORD, which appears to be important in developing multi-institutional research.[16] These successful collaborations started with an author group that was passionate about a specific question and topic. Second, after working together on smaller projects, relationships and research groups formed that then led to working on other papers. These groups changed over time as new people joined and left, and new connections were made. As some research groups matured, collaborators brought in new members leading to new ideas and an organic growth of the network. Finally, sometimes groups have a strong educational researcher or mentor that helps to drive the work and provides opportunities for others to engage.

LIMITATIONS

Limitations of this study included inability to account for changes made by the movement of people to new institutions. It is unclear how these movements may have affected the yearly rankings based on the data from the above figures. Additionally, this SNA is a snapshot of one journal and its special issue. The *West*JEM Special Issue in Educational Research and Practice is co-sponsored by CORD, which may lead to a bias in how collaborations are created (eg, meeting at the annual CORD assembly). Another significant limitation was the potential publication bias by the supplement in the choice to publish specific manuscripts. Although some of the process may be blinded, the reviewers and editors may have their own biases regarding which types of articles they choose.

Additional research is needed to identify how research networks are formed for publications of other journals. Future research is needed to further our understanding of how network connections and academic collaborations are forged, and the factors – whether individual, institutional, or across a network such as that described here – may lead to more and stronger connections among academic educators. The time covered by this analysis, four issues of one journal in four different years, may not be sufficient to detect changes that require a greater amount of time, eg, changes resulting from key authors changing, changes in leadership, or changes to the practice environment.

CONCLUSION

By performing a social network analysis of the *West*JEM Special Issue in Educational Research and Practice, we sought to identify patterns of collaboration within the institutional authorship groups and, additionally, to understand which institutions were consistently high performers in terms of connectedness and centrality within the network. This social network analysis provides insight into the early network created by the initial four years of the special issue. Future work is required to determine whether these findings are consistent across other journals (generalizable) and whether or not changes take place in the network that were not identified by this study due to a limited period.

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Characterization of Regional Poison Center Utilization Through Geospatial Mapping

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Introduction: Penetrance is the annual rate of human exposure calls per 1000 persons, a measure that historically describes poison center (PC) utilization. Penetrance varies by sociodemographic characteristics and by geography. Our goal in this study was to characterize the geospatial distribution of PC calls and describe the contribution of geospatial mapping to the understanding of PC utilization.

Methods: This was a single-center, retrospective study of closed, human, non-healthcare facility exposure calls to a regional PC over a five-year period. Exposure substance, gender, age, and zone improvement plan (ZIP) Code were geocoded to 2010 US Census data (household income, educational attainment, age, primary language) and spatially apportioned to US census tracts, and then analyzed with linear regression. Penetrance was geospatially mapped and qualitatively analyzed.

Results: From a total of 304,458 exposure calls during the study period, we identified 168,630 non-healthcare exposure calls. Of those records, 159,794 included ZIP Codes. After exclusions, we analyzed 156,805 records. Penetrance ranged from 0.081 - 38.47 calls/1000 population/year (median 5.74 calls/1000 persons/year). Regression revealed positive associations between >eighth-grade educational attainment ($\beta = 5.05$, $p = 0.008$), non-Hispanic Black ($\beta = 1.18$, $p = 0.032$) and American Indian ($\beta = 3.10$, $p = 0.000$) populations, suggesting that regions with higher proportions of these groups would display greater PC penetrance. Variability explained by regression modelling was low ($R2 = 0.054$), as anticipated. Geospatial mapping identified previously undocumented penetrance variability that was not evident in regression modeling.

Conclusion: PC calls vary substantially across sociodemographic strata. Higher proportions of non-Hispanic Black or American Indian residents and >eighth-grade educational attainment were associated with higher PC call penetrance. Geospatial mapping identified novel variations in penetrance that were not identified by regression modelling. Coupled with sociodemographic correlates, geospatial mapping may reveal disparities in PC access, identifying communities at which PC resources may be appropriately directed. Although the use of penetrance to describe PC utilization has fallen away, it may yet provide an important measure of disparity in healthcare access when coupled with geospatial mapping. [West J Emerg Med. 2020;21(6)249-256.]

INTRODUCTION

Poison centers (PC) accredited by the American Association of Poison Control Centers (AAPCC) offer high-quality information to callers seeking information and medical consultations for poisoned patients. They serve critical roles in real-time epidemiological surveillance of poison exposures

and disease epidemics, and are a key component of our national health surveillance system.[1] Increased PC utilization has been associated with decreased emergency medical services utilization and unnecessary hospitalizations[2] and with shortened hospital stays following exposure.[3,4]

PC utilization has historically been assessed in terms of *penetrance*, defined as the annual number of calls per 1000 persons in a defined call area.[5,6] Penetrance rises with changes in United States Census Bureau (USCB) population estimates and live birth rates,[7] suggesting a correlation between population growth and childhood poison exposures. Low PC penetrance is associated with increased healthcare utilization, particularly in children.[5,8] Variations in penetrance have been attributed to seasonality,[6] changing pediatric population proportions,[9] limited awareness of PC services,[10] and suspicion regarding PC cost and safety of personal information.[11] Social determinants of PC penetrance are less well-defined, although several racial (Black and Native American) and linguistic (low English proficiency and native Spanish-speaking) characteristics are associated with lower PC utilization when compared to White and English-speaking populations.[5,10,12,13]

The use of penetrance has been disputed over time, largely due to a perceived limited efficacy in assessing both PC efforts and outcomes.[9] Although the AAPCC discontinued its use of penetrance as one of multiple methods to ascribe efficacy to individual PC outreach and promotion efforts in 2001, it was done prior to the advent of easily accessible, geospatial mapping tools to provide a more refined data than at a county level, suggesting that penetrance may once again serve a purpose in identifying areas in which PCs are underused. The same variation in penetrance attributed to sociodemographic variables that led to its discontinuation as a metric for PC accreditation is suggestive of its value in further exploring predictors of PC utilization.

Few studies describe geographic penetrance at a level more granular than county-wide, despite intra-county variability in race, income, ethnicity, and other socioeconomic determinants of health.[14–17] Focal exposure clusters may be localized within close proximity and overlooked within county-wide analyses.[18] Therefore, exposure patterns may be better understood when mapped geospatially. We hypothesized that highly granular geospatial mapping would reveal previously unidentified sociodemographic predictors of penetrance. The goal of the study was to characterize PC call penetrance by USCB tracts to better characterize variation across the PC catchment area.

Population Health Research Capsule

What do we already know about this issue?
Poison centers (PC) serve large populations, but call penetrance may vary.

What was the research question?
We sought to characterize the geospatial distribution of calls to a single regional PC.

What was the major finding of the study?
Calls to a PC vary substantially by sociodemographic strata, with significant geospatial variation in call origin, while regression modelling suggested greater penetrance in regions with higher proportions of non-Hispanic Black and American Indian populations, and >8th grade educational attainment, however variability explained by the model was low.

How does this improve population health?
Statistical analyses describe patterns to regional PC callers, but spatially mapping call density may identify areas of low call penetrance to guide outreach efforts.

METHODS

Setting

This was a retrospective study characterizing the group-level demographic characteristics and geospatial distribution of human exposure calls to a regional PC from locations other than healthcare facilities over a five-year period, from January 1, 2010–December 31, 2014. The Minnesota Poison Control System covers a catchment area of nearly 87,000 square miles (greater than 218,000 square kilometers) and serves approximately 5.5 million people. It receives more than 50,000 calls annually; a majority of these originate in sites other than healthcare facilities.

Minnesota is a diverse state. Smaller proportions of the population than the national average live in poverty (11.5% vs 15.4%) and fewer report non-English language use (11.5% vs 15.4%), but racial disparities are profound: higher proportions of Blacks and Native Americans in our state live in poverty than nationally (36.5% vs 27.3% and 36.0% vs 28.8% in 2014, respectively).[19,20] Attainment of a bachelor's degree or higher varies substantially across racial groups, from 8% among Ojibwe to 85% among Asian-Indian residents.[21] Additionally, the state is home to the country's largest Somali population, second largest Hmong population, third largest Lao population, and fifth largest Burmese population.[22] One in seven Liberians in the US resides in Minnesota, while one in 12 of Ethiopian descent resides here.[23] Overall, 4.25% of our service population possesses limited English proficiency.[24] Data characterizing statewide health literacy is limited, but suggest that up to one in five patients seeking emergency services possesses limited health literacy.[25,26]

Recent multi-patient toxicological exposures in minority communities[27,28] have highlighted the importance of PC penetrance in historically underserved populations. These outbreaks have been concentrated in small geographic areas

incompletely captured by county-level geospatial mapping, suggesting a potential benefit to improved understanding of the spatial distribution of PC calls. Despite known multi-patient exposures in language- and ethnic-minority communities, telephonic interpretive services are engaged on average fewer than five times per month in the PC, or less than 0.2% of all calls. While it is plausible that linguistically under-represented and economically disadvantaged segments of the population experience fewer poisonings than others, such disparities raise suspicion for a lack of access to PC services.

Thus, following approval from the governing institutional review board, we queried the National Poison Data System (NPDS) for all closed human-exposure calls originating within Minnesota (Caller site/Exposure site: Own residence, Other Residence, Workplace, School, Restaurant / food service, Public area, Unknown, NULL). The NPDS maintains all call data generated by the nation's 55 PCs, with nearly continuous real-time database updates.[1] Because the goal of this study was to characterize non-healthcare penetrance across an entire PC call area, we excluded calls coded as originating from healthcare facilities or referencing exposures occurring in healthcare facilities, as their inclusion would have over-represented a small number of census tracts rather than accurately describe exposure distribution. Calls originating outside of Minnesota, calls without zone improvement plan (ZIP) Codes, and calls for which ZIP Code geocoding was not possible were excluded from analysis. No further exclusions were made.

Data Analysis

Patient-level data including ZIP code, gender, age, exposure reason (intentional or unintentional), caller and exposure sites were electronically abstracted from NPDS. We then imported call records to Microsoft Excel 2013 (Microsoft Corporation, Redmond, WA). PC data, including postal ZIP Code, were geocoded to USCB tract data (2010) for household income, educational attainment, age, ethnicity and primary language. The resulting dataset was spatially apportioned to USCB tracts based on quantifiable spatial and population overlaps. ArcGIS 10.5 (Esri, Redlands CA) was then used to generate heat maps defining the penetrance of callers to the PC over USCB tracts overlapping 87 Minnesota counties.

We developed a multiple regression model of penetrance using clinically important variables within the USCB dataset, including the continuous (0 to 1.0) proportions of households reporting greater than eighth-grade educational attainment, population <5 years of age, households below the federal poverty line, and households that reported speaking a language other than English. The proportion of the population identifying as Hispanic, non-Hispanic Black, non-Hispanic American Indian, and non-Hispanic Asian were also included. We evaluated the distributions of predictor variables for normality using standardized normal probability and kernel density plots (pnorm, qnorm, and kdensity commands). Those with non-normal distributions were considered for transformation prior to multivariate analysis using linear regression modeling in order to meet the assumptions of the model. All data were analyzed using Stata 12 (StataCorp, College Station, TX).

We compared the resulting penetrance heat map to known geographic, political, and sociodemographic maps of the state. A qualitative comparison of penetrance "hot spots" (areas of increased penetrance) and "cold spots" (areas of decreased penetrance) to areas of known sociodemographic or geographic importance was then made. The assessment of importance was made by PC staff, medical toxicologists and medical toxicology fellows, based on PC-identified areas of interest. As discussion of heat mapping of each of more than 1300 USCB tracts was infeasible for the purpose of a single study, we highlighted previously unidentified geospatial findings of potential clinical importance to the PC as exemplars of the utility of geospatial analysis for PCs.

RESULTS

Annual call volume to the PC ranged from approximately 51,000 to 58,000 calls during the study period; of these, approximately 85-89% were exposure calls annually, and 77-81% were unintentional. Over the five-year study period, 304,458 exposure calls to the PC were identified (Figure 1). Of these we excluded 147,653, largely accounted for by those originating

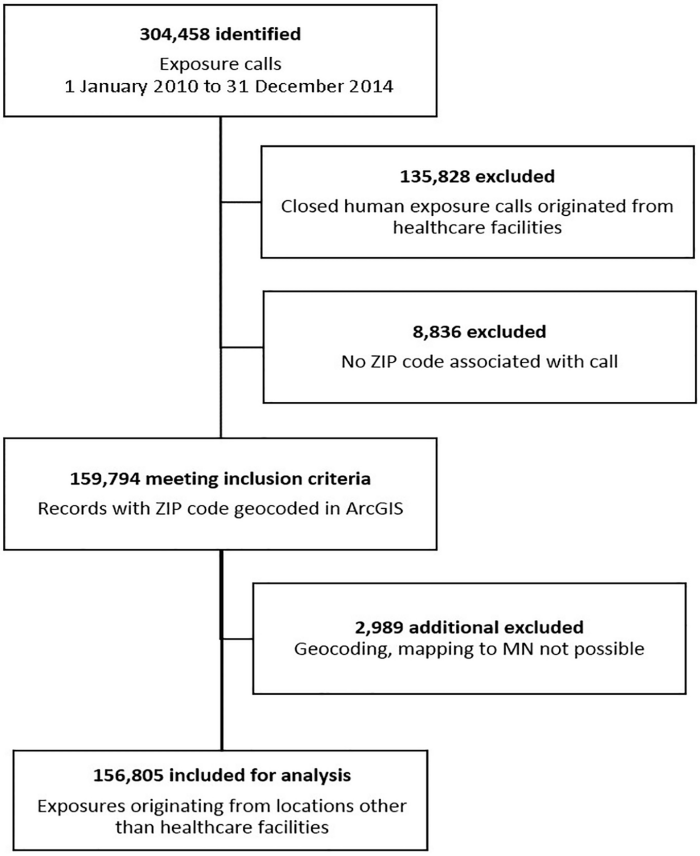

Figure 1. Study flow diagram of phone calls made to Minnesota Poison Control System, using geospatial analysis to pinpoint origin.

from healthcare facilities (91.99%). Smaller exclusions were due to missing ZIP Codes (5.98%) or ZIP Codes that were not mappable to the state (2.02%). The remaining 156,805 exposure calls not originating from healthcare facilities were included for regression analysis and geospatial mapping.

Non-normal distributions of observations were noted for all variables but the proportion of population less than five years of age. Numerical and graphical evaluation suggested square root variable transformations as most appropriate to meet the regression assumption of normally distributed data for all but the population proportion reporting educational attainment of eighth-grade or better to the USCB. In that case, transformation did not meaningfully impact observation distribution, and was not applied. Post-hoc model assessment revealed heteroskedastic distribution of regression residuals (estat hettest, Breusch-Pagan χ^2 303.6, p = 0.000), and thus robust standard errors were applied to the model.

Linear regression revealed significant associations between PC penetrance and USCB tracts with higher proportions of eighth-grade educational attainment or higher (β = 5.05, p = 0.008), non-Hispanic Blacks (β = 1.18, p = 0.032), and American Indians (β = 3.10, p = 0.000), indicating that census tracts with higher proportions of these demographic groups would be expected to display greater PC penetrance. No significant association was noted between PC penetrance and population proportions below the federal poverty line, proportions identifying as Asian, Hispanic, non-English speaking, or proportions of population less than five years of age. Variance in penetrance explained by regression modelling was low (R^2 = 0.054).

Previous county-based geospatial penetrance mapping (Figure 2b) revealed a caller distribution profoundly more complex than previously available county-wide penetrance maps (Figure 2a), with substantial intra-county variability in PC penetrance. "Cold spots," or regions of low penetrance, were identified in southern, southeastern, and west central regions of the state, while "hot spots," or regions of increased penetrance, were identified in small north central and northern areas of the state, and within the state's two largest urban centers. These consequential variations in the geospatial distribution of PC calls were not captured by statistical modelling. Case examples elucidate nuances to call distribution not captured by regression analysis.

Case Examples

Leech Lake Reservation

An isolated penetrance "hot spot" in north central Minnesota correlated with the intersection of Cass, Beltrami,

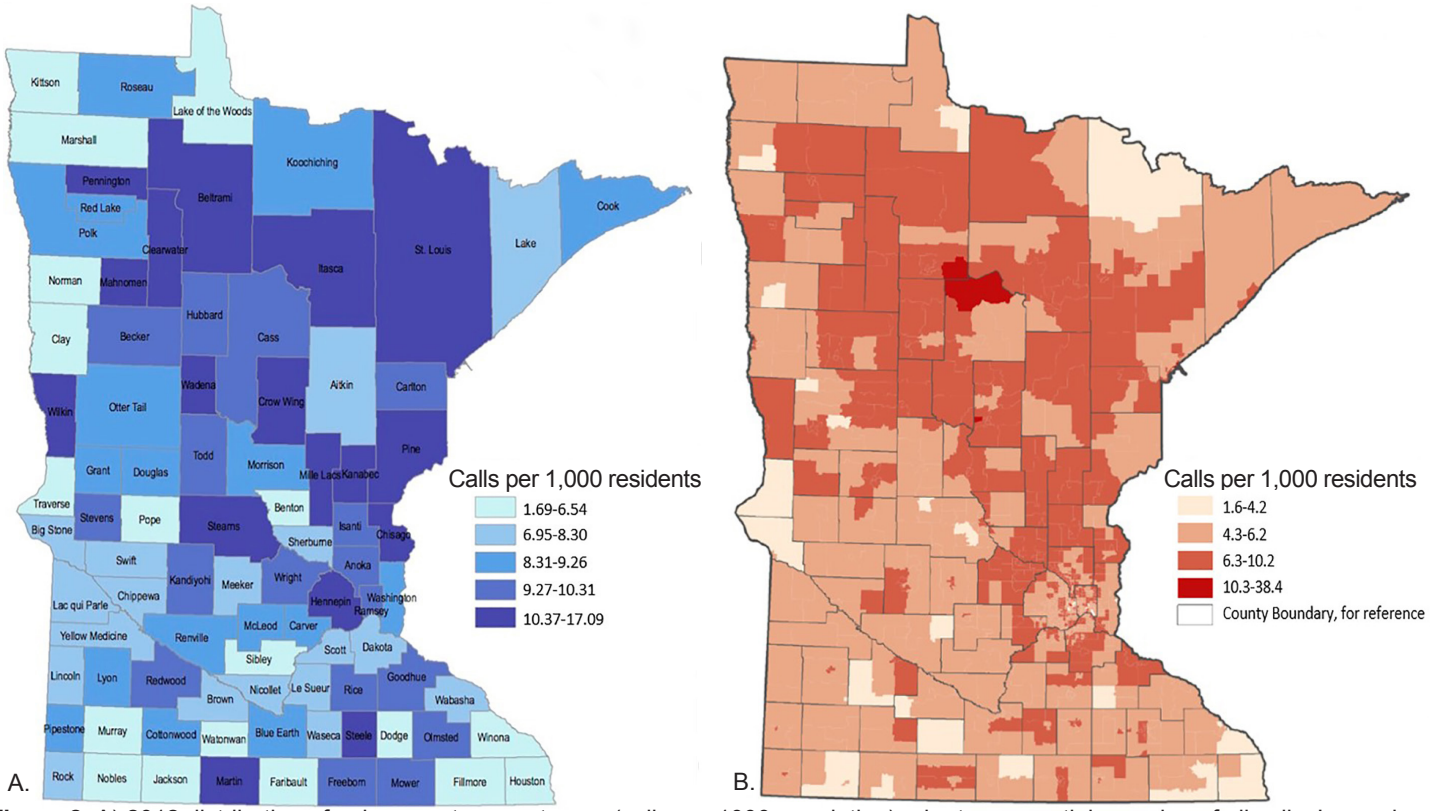

Figure 2. A) 2012 distribution of poison center penetrance (calls per 1000 population) prior to geospatial mapping of all calls. Legend reports penetrance as calls per 1000 residents per year. B) 2010 – 2014 census tract geospatial mapping of poison control call penetrance. Legend reports penetrance as calls per 1000 residents per year over the study period.

and Itasca counties (Figure 3a). No regional suggestion of increased calls was apparent by county-based spatial mapping of call penetrance (Figure 2a). Census-tract spatial distribution of penetrance revealed a hot spot substantially and uniquely overlapping the legally designated Leech Lake Indian Reservation. This finding suggests a previously undetected variation in penetrance within the reservation with no clearly apparent etiology.

Southeast Minnesota

A "cold spot" was identified in far southeastern Minnesota correlating with Fillmore, Houston, and Winona counties (Figure 3b). All three counties were low penetrance by county-based mapping; however, census tract mapping revealed that the extreme southeastern component of the area had considerably lower penetrance than the northern and western portions of the counties. This subregion represents the most sparsely populated area of the three low-penetrance counties, and correlates with one of the 25 largest Amish settlements in the US as a percentage of county population (4.69% of Fillmore county in 2010).[29] Amish communities commonly de-emphasize ownership or use of private telephones,[30,31] and PC penetrance within this community may thus be constrained by technology, suggesting a need for further exploration of this finding, and for consideration of alternate communication methods in areas of low telephone availability.

Cedar-Riverside

A "cold spot" was identified in central Minneapolis overlapping Cedar-Riverside (Figure 3c), a triangular neighborhood contained on two sides by freeways, and on the other by the Mississippi River. Forty-eight percent of the Cedar-Riverside population is Black, while 51.3% of the population there speaks a language other than English.[32] This diverse neighborhood is the epicenter of Minnesota's Somali diaspora, estimated between 27,000 born in Somalia and 46,000 reporting Somali ancestry.[33] The western and southern regions of Cedar-Riverside are more heavily populated by the Somali population, while the northern and eastern regions are occupied by the University of Minnesota campus. Low PC penetrance appears limited to areas of Cedar-Riverside with the highest Somali population density, while the remaining neighborhood heat map displays no observable low penetrance.

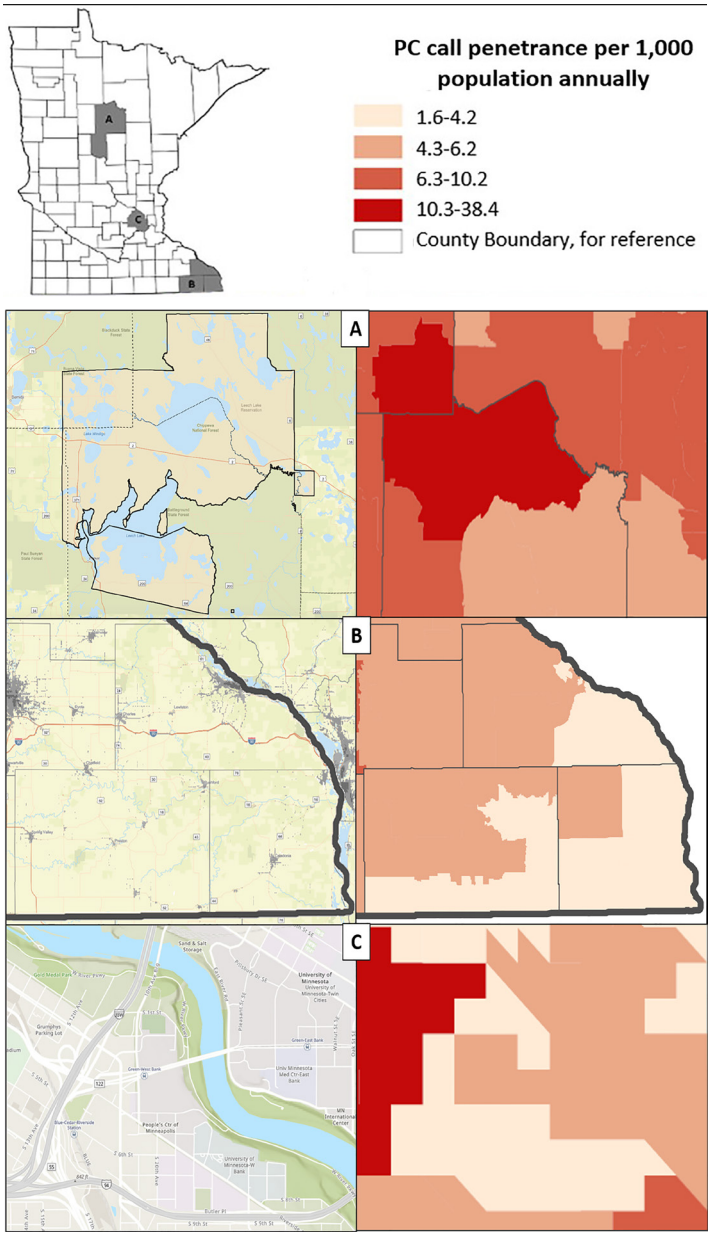

Figure 3. Case examples. A) High penetrace region at the confluence of three rural counties and overlying Leech Lake Reservation. B) Low penetrance region in far southeastern Minnesota. C) Low penetrance region correlating with the Cedar-Riverside neighborhood of Minneapolis.

DISCUSSION

In a regional PC in a state with significant racial and cultural disparities, USCB-defined characteristics of greater than eighth-grade educational attainment, non-Hispanic Black identity, and Non-Hispanic American Indian identity were associated with increased call penetrance to a PC. This suggests increased PC utilization among those with higher educational attainment and those who identify as Black or American Indian. Our findings share some of the findings reported in 2010 by Litovitz et al, who noted an increase in penetrance in populations with high percentages of residents with Asian background, residents younger than five years of age, and residents holding bachelor's degrees, among others.[5] Our studies stand in distinction to the findings reported by Vassilev et al, who identified high population density and high proportions of non-White races as predictors of low, rather than high, PC utilization.[34] Still other studies have identified Hispanic background as a negative predictor of PC utilization[12]; our results describing this association did not achieve statistical significance, despite suggesting a similar relationship.

Nonetheless, in the context of finite PC resources, the results of regression modeling are useful but insufficient to plan strategic and cost-effective PC outreach. Regression modeling alone cannot identify specific geographic regions of low penetrance, and ultimately this is inadequate to implement fully informed, ground-level decisions regarding resource utilization and geographic targeting of PC outreach. Routine statistical modeling, therefore, provides a conceptual framework for understanding PC penetrance, while geospatial mapping offers a direct assessment of low and high penetrance areas of interest on which PCs may focus outreach resources.

The three cases of Leech Lake, southeast Minnesota, and the Cedar-Riverside neighborhood of Minneapolis provide unique examples of regions inadequately described by statistical modeling and prior county-level geospatial descriptions of PC penetrance. The etiology of increased PC penetrance in the Leech Lake region is obscure but consistent with regression modeling, and this "hot spot" was not identified prior to granular PC penetrance mapping. While a culture of increased utilization may exist across residents of this geographic region, a single "super user" in a sparsely populated region may also be responsible for this finding. Alternately, a higher than expected volume of exposures reported from non-healthcare locations may be related, warranting further public health outreach and PC investigation. Finally, in a resource-poor area of the state, access to expert medical opinion regarding poisonings may be more feasible by phone than by physical presentation to a medical provider.

In southeast Minnesota, multiple plausible explanations for decreased penetrance exist. A relatively large proportion of the regional population is of the Amish faith, and many are likely without telephone service in their homes. While other regions of Minnesota are home to significant Amish populations, few are as large or established, and most are much more recently founded. This raises the possibility of important cultural differences, including telephone ownership, between older and more conservative Amish communities in southeast Minnesota and more recently founded, more progressive communities in other regions.[29] Despite prior studies identifying mass-mailing campaigns as ineffective in reaching rural populations[35] and increased rural call volumes following the implementation of toll-free access to PCs,[36] this region may stand in contradistinction given the higher than normal proportion of residents with minimal access to technology including telephones and electricity. Lastly, our findings may simply identify an area where PC outreach efforts have heretofore been inadequate, where lower than expected rates of poisonings occur, or where poisoned patients and those around them more commonly present to healthcare facilities than contact the PC.

Finally, Cedar-Riverside represents an area of particular concern for the PC, and likely reflects challenges experienced by other PCs. While the volume of PC calls using a telephonic language-interpreting line remained very low as a percentage of all calls over the study period, no prior efforts had been made to objectively study our poor penetrance into language minority groups. The present study strongly suggests that the PC is not attending to one of the largest regional minority groups. During the study period, Somali language interpreters were used for only four calls, and as recently as 2015–2017, Somali interpreters were used for 3-5 calls annually despite a known population of more than 40,000. Whether this poor penetrance represents sociocultural or linguistic barriers, low awareness of PC services, or a low rate of poisonings in this subgroup is unclear, and suggests an avenue to which outreach resources may be directed.

LIMITATIONS

Several limitations govern the interpretation of these findings. This cross-sectional study in a single state identifies associations between PC penetrance and USCB-defined variables, but causal relationships between demographic variables and penetrance variation cannot be inferred. Generalizability to other PC catchment areas is not described. Similarly, a high risk of type I statistical error is inherent to large datasets such as this: many UCSB component variables are available for statistical modeling, raising the risk of inappropriately focusing on unexpected associations or findings. To mitigate this, we identified variables of interest a priori, and did not add to our model thereafter. While our resulting regression model explained little of the variability seen in our study, this was likely a result of confounding by multiple factors, one of which is the geographic distribution of callers that we sought to study through geospatial mapping. Indeed, the limited utility of statistical modeling, absent geospatial mapping, is an important and central finding of this study.

Additionally, the assessment of penetrance in this study is rooted in its historical utilization both as a marker of PC efficacy and for accreditation through the AAPCC. The use of penetrance as an accreditation metric was discontinued in 2001 absent data to support its use. However, data from this era are characterized largely by evaluations of penetrance as it relates to differences in populations' ages, specifically the proportion of the population younger than two years old, at a time when counties were largely considered the unit of measurement, and when further geographic subanalyses would have been less accessible. Penetrance, described at a much more granular level of analysis, better defines areas of low PC utilization, inviting further evaluation prior to the redistribution of PC resources and suggesting that penetrance may yet hold value for PCs.

An additional limitation of our dataset is the predefined nature of USCB data. Within USCB-defined variables such as "non-Hispanic Black," more nuanced associations, unique to our state, may exist between PC penetrance and subgroups otherwise subsumed under USCB variables (for example, both Karen and Hmong cultural groups coding to "non-Hispanic Asian"). This limitation is at the root of the present study, which seeks to better identify underserved groups through geospatial mapping.

We excluded calls coded as originating from healthcare facilities, but miscoded or misreported calls may have been inadvertently included in the study. Nonetheless, a small number

of miscoded cases is likely mitigated by the overall large number of observations. Similarly, callers from mobile phones with area codes mapping to Minnesota may have called the PC from outside the state, causing inclusion of calls from an unintended region. Callers from mobile phones with area codes mapping outside of Minnesota, but residing within the state, may have been inadvertently excluded. This is likely addressed, however, by exclusion of such calls when documenting caller-reported ZIP Codes not mapping to Minnesota at call initiation.

Finally, spatial apportionment of US ZIP Codes to USCB tracts is a good measure of population parameters, but it imparts a small degree of imprecision when combining these datasets, both of which are characterized by similar but unique geographic boundaries. In describing penetrance, this imprecision, likely to occur on the edges of identified boundaries, is unlikely to meaningfully affect the interpretation of results intended to geographically guide outreach efforts. While some case records report addresses, far more contained ZIP Codes, making this a more adequate data point to map calls. Further, the extraction of addresses was not feasible due to limitations in data extraction from local call management software. Additionally, ZIP Codes may change periodically, but it was beyond the scope of this investigation to identify small changes to ZIP Code areas, potentially imparting further imprecision to our findings.

CONCLUSION

In this investigation, historically employed statistical and county-based methods to define poison center penetrance fail to recognize systematic failures to reach specific demographic and geospatially defined groups. Higher American Indian and non-Hispanic Black population proportions, and greater than eighth-grade educational attainment, are characteristics associated with increased PC penetrance in this study. Evaluating the geospatial distribution of calls to other PCs may enhance understanding of penetrance patterns, improve resource allocation and elucidate previously unknown predictors of PC penetrance. This novel and detailed visual account of PC penetrance, uniquely interpretable when contextualized in a knowledge of the state served by the poison center, offers a new tool to optimize PC outreach.

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Beyond Buprenorphine: Models of Follow-up Care for Opioid Use Disorder in the Emergeny Department

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Recent evidence shows that emergency physicians (EP) can help patients obtain evidence-based treatment for Opioid Use Disorder by starting medication for addiction treatment (MAT) directly in the Emergency Department (ED). Many EDs struggle to provide options for maintenance treatment once patients are discharged from the ED. Health systems around the country are in need of a care delivery structure to link ED patients with OUD to care following initiation of buprenorphine. This paper reviews the three most common approaches to form effective partnerships between EDs and primary care/addiction medicine services: the Project Alcohol and Substance Abuse Services and Referral to Treatment (ASSERT) model, Bridge model, and ED-Bridge model.

The ASSERT Model is characterized by peer educators or community workers in the ED directly referring patients suffering from OUD in the ED to local addiction treatment services. The Bridge model encourages prescribing physicians in an ED to screen patients for OUD, provide a short-term prescription for buprenorphine, and then refer the patient directly to an outpatient Bridge Clinic that is co-located in the same hospital but is a separate from the ED. This Bridge Clinic is staffed by addiction trained physicians and mid-level clinicians. The ED-Bridge model employs physicians trained in both emergency medicine and addiction medicine to serve within the ED as well as in the follow up addiction clinic.

Distinct from the Bridge Clinic model above, EPs in the ED-Bridge model are both able to screen at-risk patients in the ED, often starting treatment, and to longitudinally follow patients in a regularly scheduled addiction clinic. This paper provides examples of these three models as well as implementation and logistical details to support a health system to better address OUD in their communities. [West J Emerg Med. 2020;21(6)257-263.]

INTRODUCTION

There were more than 70,000 drug overdose deaths in the United States in 2017, 68% of which involved opioids, an increase of 12% from 2016.[1,2] This rapid rise in opioid-related deaths has prompted swift action by the medical and public health communities to slow the epidemic and prevent further loss of life. One intervention which is known to reduce mortality from overdose and morbidity from addiction is providing medication for opioid use disorder (MOUD) with buprenorphine. Extensive research demonstrates the efficacy and effectiveness of MOUD with buprenorphine in respect to retention in treatment, reduction in illicit opioid use, decreased cravings, reduced diversion and improved social function.[3-6] Additionally, data suggests that MOUD with buprenorphine after a nonfatal overdose decreases all-cause and opioid-related mortality following initiation of the drug and results in fewer future hospitalizations, ED visits and health care dollars spent among those maintained on treatment.[7,8]

However, while there are clear benefits for patients with opioid use disorder (OUD) engaged in treatment with MOUD, many patients find that accessing this life-saving therapy is

difficult due to barriers in the addiction treatment system and current prescribing structure. These barriers include the following: an inadequate number of buprenorphine prescribers, particularly in rural areas; specialty addiction treatment clinics that don't offer MOUD; insurance restrictions; the need for a Drug Enforcement Administration (DEA) X waiver to prescribe buprenorphine, and stigma and discrimination against MOUD. Additionally, OUD may co-occur with other psychosocial complexities that may make establishing primary care difficult. This combination of barriers and having convenient access to withdrawal management in the ED provides means that many patients use the ED as their primary source of care for opioid related issues (withdrawal symptoms, overdose, treatment seeking)[9] There were 209 opioid related visits to the ED per 100,000 population in 2015, representing a steady rise over recent years.[9]

Recent landmark studies showed that EDs may be able to play a more active role in the management of OUD. D'Onofrio et al. showed that initiating buprenorphine during the patient's ED visit and directly linking them with primary care follow-up doubled the percentage of patients engaged with buprenorphine treatment, as compared to those receiving only a referral and reduced the total amount of illicit opioids used in the following months.[10] This review article outlines the various approaches to developing linkages to care for patients with OUD.

TREATMENT WITH BUPRENORPHINE

Buprenorphine is one of three US Food and Drug Administration (FDA)-approved forms of MOUD and the only opioid agonist treatment for OUD that can be prescribed in an office-based setting. Clinical trials have demonstrated the efficacy of buprenorphine and other forms of MOUD for individuals with OUD. In a meta-analysis conducted by Mattick et al, buprenorphine was superior to placebo in retaining people in treatment in all of the 14 placebo-controlled comparisons.[2] This finding was further supported by D'Onofrio et al through a randomized clinical trial involving 329 opioid-dependent patients who were treated at an urban teaching hospital. They found that among patients with OUD, ED-initiated buprenorphine treatment, when compared to brief intervention or referral only, significantly increased engagement in addiction treatment, reduced self-reported illicit opioid use, and decreased use of inpatient addiction treatment services.[11] Clark et al demonstrated a 50% lower risk of relapse than behavioral treatment without MOUD.[12] In a study of 33,923 Medicaid patients diagnosed with OUD, treatment with buprenorphine was found to be effective across a range of outcomes, including reducing all-cause mortality, improving physical and mental health, and decreasing illicit drug use. Patients treated with buprenorphine experienced a 75% reduced mortality as compared to those treated with three psychosocial interventions alone.[13]

Practically, buprenorphine is also the most realistic type of MOUD for emergency physicians (EP) to initiate. While methadone can be easily started in an ED setting continued treatment requires direct admission to an opioid treatment program, which can be challenging for EDs to coordinate particularly in areas where wait times for opioid treatment programs are long. Providers are granted the power to prescribe buprenorphine through the Drug Addiction Treatment Act of 2000. This act requires qualified clinicians to obtain a special waiver from the separate registration requirements of the Narcotic Addict Treatment Act – 1974 to treat opioid use disorder with Schedule III, IV, and V medications or combinations of such medications that have been approved by FDA for that indication.[14] Qualified clinicians include licensed physicians, physicians assistants, nurse practitioners, clinical nurse specialists, certified registered nurse anesthetists and certified nurse-midwives. These clinicians must complete a training course (8 hours for physicians and 24 hours for all other clinicians) and submit a waiver application through the Substance Abuse and Mental Health Services Administration (SAMHSA) to the Drug Enforcement Agency to qualify for a waiver to prescribe buprenorphine.[15] ED physicians to obtain waviers yet, only 1% of all emergency physicians have this waiver.[16, 17]

FOLLOW-UP

ED initiation of buprenorphine is optimized through connection to effective, outpatient follow up options. Importantly, as EDs look to expand the services they provide for OUD, patients lack of timely follow-up for continued prescribing could pose a significant, yet surmountable, barrier. Thus far there have been several models that have been used throughout the country. We review three of these models below in detail and summarized in Table 1.

Model 1: ASSERT Model

The Project Alcohol and Substance Abuse Services Education and Referral to Treatment (ASSERT) model is characterized by peer educators or community workers in the ED directly referring patients found to be suffering from OUD in the ED to local addiction treatment services.

Background

The ASSERT model was first developed, implemented and tested at the Boston Medical Center (BMC) in 1995. Health Promotion Advocates (HPAs) are at the center of this model. HPAs are alcohol and drug treatment counselors certified by the Massachusetts Department of Public Health. They are linguistically and ethnically suited to meet the needs of the Boston Medical Center (BMC) patient base, well-versed in interview and screening tools and most importantly, members of the communities the project aimed to serve.

Examples of Implementation

On service daily in the ED from 9AM to 11PM, the HPAs are charged with screening patients suspected to be suffering from substance use disorder and enrolling them in Project ASSERT. Following initial screening and retrieval of informed consent,

Table 1. Comparison of three models that link emergency care and addiction treatment.

Model	Description	Benefits	Challenges
ASSERT model	Peer support staff or community health workers in the ED directly refer patients with OUD to local addiction treatment services.	Peer-centered approach Leverages community resources rather than creating resources in the hospital system	Limited by community resources ED clinicians are not the primary staff members interacting with the patient on their use disorder, thereby potentially displacing the responsibility of treating patients with OUD in the ED onto other providers Licensure and scope of practice for the support staff vary considerably between states
Bridge model	Prescribing physicians in the ED screen patients for OUD, provide a short-term prescription for buprenorphine, and then refer the patient directly to an outpatient Bridge clinic that is co-located in the same hospital but is separate from the ED.	Co-location of ED and Clinic potentially reduces likelihood of no-shows Reduced barriers to entry into evidence-based clinic Communication through shared EHR	Clinic capacity is a constraint Excellent coordination between ED and Clinic is paramount to establish effective handoff Significant investment required by health system to create the Bridge Clinic Cost of the 8-hour waiver training for ED clinicians No continuity of care between prescribing clinician in the ED and prescribing clinician in the Bridge Clinic
ED-Bridge model	Physicians trained in both emergency medicine and addiction medicine both screen at-risk patients in the ED, often starting treatment in the ED, and also are able to longitudinally follow patients in the outpatient setting.	Enhanced continuity of care Decreased need for a separate, trained workforce of outpatient addiction clinicians	Highly specialized emergency physicians double boarded in emergency medicine and addiction medicine, leading to a limited supply of providers Likely limited to major urban/academic centers

ED, emergency department; *OUD*, opioid use disorder; *EHR,* electronic health records.

the HPAs then engage in a trauma-informed, non-judgmental conversation utilizing the Brief Negotiated Interview algorithm developed at BMC. This interaction is primarily a motivational interview that focuses on patients' cultural background, beliefs, values, and readiness to engage in treatment. Given the extra time afforded by their role, HPAs get to know the patients on a deeper level often unachievable by EPs and thus provide a service not previously available. Together with the patient, the HPAs craft a harm reduction plan. The HPAs may refer patients to local resources such as in-patient detoxification programs, methadone clinics or outpatient centers in the surrounding area where they can begin MOUD. These advocate teams do not directly supply the medication but rather serve as a knowledgeable source of information about the resources patients can utilize immediately after their ED visit. The patients also agree at enrollment to follow up with the HPA after 60 days.

A 1997 study by Bernstein et al. found that 18% of the total ED population for the study period was screened and a substance use problem was detected in 41% of those patients.[18] OF those detected patients, 37% enrolled in Project ASSERT. For those enrolled, an average of 1.2 referrals were made per patient over the course of the study period, many for basic health screenings like mammograms or referrals to primary care clinics. The study found that many of the patients screened lacked a regular primary care physician and utilized the ED to seek care. At the 60- to 90-day follow-up visit, patients reported keeping over half of appointments made to the Boston Office of Treatment Improvement Central Intake, inpatient facilities and outpatient services, Narcotics Anonymous, or Alcoholics Anonymous. Patients also reported a reduction in quantity and/or frequency of drug use for the 2 months preceding the follow-up visit, compared with the 2 months before enrollment. Some stopped using altogether.

The Boston Medical Center has continued to see success throughout the program's duration, enrolling tens of thousands of patients since its implementation. In 2016, for example, BMC successfully placed 56% of patients who were requesting acute treatment for substance use disorder through detox.[19] Today, their Faster Paths to Treatment program utilizes the ASSERT model of directly evaluating, motivating, and referring patients with substance use disorder to a comprehensive care network of inpatient and outpatient detoxification, treatment, and aftercare services integrated with mental health and medical care.

The Yale New Haven Hospital was similarly successful

in implementing an ASSERT model of peer educator-based referrals. Patients directly referred by Project ASSERT were found to be twice as likely to enroll in a specialized treatment center. Additionally, 55% of patients referred to a specialized treatment center through Project ASSERT successfully enrolled within one month of referral.[20] As of 2018, Project ASSERT at Yale had screened over 50,000 patients since its implementation in 1999 and is now distributing life-saving naloxone to hundreds of families in the community.[21]

Benefits, Logistics, and Limitations of this Model

Each of these permutations of the ASSERT model necessitates dedicated community health workers or peer support staff versed in addiction, motivational interviewing and trauma-informed care to be physically present in the ED. Licensure and scope of practice for these support staff vary considerably between states which may explain the variability seen within successful models. Health systems considering implementation of the ASSERT model must consider the hours that these staff will be present, hiring practices and support structures for peer support staff, how these support staff communicate with clinicians and what local resources are at the ED's disposal for patients with OUD. Peer support staff support patients in their efforts to seek relief in the ED and support clinicians in their attempts to meet the complex psychosocial needs of addicts in settings where they are often ill-equipped in terms of training, comfort and capacity. This model may not be effective if community resources are not robust enough to support longitudinal care for patients with OUD.

Model 2: Bridge Model

The second model of care examined is the Bridge model. In this model, prescribing physicians in an ED screen patients for OUD, provide a short term prescription for buprenorphine, and then refer the patient directly to an outpatient clinic called a Bridge Clinic that provides MOUD. The Bridge Clinic is co-located in the same hospital but is a separate from the ED and is staffed by addiction trained physicians and mid-level clinicians.

Background

In contrast to the ASSERT model, which largely relies on peer support staff in identifying and facilitating the referral of patients from the ED to addiction services, the Bridge model relies on the diagnostic and prescribing capacity of the EP, sometimes with the support of peers. This prescribing power is granted by obtaining a DEA X Waiver.[22] This necessitates completing an 8-hour course approved by the Substance Abuse and Mental Health Services Administration. Allied health professionals must meet a 24 hour training requirement. The Yale New Haven Hospital and Massachusetts General Hospital are the first hospital EDs to have the majority of their physicians waivered to prescribe buprenorphine following an in-house training.[23] Once X-waivered, physicians engaged in the Bridge Model of treatment are responsible for identifying patients with OUD.

Examples of Implementation

The most notable example of the Bridge Clinic Model is the Massachusetts General Hospital OUD program, which became the first hospital in the state to offer seamless ED-initiated buprenorphine with rapid next day follow up in its Bridge Clinic. EPs in this program engage with the patient, assessing their interest in buprenorphine treatment, and offering initiation while in the ED. The physician then facilitates a "warm" hand-off to the Bridge Clinic, an outpatient site in the same hospital system well versed in the longitudinal treatment and management of OUD. This clinic is available to see patients within normal business hours including weekends.

During Bridge Clinic hours, patients are discharged directly from the ED to the Bridge Clinic where they can begin or continue buprenorphine and continue accessing addiction services. Those discharged in the evening or overnight are given a two day supply of buprenorphine called a home pack, or a prescription for buprenorphine, to be taken at home and are instructed to return to the Bridge Clinic the next day for ongoing treatment.

Mid Coast Hospital in Brunswick, ME provides another example of the Bridge Clinic model. Its program became the first hospital in Maine to prescribe buprenorphine in its ED leveraging a Bridge Clinic for follow up. Patients suffering from OUD who are seen in the ED at this hospital are evaluated by ED physicians and are referred to Mid Coast Hospital's Addiction Resource Center (ARC) program. In the majority of cases patients leave the ED with an appointment at the ARC on the next business day.

Benefits, Logistics, and Limitations of this Model

To be maximally effective the Bridge model requires a substantial proportion of ED clinicians within the department to be X-waivered. The training requirement, while minimal, remains a barrier for clinicians to prescribing MOUD with buprenorphine. This barrier can be overcome on a case by case basis as the DEA allows a 72-hour exemption that permits non-waivered prescribers to administer buprenorphine or methadone while arranging linkage to ongoing treatment. Thus, variations of the Bridge model are feasible even when ED physicians do not have their waiver. These clinicians may instead use the 72-hour exemption to administer one dose of buprenorphine prior to discharge of patients in withdrawal and arrange direct follow-up in a Bridge Clinic. The clinician must, however; be comfortable engaging with patients that present with needs specific to OUD. They must be versed in the referral process of the health system's Bridge Clinic and be able to engage in motivational interviewing to support the patient in addressing their health needs.

The Bridge model is most defined by the ability for providers, waivered or not, to immediately connect a patient to a clinic that is co-located to the ED. This co-location supports low-barrier access to evidence-based treatment because the clinic provider has access to notes written by the ED clinician(s), can connect with the patient when they aren't in acute withdrawal and can help a patient along their journey

to recovery that was already jumpstarted by the EP. This Bridge Clinic requires addiction-trained clinicians capable of prescribing MOUD, peer support staff to address the patients' accompanying psychosocial needs, connections to therapists and physical space within the hospital or health system that is accessible immediately from the ED.

The Bridge Model seeks to treat OUD like any other acute medical condition treated in the ED by providing low-threshold follow-up care by a separate, highly trained specialist in the outpatient setting within the same hospital as the referring ED.[24]

Model 3: ED-Bridge

The final model we will examine is the ED-Bridge model, a novel system that employs physicians trained in both Emergency Medicine and Addiction Medicine to serve within the ED as well as in the follow up addiction clinic.

Background

As opposed to the Bridge Clinic model detailed above, EPs in this model are both able to screen at-risk patients in the ED, often starting treatment in the ED, and are also able to longitudinally follow patients in a regularly scheduled addiction clinic. The unique feature of this model relies on the fact that the majority of clinicians that engage in it are EPs who also board certified in addiction medicine. This added expertise allows for continuity of care and a consistent patient-provider relationship.

Examples of Implementation

One notable application of this approach is a clinic run by Dr. Andrew Herring in Oakland, CA at Highland Hospital. Physicians within the ED at Highland Hospital are trained to identify and screen patients for OUD. Key addiction specialty-trained EPs among this group act as both gateways to addiction treatment and longitudinal care clinicians by first offering patients buprenorphine therapy in the ED, if applicable, and access to the follow up clinic appointments during regularly scheduled weekly clinic times.[25] In this model, EPs like Dr. Herring are able to utilize these clinic times to follow patients through the first parts of their recovery journey after engaging with them in the ED.[26] This clinic is staffed by EPs with addiction training as well as by substance use navigators who are staff tasked with providing motivation and reassurance, and who address all manner of issues ranging from transportation to childcare and dealing with landlords and legal issues.[27]

Another example of this longitudinal model led by EPs who are able to fill both roles is the Upstate Emergency Opioid Bridge Clinic program which is led by Dr. Ross Sullivan, an EP who is also board certified in addiction medicine at the State University of New York Upstate Medical University in Syracuse. This clinic operates twice a week from the Downtown Campus and is housed in a space adjacent to the ED. Patients who are started on buprenorphine in the ED are then referred to the clinic for a follow-up visit within one to three days. Along with EPs who continue to prescribe buprenorphine for patients longitudinally, this clinic is staffed by peer specialists who provide information and encouragement as well as helping to address the broader social determinants of health such as finding housing and accessing Social Security benefits.[28]

Benefits, Logistics, and Limitations of this Model

All the aforementioned benefits and considerations for the Bridge Clinic model remain with a significant addition in the ED-Bridge model: the ED-Bridge physicians also see patients in clinic thereby leveraging the therapeutic relationship created by the emergency physician during the initial ED encounter. Given this, the ED-Bridge model moves beyond requiring that EPs feel comfortable having conversations with patients about addiction. Instead, it calls for the EPs to be trained in providing treatment for addiction and necessitates that they be X-waivered at a minimum. Very few EPs are formally trained—let alone board certified in addiction medicine—in this manner which may present a significant barrier for hospitals and health systems. Outpatient clinic settings can be foreign for classically trained EPs which supports the need for additional addiction training.

The ED-Bridge Model, exemplified by these two programs, seeks to blend the roles of emergency and addiction physicians offering an opportunity to provide longitudinal care and a basic way to continue to prescribe patients buprenorphine in the immediate period following ED evaluation. The CA Bridge program offers focused technical assistance and training for any hospital or health care facility in the United States to design their own ED-Bridge model.[29]

SUMMARY RECOMMENDATIONS

The unique contextual features of the hospital system and ED where these follow-up models could be implemented will necessarily impact the decision to choose one over the others. Given the peer-centered approach, which leverages less highly skilled advocates rather than clinicians, the ASSERT model is a viable solution for departments which do not have the resources to support ED clinician waiver training or hospital systems that are not interested in investing in a functional Bridge Clinic. The drawbacks of this model, however, are that ED clinicians are not the central point of contact for patients with regard to their use disorder while they are in the ED. This results in ED providers potentially building a reliance on the advocates to interface with patients with opioid use disorder rather than developing the vocabulary and skillset to address these issues themselves.

The Bridge model offers a convenient patient experience as the addiction clinic is often co-located on the same floor as the ED or within walking distance, allowing for logistically easier handoffs to addiction treatment teams post-ED discharge. This co-location potentially reduces the likelihood of no-shows and reduces the barriers to entry into evidence-based treatment clinics. The cost of initiating a Bridge Clinic include but are note limited to; the physical clinical space, clinician time, and administrative support. These costs are nontrivial. For hospitals with limited resources the Bridge Clinic model could represent a significant

time and cost investment over and above what is feasible.

The ED-Bridge model offers a near-seamless patient experience of patient-provider engagement given the consistency of who the prescribing clinician is in the ED and the longitudinal prescriber in the addiction clinic. The significant downside in this model, however, is the hyper-specialization required to make this model viable. The ED clinician must not only be a board-certified EP but must also have, in the majority of cases, board certification in addiction medicine. This emphasis on highly specialized clinicians may preclude this from being a realistic model in anything other than academic or large, urban medical centers.

CONCLUSION

Opioid use disorder is a treatable condition and yet our healthcare system currently lacks access to provide patients with seamless ways of accessing treatment. Treatment with MOUD reduces mortality and improves the likelihood of disease remission; yet most patients with OUD never receive these lifesaving medications. As outlined above, EDs play a critical role in the effective screening, treatment initiation, and direct linkage to care for patients with OUD. A recent body of evidence shows emergency physicians can expand both their role and effectiveness in creating this link by providing buprenorphine directly in the ED. With this new knowledge, EDs around the US are in need of a framework for better treating and referring patients who present to the ED with OUD.

The current structures of the relationship between EDs and addiction services are variable around the country. This review article has outlined some of the most impactful approaches currently in place including the ASSERT model, Bridge model, and the ED-Bridge model. These models are constantly being improved but can serve as a template for the development of emergency-addiction linkages in other communities. Future research should aim to assess the effectiveness of each of these designs as well as to understand which models work best in specific populations or settings. Further work should seek to inform and equip EDs around the nation with a guide for setting up life-saving linkages between EDs and sustainable outpatient addiction care with MOUD in their respective communities.

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Applying a Model of Teamwork Processes to Emergency Medical Services

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Introduction: Effective teamwork has been shown to optimize patient safety. However, research centered on the critical inputs, processes, and outcomes of team effectiveness in emergency medical services (EMS) has only recently begun to emerge. We conducted a theory-driven qualitative study of teamwork processes—the interdependent actions that convert inputs to outputs—by frontline EMS personnel in order to provide a model for use in EMS education and research.

Methods: We purposively sampled participants from an EMS agency in Houston, TX. Full-time employees with a valid emergency medical technician license were eligible. Using semi-structured format, we queried respondents on task/team functions and enablers/obstacles of teamwork in EMS. Phone interviews were recorded and transcribed. Using a thematic analytic approach, we combined codes into candidate themes through an iterative process. Analytic memos during coding and analysis identified potential themes, which were reviewed/refined and then compared against a model of teamwork processes in emergency medicine.

Results: We reached saturation once 32 respondents completed interviews. Among participants, 30 (94%) were male; the median experience was 15 years. The data demonstrated general support for the framework. Teamwork processes were clustered into four domains: planning; action; reflection; and interpersonal processes. Additionally, we identified six emergent concepts during open coding: leadership; crew familiarity; team cohesion; interpersonal trust; shared mental models; and procedural knowledge.

Conclusion: In this thematic analysis, we outlined a new framework of EMS teamwork processes to describe the procedures that EMS operators employ to convert individual inputs into team performance outputs. The revised framework may be useful in both EMS education and research to empirically evaluate the key planning, action, reflection, and interpersonal processes that are critical to teamwork effectiveness in EMS. [West J Emerg Med. 2020;21(6)264-271.]

INTRODUCTION

Despite improvements in quality and effectiveness in emergency medical services (EMS),[1-2] improving patient safety remains an important, ongoing concern.[3] As an integral component of the healthcare system, significant work has been done in EMS to improve patient safety by adopting evidence-based approaches to care.[3-6] Unfortunately, research on teamwork-based strategies to improve care in EMS has only recently started to emerge.[7] In other areas of healthcare, interventions to improve teamwork have demonstrated reductions in medical errors in the emergency department[8,9] and intensive care unit,[10] as well as the operating room setting,[11] primarily on building teamwork

competencies, such as effective communication.[12-17] Building on the current teamwork literature,[8-17] we sought to apply the language of the science of teamwork to the work performed in EMS. To do this, we conducted a theory-driven qualitative study of *teamwork processes*—the interdependent actions that convert inputs to outputs (or outcomes)—by frontline EMS personnel that are associated with team effectiveness.[18-22]

Population Health Research Capsule

What do we already know about this issue?
Teamwork processes, critical to organizational success, may be grouped into performance episodes: planning, action, reflection, and interpersonal processes.

What was the research question?
Can the model of teamwork processes in emergency care be extended to the EMS context?

What was the major finding of the study?
This study provides early empirical support to applying a model of teamwork processes in emergency care to EMS.

How does this improve population health?
The revised model may be useful to guide future "deliberate practice" training or focused evaluation of key teamwork processes to improve teamwork performance in EMS.

Conceptual Framework

We define *teamwork* as the interaction of two or more individuals to perform a given task.[19] Teamwork is the interrelated set of team member's thoughts, beliefs, and feelings needed for the team to function as a unit.[12] Team members see themselves—and are seen by others—as belonging to a specific social entity within an organization.[20] *Teamwork processes* are the cognitive, verbal, and behavioral activities directed toward organizing tasks (inputs) to achieve collective goals (outputs), and form the basis for team competencies (eg, knowledge, skills, and attitudes) that are crucial for effective healthcare team performance.[18-19] One of the foundational models of teamwork is the input-process-output (IPO) model.[18-19,21] In this model, *inputs* are the individual characteristics of employees, the available organizational resources, and the demands of the task to be done. *Processes* are the interdependent actions and behaviors that convert inputs to outputs. *Outputs* include objective outcomes such as overall team performance and mission completion, as well as less tangible outcomes such as patient and employee satisfaction.[18-22]

Building on the IPO model, Marks, Mathieu, and Zaccaro proposed a temporally based model of teamwork processes.[18-19,23] In this framework, teamwork processes are thought to occur in interacting performance episodes: transition processes; action processes; and interpersonal processes. Further refinements to the model were proposed by Fernandez et al,[18] who separated transition processes into planning processes (eg, setting goals and prioritizing tasks to be completed) and reflection processes (eg, feedback on areas of improvement), as these domains were thought to occur in distinct episodes of time (Figure 1).[18-19,23] In the revised model, planning, action, and reflection processes inform one another over time, while interpersonal processes contemporaneously affect the success of the other processes.[19,23] A list of teamwork processes and their definitions appear in Table 1. (See supplementary content online.)

METHODOLOGY

Study Design

This was a qualitative study of EMS personnel (ie, key informants) regarding teamwork in EMS. We approached individual EMS providers for enrollment via purposive sampling of personnel to complete a semi-structured, audiotape-recorded phone interview.

Study Population

The study population was a convenience sample of fire department-based EMS agency in Houston, TX, which responds to over 225,000 911 calls annually. All firefighters in the agency have been certified at the emergency medical technician (EMT) level of training, while approximately 10% are paramedic-certified.

The enrollment criteria were as follows:

1. A valid state EMT license, and
2. Full-time employment in the agency.

Study Procedures

We conducted confidential, one-on-one telephone interviews among participants to identify barriers and enablers of effective teamwork in their organization. Interviews were scheduled in advance and were conducted by calling into a conference call service (FreeConferenceCall.com, Long Beach, CA) that allowed for interviews to be recorded on a secured, password-protected site. Prior to commencing the study, we piloted interview questions with members of a separate, hospital-based EMS agency.

Recruitment of Study Participants

Study participants were recruited through the following means: 1) recruitment email from the agency's medical director; 2) visits to fire stations to promote the study; and 3) announcing the study at a training conference. We explained the purpose of the study, as well as identified the enrollment

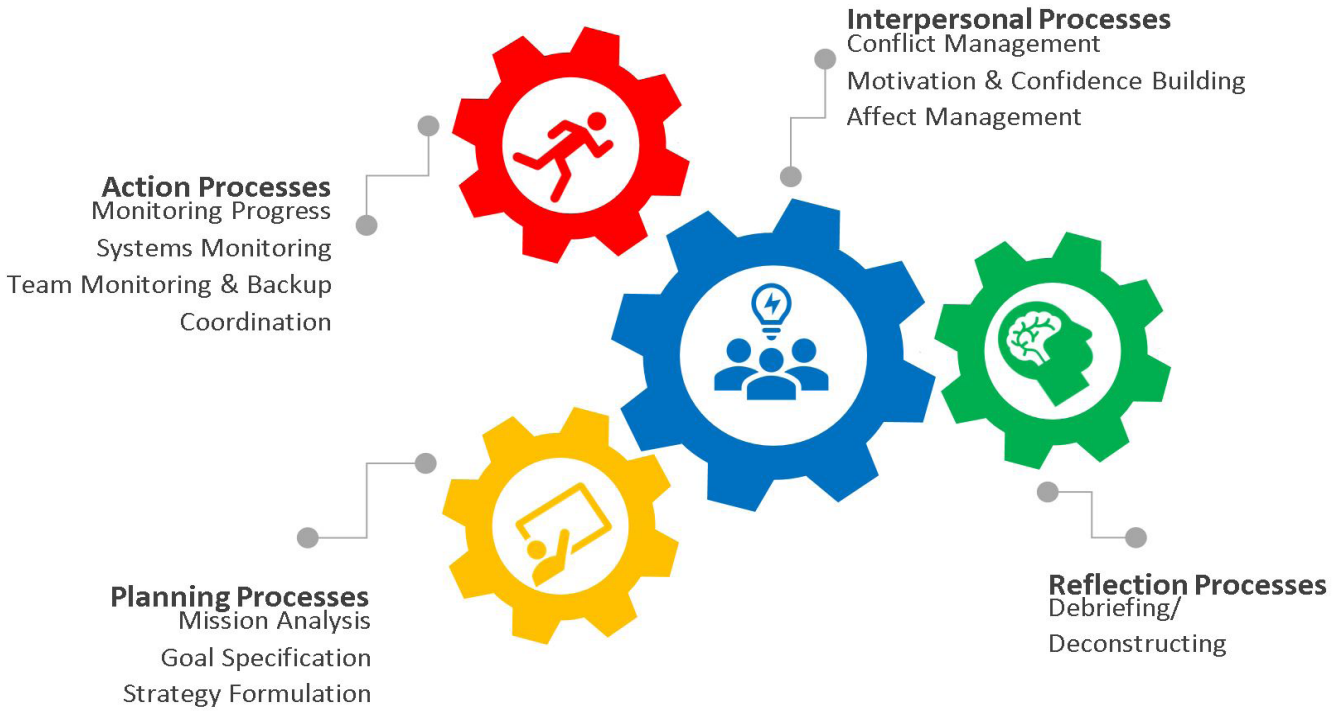

Figure 1. Temporal model of teamwork processes in emergency care.[18]

criteria. Those interested were contacted to set up a phone interview. We recruited participants until we achieved the point of theoretical saturation. "Theoretical saturation" occurs when additional data collection does not produce additional knowledge or understanding with respect to the study questions.[24-26] In other words, this is the point at which an interviewer is able to predict the answers that participants would provide given a certain question (ie, when no new perspectives on a topic are gained).

To estimate the sample size necessary for saturation, we anticipated a baseline of 15-20 interviews.[24-25] Given the degree of segmentation within the organization by professional certification (ie, paramedic vs EMT) as well as by rank (officers vs firefighters), we anticipated that we would need to sample approximately 30-40 key informants to reach theoretical saturation. Also, due to the time lag between participant enrollment and completion of phone interviews, we estimated a 50% dropout rate among enrollees. To account for this, we planned to recruit between 60-80 EMS personnel to satisfy our ultimate participation goal of 30-40 participants who would complete the telephone interview.

Phone Interviews

Phone interviews followed a semi-structured format. Key informants were asked "grand tour" questions, that is, broad open-ended queries about the general characteristics of a given setting or role, regarding typical EMS runs during a typical shift (eg, "Can you walk me through a typical ambulance run during a typical shift?"). These "ice-breaker" questions are thought to encourage participants to feel more comfortable sharing during the interview.[26-27] These were followed up with questions about specific teamwork processes (ie, planning processes – "What are you thinking/saying to your partner on the way to the scene?"; action processes – "During a typical 911 call, how are tasks divided up between partners?"; "When you're on the way to the hospital with a patient, what sort of things are you thinking/doing?"; "Can you describe a typical interaction between the EMS crew and the hospital staff?"); reflection processes – "What sort of things happen after you've handed off care at the hospital and you're on your way back to the station?"; and interpersonal processes – (eg, "How often are there disagreements about what should be done?"), routine task activities (eg, "What sort of tasks are typically required during a typical call?"), as well as task activities that required teamwork (eg, "What tasks are better done by groups of two or more, rather than by just one person?").

Additionally, officers in the fire department were asked about supervisory/coordination activities (eg, "What makes your job managing a critical event such as a multi-casualty incident go more smoothly?"), or the role of senior leadership/management in promoting teamwork (eg, "What can senior leadership/management do to promote teamwork?"; and "How does scheduling crews for 24 hours at a time affect teamwork?"). Finally, participants were asked about enablers and barriers to teamwork in their typical work day. The complete interview protocol is available in Appendix A. The

Table 1. Teamwork processes.[18-19]

Concept	Definition
Planning processes	
Mission analysis	Interpretation and evaluation of the crew's overall mission, including the key tasks to be performed, the operating environment that will be encountered, as well as the human and material resources necessary to accomplish the pending mission
Goal specification	Identification and prioritization of goals that are aligned with, and necessary to accomplish, the overall mission
Strategy formulation	Development of contingency courses of action necessary for mission accomplishment based on current environment and available resources
Action processes	
Monitoring progress	Tracking tasks and advancement toward mission completion
Systems monitoring	Tracking team resources and external conditions
Team monitoring and backup	Awareness and anticipation of tasks to be completed, as well as assisting team members with completing a task
Coordination	Orchestrating the sequence and timing of interdependent actions
Reflection processes	
Debriefing	A critical evaluation of the events that transpired during the team's performance
Interpersonal processes	
Conflict management	Processes that assist with interpersonal disagreements among team members
Motivation and confidence building	Processes that increase confidence and motivation among team members
Affect management	Regulating team members' emotions to accomplish team goals

lead author conducted all interviews. No personal identifiers were included during the interviews. All interviews were audio-recorded, transcribed verbatim, and reviewed for accuracy. The institutional review board approved this study.

Coding

We used a commercially available software program designed for qualitative data management to code data for later analysis (NVivo 11 Student Version; QSR International, Victoria, Australia). We created a codebook where the transcribed data were systematically sorted into separate, individual "chunks" of data, or codes.[26-27] In this initial round of coding, the first author categorized coherent thoughts identified within the textual data using deductive, "theory-based" codes. A key part of this process was the use of "memoing" in which observations were made during the data analysis, including annotation of interesting, unique, and recurrent patterns in the text, and preliminary coding decisions were recorded. Additionally, the lead author identified inductive codes by reviewing data that was not captured within the theory-based coding; this resulted in six emergent concepts.

Data Analysis

We used a thematic analytic approach[27-28] to identify themes within the coded data. The first author conducted all data analyses by reviewing transcripts[27] in an iterative process to engage closely with the data. Two authors combined codes into candidate themes that depicted the data accurately. Unlike codes, themes consist of ideas and descriptions that identify what the data is about and/or what it actually means.[27] In other words, themes are distinct units of meaning that are observed in the textual data. Several candidate themes emerged from this process. Finally, all authors reviewed the candidate themes to determine how they supported the data, and how they aligned with the Marks teamwork-processes framework, as modified by Fernandez et al.[18-19,29] All authors iteratively selected themes that were most relevant and made the most meaningful contribution to understanding what was going on within the data. The result of this deliberative process was the revised model of teamwork processes applied to EMS.

RESULTS

We reached a point of saturation once 32 respondents completed phone interviews. Participants were selected from across the organization, from firefighter-EMTs with one year of experience in EMS to senior fire captains with 40 years of experience; the median work experience was 15 years. The sample consisted of substantially more males than females (30 vs 2), which is consistent with the percentage in the organization as a whole. The sample consisted of substantially more paramedic-certified firefighters (28 vs 4) than those certified as EMT. The data provided general support to the

existence of teamwork processes that clustered into four domains: planning; action; reflection; and interpersonal processes. Additionally, six emergent concepts were identified during the open coding phase of data analysis: leadership; crew familiarity; team cohesion; interpersonal trust; shared mental models; and procedural knowledge. A summary of themes along with illustrative quotes are presented in Table 2. (See supplementary content online.) The revised model illustrating the relationships between the emergent concepts and teamwork processes are illustrated in Figure 3.

Table 2. Demographic characteristics of sample (n = 32).

Gender	
	Female: 2
	Males: 30
Professional certification	
	EMT: 4
	Paramedic: 28
Rank	
	Firefighter: 9
	Engineer operator: 7
	Captain: 12
	Senior captain: 3
	District chief: 1
Experience	
	Median: 15 years
	Range: 1–40 years

DISCUSSION

In this theory-driven study, we sought to apply a model of teamwork processes[18] to EMS. Our analysis provided support to distinct teamwork processes, which were grouped into four domains: planning; action; reflection; and interpersonal processes.[18] The data also uncovered several emergent concepts that respondents felt were central to effective teamwork in EMS: leadership[30-31]; crew familiarity[32]; team cohesion[32-33]; interpersonal trust[23,30-31]; shared mental models[34-25]; and procedural knowledge[36-37].

Leadership was revealed as influencing both action and interpersonal processes.[30-31] In other words, effective leadership is critical to ensuring that "things get done"[38,39] and to creating conditions that facilitate team effectiveness.[40] These behaviors can be broadly separated into task-focused and person-focused behaviors.[41] Task-focused behaviors are activities that foster understanding of task requirements and the procedures for task completion.[21,39,41] Person-focused behaviors are those that facilitate behavioral interactions, cognitive structures, and attitudes so that members can work effectively as a team.[21,40,41] In a recent meta-analysis, both task-focused (understanding/accomplishing tasks) and person-focused behaviors (promoting norms) were important correlates of team performance.[41] The current study shows how leadership affects EMS teamwork processes.

Additionally, shared mental models were linked to coordinated action.[34] A study of primary care teams revealed a similar relationship, which was helpful for managing unexpected situations.[23] Alonzo and Dunleavy[30] showed that teammates with a shared understanding of collective tasks to be done are more likely to interpret situational cues similarly, improving coordination.[42]

Procedural knowledge, the tacit information gained from hands-on task-specific training (ie, "know-how"), was important to team monitoring and backup.[36-37] Marks et al found a similar association between procedural knowledge and the development of backup behaviors through cross-training, which may improve team effectiveness.[42]

Crew familiarity was found to influence the teamwork process of affect management in our study.[32] Crew familiarity is an aspect of team design (ie, the work schedule) that results in cohorts of individuals maintaining a stable work group over an extended period of time. Patterson et al showed that crew familiarity can influence both interpersonal and action processes.[32] Patterson reports that EMTs work with their most frequent partner only 35% of the time.[32] Unfamiliar EMS teams might be "unclear about their partner's expectations and may be hesitant to speak up when necessary."[32] Further, unfamiliar teams are more likely to experience disruptions in team cohesion, delays in critical actions, and may threaten occupational safety among EMS crews.[31] Additionally, Gersick noted that such unfamiliar teammates may feel "anxiety, confusion, or apprehension" as a result ofsuch lack of professional familiarity with one another.[43,44] Furthermore, others noted that EMS teams with limited prior exposure to one another are more likely to experience lower quality performance.[45-47]

We found that team cohesion was positively related to motivation and confidence building. As noted above, the shared self-efficacy that members had when working with "my crew" gave EMS personnel a sense of collective confidence in their team's ability to accomplish challenging tasks. Similarly, a meta-analysis showed that interpersonal attraction among teammates was associated with an increased motivation for teammates to perform well on tasks.[48]

Additionally, we found that interpersonal trust influenced conflict management. A similar relationship was observed by Benzer et al, who found that psychological safety influences the interpersonal process of conflict management.[23] They noted that "psychological safety promotes effective interpersonal processes by strengthening a collective sense of trust," which is closely related to the concept of trust that emerged from our interviews.[23]

Participants shared that they often compartmentalize their emotions rather than addressing them as part of

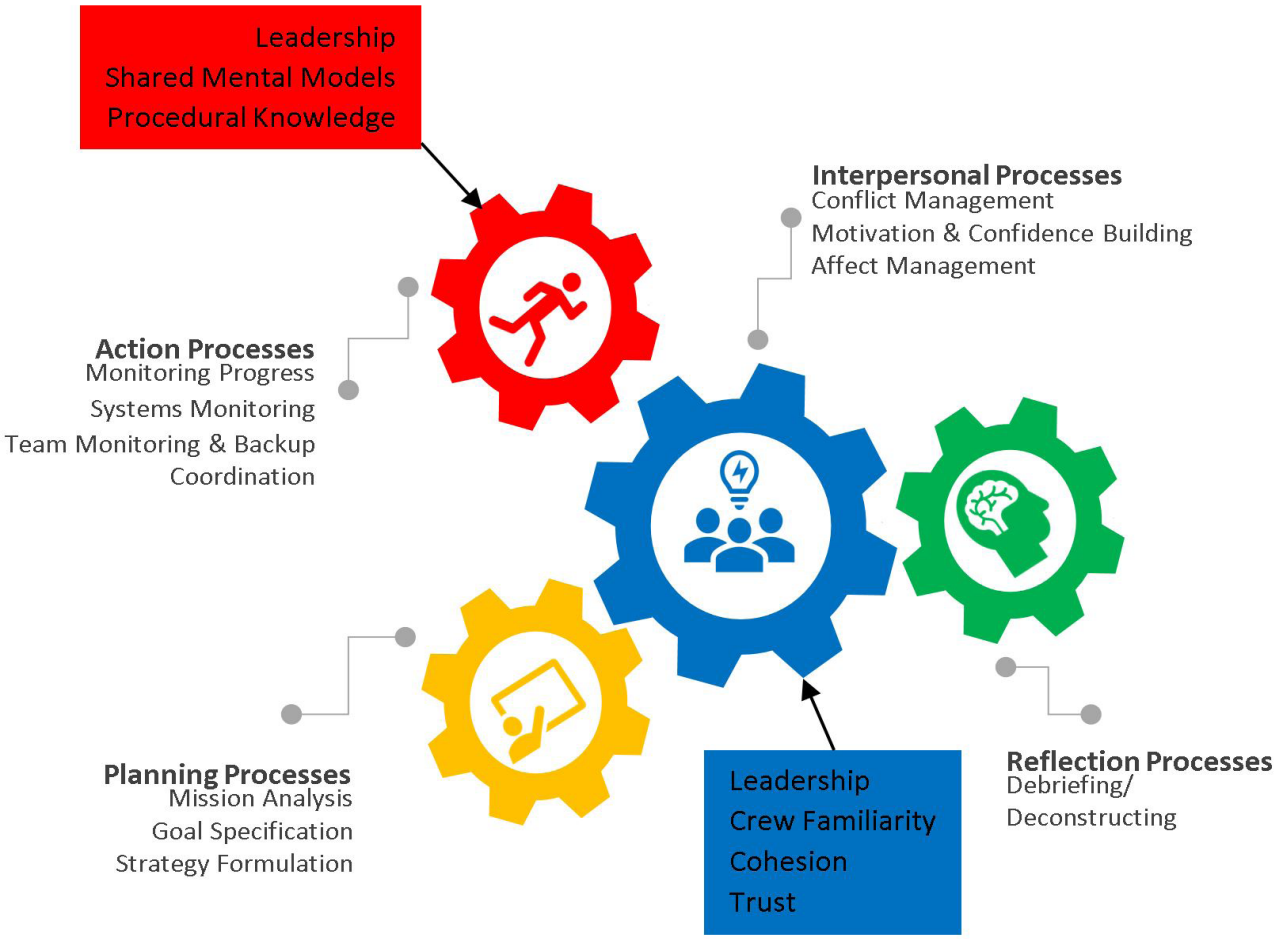

Figure 3. Revised model of teamwork processes in emergency care, applied to emergency medical services.

open interpersonal processes. Although many EMS and fire service organizations employ psychologists, conduct occupational stress training, and sponsor in-house peer support groups, the culture within many agencies is one of "do not admit to needing help."[48] Similar barriers are seen in the military setting.[49] It is presumed that the negative stereotypes reduce service members' motivation to seek help.[50] As in the military, normalizing the culture on seeking mental health services is necessary.[51]

This framework may be useful for EMS leaders (eg, medical directors, department chiefs, training officers) as well as researchers to identify the strengths and weaknesses in their organization's teamwork performance during team training and evaluation. An EMS agency could then use the results of training evaluations as feedback to modify or emphasize training on weaker teamwork processes, and conversely, allocate resources away from those processes that were judged the strongest.

LIMITATIONS

Our study had some limitations. First, we enrolled individuals at a single agency, which may limit the generalizability of our findings to other agencies. However, the respondents in this study were drawn from a range of ranks (ie, officers and firefighters) and experience levels. Second, the choice of a fire-based EMS agency may limit the generalizability of our findings to agencies whose emergency care services are not organized within a fire department structure. However, the majority of EMS agencies in the United States are fire department based.[52] Third, we enrolled more paramedics than EMTs. However, our aim was to sample a range of EMS providers, including those in senior leadership positions. This likely led to further oversampling of paramedic-certified personnel.

CONCLUSION

In this thematic analysis, we have outlined a model of EMS teamwork processes that describe the procedures that EMS operators employ to convert individual skills, knowledge and resources (ie, inputs) into collective team performance (ie, outputs). Although there are notable exceptions cited in this paper, the science of teamwork research in EMS is still relatively new and developing. Our findings extend prior teamwork research to the EMS context, and form the basis

for an evolving model of teamwork processes in EMS. This framework of EMS teamwork processes may be useful to help EMS leaders, educators, and researchers evaluate the key processes that are critical to teamwork effectiveness in EMS. Given the relative dearth of prior attention in this area, we feel future investigation is warranted that is focused on empirically testing the utility of this model to predict outcomes based on the performance of these teamwork processes.

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Accuracy of Hemolyzed Potassium Levels in the Emergency Department

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Introduction: In the emergency department (ED), pseudohyperkalemia from hemolysis may indirectly harm patients by exposing them to increased length of stay, cost, and repeat blood draws. The need to repeat hemolyzed potassium specimens in low-risk patients has not been well studied. Our objective was to determine the rate of true hyperkalemia among low-risk, adult ED patients with hemolyzed potassium specimens.

Methods: We conducted this prospective observational study at two large (129,000 annual visits) academic EDs in the mid-Atlantic. Data were collected from June 2017–November 2017 as baseline data for planned departmental quality improvement and again from June 2018–November 2018. Inclusion criteria were an initial basic metabolic panel in the ED with a hemolyzed potassium level > 5.1 milliequivalents per liter that was repeated within 12 hours, age ≥18, and bicarbonate (HCO_3) > 20. Exclusion criteria were age > 65, glomerular filtration rate (GFR) < 60, creatine phosphokinase > 500, hematologic malignancy, taking potassium-sparing or angiotensin-acting agents, or treatment with potassium-lowering agents (albuterol, insulin, HCO_3, sodium polystyrene sulfonate, or potassium-excreting diuretic) prior to the repeat lab draw.

Results: Of 399 encounters with a hemolyzed, elevated potassium level in patients with GFR ≥ 60 and age > 18 that were repeated, we excluded 333 patients for age > 64, lab repeat > 12 hours, invalid identifiers, potassium-elevating or lowering medicines or hematologic malignancies. This left 66 encounters for review. There were no instances of hyperkalemia on the repeated, non-hemolyzed potassium levels, correlating to a true positive rate of 0% (95% confidence interval 0-6%). Median patient age was 46 (interquartile range [IQR] 34 - 56) years. Median hemolyzed potassium level was 5.8 (IQR 5.6 - 6.15) millimoles per liter (mmol/L), and median repeated potassium level was 3.9 (IQR 3.6 - 4.3) mmol/L. Median time between lab draws was 145 (IQR 87 - 262) minutes.

Conclusion: Of 66 patients who met our criteria, all had repeat non-hemolyzed potassiums within normal limits. The median of 145 minutes between lab draws suggests an opportunity to decrease the length of stay for these patients. Our results suggest that in adult patients < 65 with normal renal function, no hematologic malignancy, and not on a potassium-elevating medication, there is little to no risk of true hyperkalemia. Further studies should be done with a larger patient population and multicenter trials. [West J Emerg Med. 2020;21(6)272-275.]

INTRODUCTION

Hyperkalemia is a major concern in the clinical setting due to its life-threatening effects on skeletal muscle and risk of cardiac arrhythmia secondary to impaired neuromuscular transmission. Accordingly, evaluation and treatment of hyperkalemia is treated as a priority in the emergency department (ED). However, many blood sample specimens report a falsely elevated potassium level from hemolysis during the collection process. In 1958 Hartmann et al first reported this finding as pseudohyperkalemia, an elevation of measured potassium levels in the absence of clinical evidence of electrolyte imbalance.[1] Pseudohyperkalemia most commonly occurs due to variability in venipuncture, including the use of tourniquets, repeated fist clenching, and sheer trauma that results in hemolysis.[2,3] Hemolysis is reported to occur frequently, with one ED-based study reporting 32% of all samples had some degree of hemolysis.[3]

In the presence of a high potassium level due to hemolysis, clinicians often repeat the test to confirm a normal potassium level, which can lead to increased length of stay, multiple blood draws, increased use of healthcare resources, and needless extra risk for patients. Pseudohyperkalemia is of particular concern in the busy setting of the ED as it requires timely management and resource use until proven to not be a true emergency. The need to repeat hemolyzed potassium specimens in low-risk patients has not been well studied; there is only one prior observational study in the published literature. Khodorkovsky et al found that among a convenience sample of 42 patients with hyperkalemia from a hemolyzed specimen, glomelular filtration rate (GFR) ≥60 and normal electrocardiogram (ECG) had a 100% negative predictive value of true hyperkalemia.[4] Our objective was to determine the rate of true hyperkalemia among low-risk adult ED patients with hemolyzed potassium specimens from a larger sample size at our institution. We hypothesized that for patients with hemolyzed potassium samples but normal renal function a priori selected criteria could exclude true hyperkalemia in 100% of cases.

Population Health Research Capsule

What do we already know about this issue?
Hemolyzed potassium levels often require repeat blood draw in the ED, even in lower risk patients such as those <65 with normal renal function and no malignancy

What was the research question?
What is the rate of true hyperkalemia among lower risk adult ED patients with hemolyzed potassium specimens?

What was the major finding of the study?
Of 66 patients who met our pre-defined low-risk criteria, all had repeat potassiums within normal limits.

How does this improve population health?
It may be possible to safely avoid a repeat blood draw in appropriately selected ED patients, thereby decreasing pain, cost, and length of stay.

METHODS

We conducted this prospective observational study at two large (129,000 combined annual visits) academic EDs in the mid-Atlantic region. Background hemolysis rate was known to be 0.28% of chemistry samples at the institution. Data collection was approved by the institutional review board as part of a quality improvement initiative observing departmental management practices for hyperkalemia. Data were collected by an automated electronic health record (EHR) search algorithm to identify all patients meeting inclusion criteria from the period June 2017–November 2017 and again from June 2018–November 2018. Exclusion criteria were recorded for all charts and reviewed by consensus among all the physician authors to determine exemption. These criteria were intentionally limiting in order to produce a highly sensitive decision rule (Table 1).

Inclusion criteria were an initial basic metabolic panel in the ED with a hemolyzed potassium level > 5.1 milliequivalents per liter that was repeated within 12 hours, age ≥ 18, and bicarbonate (HCO_3) > 20. Exclusion criteria were defined a priori as age > 65, lab calculated estimated GFR < 60, creatine phosphokinase > 500, hematologic malignancy, taking potassium-sparing or angiotensin-acting agents, or treatment with potassium-lowering agents (albuterol, insulin, HCO_3, sodium polystyrene sulfonate, or potassium-excreting diuretic) prior to the repeat lab draw. These criteria were felt by consensus at our institution to carry a historically elevated risk of hyperkalemia that would require a repeat measurement in the setting of potential hyperkalemia. We

Table 1. Selection criteria to predict the absence of truly elevated potassium levels on repeat blood draw.

Selection criteria
a. 18 ≤ age < 65
b. eGFR ≥ 60
c. HCO_3 > 20
d. CPK < 500 (if measured)
e. Not taking potassium-modulating drugs at time of presentation (spironolactone, triamterene, aldactone, ACE-inhibitor)
f. Without known hematologic malignancy
g. Not administered albuterol, HCO_3, insulin, furosemide or potassium binding medications after the first potassium draw and before the second potassium draw

eGFR, estimated glomerular filtration rate;*CPK,* creatine phosphokinase.

used an Excel spreadsheet (Microsoft Corporation, Redmond, WA) for descriptive statistics to evaluate our primary outcome: the rate of true hyperkalemia in adults without clinical risk factors for hyperkalemia. Pearson correlation coefficient was used to assess trend associations.

RESULTS

As presented in Figure 1, there were 399 encounters with a hemolyzed, elevated potassium level in patients with GFR > 60 and age > 18 that had a repeat potassium draw during the study period. We excluded 162 patients for age > 64, 106 patients for lab repeat > 12 hours, 30 patients for duplicate and thus invalid account identifiers, 11 patients on potassium-elevating medicines, 22 patients treated with potassium-lowering medicines, and 2 patients with hematologic malignancies. This left 66 encounters after applying exclusion criteria. There were no instances of hyperkalemia on the repeated, non-hemolyzed potassium levels, correlating to a true rate of hyperkalemia of 0% (95% confidence interval 0-6%). There was no correlation between the magnitude of elevation of the hemolyzed sample and subsequent true potassium level upon repeat ($r^2 = 0.005$)

Study demographics were as follows: Median patient age was 46 (interquartile range [IQR] 34 - 56) years. Median hemolyzed potassium level was 5.8 (IQR 5.6 - 6.15) millimoles per liter (mmol/L), and median repeated potassium level was 3.9 (IQR 3.6 - 4.3) mmol/L. Median time between lab draws was 145 (IQR 87 - 262) minutes.

DISCUSSION

Of 66 patients who met our pre-specified exclusion criteria, all had repeat non-hemolyzed potassiums within normal limits. This supports our hypothesis that in appropriately selected adult ED patients < 65 years of age with normal renal function, no hematologic malignancy, and not on potassium-modulating drugs, there is no risk of true hyperkalemia. This contrasts to higher risk populations such as the large inpatient/outpatient cohort described in 2009 by Einhorn et al who associated chronic kidney disease, and ACE-inhibitor use with a hyperkalemic event rate of 3.2% and with excess mortality.[5] This underlines the importance of safely identifying ED patients who do not need further evaluation of their pseudohyperkalemia. Khodorkovsky's prior report from an ED setting similiarly identified a safe cohort for rapid disposition without repeating potassium levels; their criteria required use of ECG testing for evaluation.[4] In contrast, our dataset was derived using easily accessible historical criteria without the need to assess variation in observer interpretation of ECG findings while still maintaining a negative predictive value of 100%.

An additional strength worth noting for our study is its ready applicability to the ED practice setting and ability to implement our findings for patient workflow improvement.

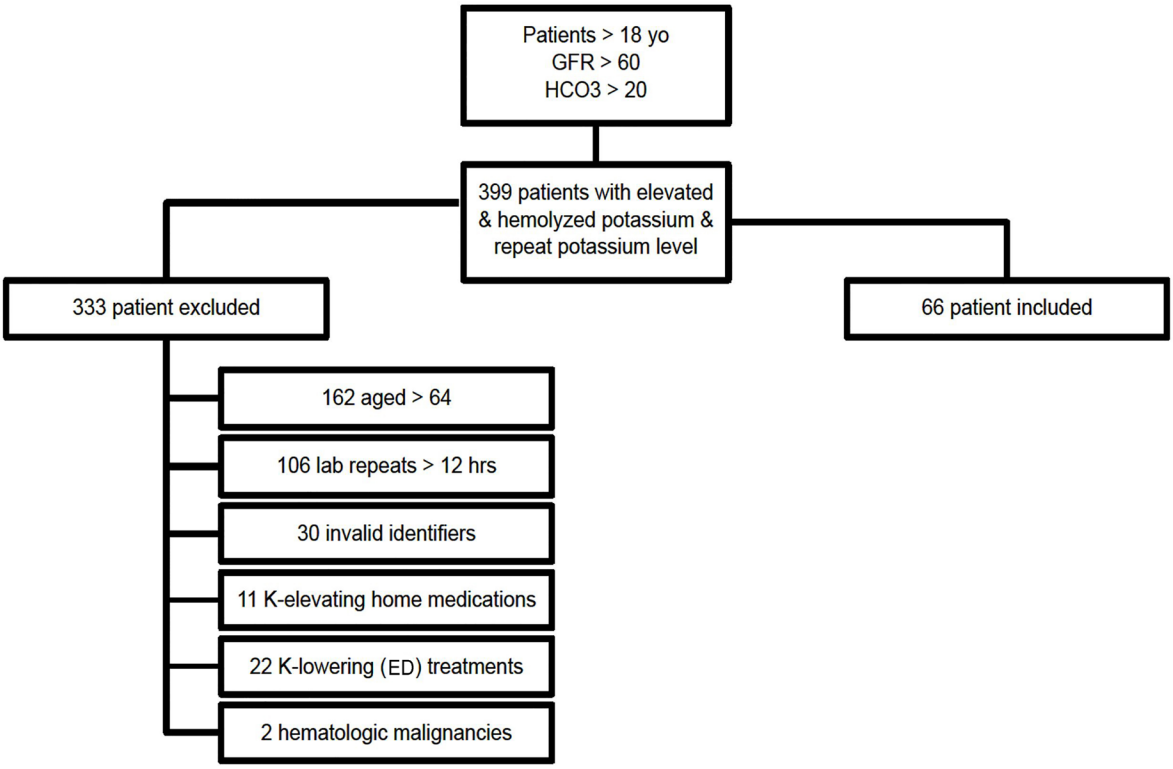

Figure 1. Inclusion flow chart demonstrating 399 patients with elevated potassium levels seen in hemolyzed lab draw. *GFR*, glomerular filtration rate; *K*, potassium; *ED,* emergency department.

The median of 145 minutes between lab draws suggests a ready opportunity to decrease the length of stay by speeding ED disposition for patients. It also suggests a safe way to decrease associated pain from intravenous sticks as well as healthcare-associated costs and potential harms.

LIMITATIONS

Limitations to the study include its non-interventional and observational nature as opposed to a randomized study. This was because we felt it to be standard of care to repeat potassium levels at the time but note that in chart review 35 cases were found to have been dispositioned without repeating a pseudo-elevated potassium draw and were thus excluded. These cases presumably reflect some level of physician comfort in dispositioning these low-risk patients without a repeat lab draw. This study contributes to evidence that in appropriately selected patients this can be a safe practice. Additionally, while the study was limited to two similar, tertiary care academic EDs, it was not limited to only one center and did include a large sample size for review with broad inclusion criteria. A final limitation is that the determination of hemolysis was made by laboratory personnel and recorded as "present or absent" as opposed to "mild, major or severe hemolysis." This may have introduced variation over time and across institutions as to what results qualified as hemolyzed; however, it would not necessarily have affected this decision rule's sensitivity. Lastly, since patients with renal insufficiency, malignancy, etc were excluded, we do not know the incidence of pseudohyperkalemia in these patients for comparison.

CONCLUSION

Our results suggest that in appropriately selected adult ED patients < 65 years of age with normal renal function, no hematologic malignancy, and who are not on potassium-modulating drugs, there is little to no risk of true hyperkalemia. Further studies should be done for confirmation of the criteria's applicability in other settings and potential expansion to older patients with normal GFR.

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Minimizing Pulse Check Duration Through Educational Video Review

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Introduction: The American Heart Association Guidelines for Cardiopulmonary Resuscitation (CPR) recommend pulse checks of less than 10 seconds. We assessed the effect of video review-based educational feedback on pulse check duration with and without point-of-care ultrasound (POCUS).

Methods: Cameras recorded cases of CPR in the emergency department (ED). Investigators reviewed resuscitation videos for ultrasound use during pulse check, pulse check duration, and compression-fraction ratio. Investigators reviewed health records for patient outcomes. Providers received written feedback regarding pulse check duration and compression-fraction ratio. Researchers reviewed selected videos in multidisciplinary grand round presentations, with research team members facilitating discussion. These presentations highlighted strategies that include the following: limit on pulse check duration; emphasis on compressions; and use of "record, then review" method for pulse checks with POCUS. The primary endpoint was pulse check duration with and without POCUS.

Results: Over 19 months, investigators reviewed 70 resuscitations with a total of 325 pulse checks. The mean pulse check duration was 11.5 ± 8.8 seconds (n = 224) and 13.8 ± 8.6 seconds (n = 101) without and with POCUS, respectively. POCUS pulse checks were significantly longer than those without POCUS (P = 0.001). Mean pulse check duration per three-month block decreased statistically significantly from study onset to the final study period (from 17.2 to 10 seconds [P<0.0001]) overall; decreased from 16.6 to 10.5 seconds (P<0.0001) without POCUS; and with POCUS from 19.8 to 9.88 seconds (P<0.0001) with POCUS. Pulse check times decreased significantly over the study period of educational interventions. The strongest effect size was found in POCUS pulse check duration (P = -0.3640, P = 0.002).

Conclusion: Consistent with previous studies, POCUS prolonged pulse checks. Educational interventions were associated with significantly decreased overall pulse-check duration, with an enhanced effect on pulse checks involving POCUS. Performance feedback and video review-based education can improve CPR by increasing chest compression-fraction ratio. [West J Emerg Med. 2020;21(6)276-283.]

INTRODUCTION

Background

Cardiopulmonary resuscitation (CPR) in the emergency department (ED) is a multidisciplinary effort to save a patient's life through return of spontaneous circulation (ROSC). Minute changes in CPR quality, such as the percentage of hands-on time, correlate with survival.[1] The American Heart Association recommends that pulse checks last a maximum of 10 seconds and that the ratio of time spent performing compressions to the total duration of CPR be 80% or higher, as these correlate with increased ROSC and survival to hospital discharge.[2] Prior studies found improved survival in patients with cardiac arrest due to ventricular fibrillation with chest compression fraction (CCF) of 0.6-0.8 and improved ROSC in patients with cardiac arrest without ventricular fibrillation with a CCF of 0.8-1.0.[3,4] In 2005 Valenzuela et al found that "frequent interruption of chest compressions results in no circulatory support during more than half of resuscitation efforts." Since then, many other studies have emphasized the importance of CCF and its relationship to outcomes including likelihood of ROSC and survival.[3-5] A recent study identified the importance of teamwork and communication as contributory factors to effective CPR.[7] Post-arrest debriefing as a means of quality improvement has not been shown to be a positive effect.[8]

Prior studies have identified video review as one method toward improving both the technical and interpersonal aspects of CPR.[9] Providers use video review of high-fidelity simulation training to improve skills and identify human factors associated with performance.[7,10,11] Video review of simulations is an effective means of teaching team competencies as well as technical skills.[12] Early use of clinical videorecording involved mostly surgical and anesthesia specialists, where researchers and at times groups of providers in conference reviewed analog video.[13,14] Since then, video review has become standard practice at many trauma centers to analyze behavior and improve treatment.[13,15,16]

Investigators have shown associations between the use of point-of-care ultrasound (POCUS) and prolongation of hands-on time during arrest.[17] Multiple studies have demonstrated the utility of POCUS to help determine the cause of a cardiopulmonary arrest, direct resuscitation efforts, assist procedures, and identify patients for whom continued resuscitative efforts would be futile.[18-20] The opportunity to glean potentially management-changing information has led to widespread use of POCUS during CPR, especially in academic ED settings.[21] However, using POCUS to assess cardiac activity may reduce "hands-on" time during resuscitation.[17,19] These findings raise concerns that POCUS may inhibit effective CPR and negatively impact patient outcomes.

Importance

Despite multiple studies showing the benefit and impact of POCUS during CPR, uncertainty exists about the potential for patient harm due to increased pulse check durations.[17,21,22] We explore ways to minimize time spent on pulse checks in which ultrasound is used, and maximizing the CCF. Furthermore, post-resuscitation recollections of events during CPR are often inaccurate.[23] Video review circumvents poor provider recall and offers an opportunity for quantitative data analysis of resuscitations including pulse check duration.[24] Through the introduction of improved methods of ultrasound use and video-based feedback we may improve CPR and outcomes.

Population Health Research Capsule

What do we already know about this issue?
Pulse checks under 10 seconds improve outcomes in cardiopulmonary resuscitation (CPR). Use of point-of -care ultrasound (POCUS) during CPR lengthens pulse check duration.

What was the research question?
Does CPR video review with feedback and education improve pulse check times with POCUS use?

What was the major finding of the study?
Educational intervention with video review was associated with reductions in pulse check duration.

How does this improve population health?
Adoption of an educational protocol that incorporates video review may lead to improved CPR pulse check durations and potentially patient outcomes in cardiac arrest.

Goals of this Investigation

Using multidisciplinary grand rounds educational sessions and individualized objective feedback, we sought to reduce pulse check duration, both with and without POCUS.

METHODS

Study Design and Setting

This was a prospective cohort study evaluating the use of ultrasound during CPR between December 2017–July 2019 in the ED of a single urban, academic hospital with an emergency medicine residency. The study conforms to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and was approved by our institutional review board (IRB# 031819).[25]

A videorecording system in three resuscitation bays continuously collected audio and video for review. Triage providers placed patients presenting to the ED with out-of-

hospital cardiac arrest (OHCA) in these videorecorded bays if they were available at the time of the patient's arrival or if nursing staff was able to move patients based on prehospital notification. Investigators collected data by reviewing the video footage and corresponding medical records. They collected data points in accordance with the Cardiac Arrest Registry to Enhance Survival (CARES).[26] The principal investigator (DY) trained junior researchers on performing video review for two weeks. The research team met on a monthly basis to evaluate videos, and a subset (50) of videos underwent review by two study researchers to assess for interobserver variability. For each case, at least one reviewer was a postgraduate year (PGY) -3 or -4 resident and the second reviewer was a postgraduate from any year (1-4).

Selection of Participants

The educational intervention included all ED practitioners, including attending physicians, residents, advanced providers, nurses, and technicians, who cared for adult patients presenting to the ED after OHCA who were placed in one of the three resuscitation areas with videorecording capability. All resuscitation teams included at least one attending and one PGY-2, -3, or -4 resident physician. Each team included a minimum of three nurses for documentation, medication administration, and bedside care. All staff members who participated in resuscitations were already being videorecorded per existing departmental policy. We consented willing staff members through an electronic opt-out method that included background information about the study, the subjects' role in the study, and their ability to opt out without risk of harm or reprisal. No staff members chose to opt out of this study.

Inclusion criteria were patients older than 18 years with OHCA who were transported to our urban, tertiary care hospital. Exclusion criteria included patients suffering traumatic arrest, death pronounced prior to arrival, ROSC prior to arrival with pulse on arrival to the ED, resuscitation in a room without video capabilities, or failed video capture. Investigators did not collect data on cardiac arrest patients who were not placed in a videorecorded room. The number of available videorecorded arrests that met inclusion and exclusion criteria during the study period determined our sample size.

Interventions

After review of a case, the reviewing team sent individualized feedback over Health Insurance Portability and Accountability Act-secure email to all involved care providers (technicians, nurses, resident physicians, and attending physicians). Providers received quantitative measures of performance including time to intravenous access, time to monitor, pulse check duration, and CCF. These summaries also included subjective feedback on ways to improve these quality metrics.

Bi-monthly presentations occurred during protected emergency medicine (EM) educational time attended by resident physicians, attending physicians, advanced practitioners, nurses, and EM technicians. A study representative (PGY-3 or PGY-4 EM resident) presented selected cases with a complete review of video footage, followed by a lecture on relevant topics related to CPR. Lecture topics included the following: team roles; POCUS; treatment of persistent ventricular fibrillation; airway management during CPR, team communication; post-resuscitation care; the presence of family during resuscitation; use of recombinant tissue plasminogen activator in cardiac arrest; the Lazarus phenomenon; CPR-induced consciousness; and termination of resuscitation. During review of the video, the presenter paused at specific times to highlight teachable moments. The attending principal investigator reviewed these prior to each presentation and the team designed teaching moments to highlight opportunities for improvement.

Presenters emphasized limiting hands-off time and shortening pulse checks. They shared POCUS-specific strategies to shorten pulse checks including positioning the probe in the desired location prior to pauses for pulse checks, counting the seconds aloud during image acquisition, and recording images during the pulse check for interpretation after CPR was resumed. We recommended a "pulse check ready" list prior to pausing CPR, including placing fingers on the pulse, ensuring that the monitor was in sight line of the resuscitation leader, and that the ultrasound probe was placed on the patient prior to the pulse check.

Measurements

Arrival time was the time of transition from the emergency medical services (EMS) stretcher to hospital gurney. Study data included all pauses in compressions, including pauses for procedures, pulse checks, compression device malfunction, or other causes. Once providers achieved ROSC, investigators considered the case complete. Investigators calculated time of death as the time providers announced the death to the room. Time of ROSC was the time a palpable pulse was announced by either the resuscitation leader or provider who palpated the pulse. Data extracted from the audiovisual record or the electronic health record included the use of ultrasound during each pulse check, the time of each pulse check, and the ultimate outcome of the patient. Only the clinical team made the decisions of when and whether to use POCUS during pulse checks. Investigators did not include final pulse checks (during which ROSC was achieved or the resuscitation efforts were terminated). The type of compressions provided, either automated device or manual, was recorded.

Multiple team members reviewed a subset of video recordings (50) to analyze interobserver variability. Discordantly recorded times of pulse checks were averaged. Investigators did not include pulse checks recorded by one

reviewer and omitted by second reviewer nor pulse checks in which reviewers disagreed on whether or not ultrasound was used. While performing data collection, the reviewers independently assessed each video and were blinded to each other's recorded values.

Outcome

The primary outcome was pulse check duration with and without the use of POCUS.

Analysis

We performed univariate analyses of pulse checks with the Mann-Whitney U test and Spearman's rank correlation coefficient, ρ, to evaluate pulse check length trends overall, with ultrasound use, and without ultrasound use. Interrater reliability between reviewers of pulse check lengths was analyzed by way of intraclass correlation coefficient (ICC) and Pearson's correlation coefficient, r. All statistical analysis was performed using SAS version 9.4 (SAS Institute Inc., Cary, NC) with $P < 0.05$ considered statistically significant.

RESULTS

Over 19 months, investigators reviewed 70 patient resuscitations. Mean age of the patients was 58.6 years old with standard deviation of 13.2. Twenty (28.8%) of the patients were female; 18 (25.7%) patients had ROSC; and three (4.3%) survived to hospital discharge (Table 1). A total of 239 patients presented to the ED in OHCA. Of those, 105 were excluded due to ROSC or death on arrival, leaving 134 eligible patients. Of the remaining patients, 61 were placed in non-videorecording rooms, or had failure of the video capture system. Three resuscitations were excluded due to incomplete data, resulting in 70 patients for analysis. (Figure 1). A total of 341 pulse checks were reviewed from the 70 patients. Sixteen pulse checks did not have concordance in reviewer reports of ultrasound use and were thus excluded, leaving 325 pulse checks for analysis (Figure 1). Interrater reliability of pulse check length was relatively strong (intraclass correlation coefficient ICC = 0.9343, r = 0.9330; P<0.0001).[13]

Table 1. Patient characteristics by case, n=70.

Variable	Overall summary statistics	No ultrasound used	Ultrasound used
Age	58.6 ± 13.2	60.6 ± 13.9	57.8 ± 12.9
	56.5 (51, 68)	59.5 (55, 67)	56 (49, 68)
Sex			
Male	50 (71.4%)	10 (45.5%)	40 (83.3%)
Female	20 (28.6%)	12 (54.5%)	8 (16.7%)
Race			
AA/Black	45 (64.3%)	14 (63.6%)	31 (64.6%)
Hispanic	2 (2.9%)	1 (4.5%)	1 (2.1%)
White	20 (28.6%)	6 (27.3%)	14 (29.2%)
N/A	3 (4.3%)	1 (4.5%)	2 (4.2%)
Prehospital rhythm			
PEA	24 (34.3%)	8 (36.4%)	16 (33.3%)
Asystole	23 (32.9%)	6 (27.3%)	17 (35.4%)
V fib	15 (21.4%)	4 (18.2%)	11 (22.9%)
V tach	3 (4.3%)	1 (4.5%)	2 (4.2%)
Unknown	5 (7.1%)	3 (13.6%)	2 (4.2%)
Compression device			
Hands	5 (7.1%)	2 (9.1%)	3 (6.3%)
Lucas	65 (92.9%)	20 (90.9%)	45 (93.7%)
Ultrasound was used at somepoint	48 (68.6%)	-	48 (100%)
ER outcome			
Admitted to hospital	18 (25.7%)	10 (45.5%)	8 (16.7%)
Death	52 (74.3%)	12 (54.5%)	40 (83.3%)
Survived hospital discharge	3 (4.3%)	3 (13.6%)	-

Reported as # (%), mean ± standard deviation, and/or median (interquartile range).
AA, African American; *PEA,* pulseless electrical activity; *ER,* emergency room; *V fib,* ventricular fibrillation; *V tach,* ventricular tachycardia.

There were 224 pulse checks without ultrasound (68.9%), and 101 pulse checks with ultrasound (31.1%). Mean length of pulse checks was 12.2 seconds with standard deviation (SD) of 8.8 seconds. The mean length of pulse checks without ultrasound was 11.5 seconds with SD of 8.8 seconds. The mean length of pulse checks that used ultrasound was 13.8 seconds with SD of 8.6 seconds. Pulse checks using ultrasound were significantly longer than those without ultrasound (P = 0.001). Mean pulse check duration per three-month block had a statistically significant decrease from study onset to the final study period. Mean pulse check duration divided quarterly decreased from 17.2 ± 12.2 to 10 ± 6.5 seconds (ρ = -0.2920, P = <0.0001] overall; pulse checks without POCUS decreased from 16.6 ± 13.2 to 10.5 ± 6.5 seconds (ρ = -0.3547, P = <0.0001); and pulse checks with POCUS from 19.8 vs ± 4.2 seconds to 9.88.0 seconds ± 6.6 (ρ = -0.3981, P <0.0001) (Table 2). Pulse check times decreased significantly over the study period of educational interventions (ρ = -0.2953, P<0.0001), with an even greater negative effect size in pulse check time with ultrasound use (ρ = -0.3640, P = 0.0002) (Figure 2). Pulse checks without ultrasound also significantly decreased over time (ρ = -0.3605, P = 0.0001) (Figure 3).

DISCUSSION

The modifiers of patient outcome in CPR are limited. Reduced hands-off time through shorter pulse checks

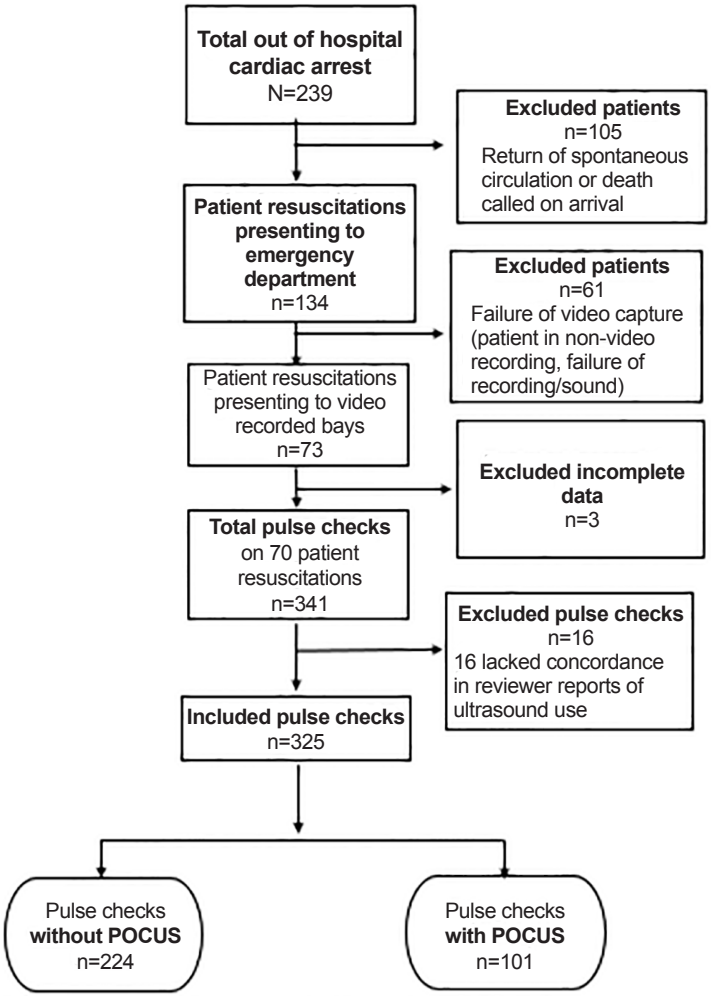

Figure 1. Flow diagram for patients approached for enrolment in this study.
POCUS, point-of-care ultrasound.

Table 2. Pulse check length by every three months of study time (QUARTERLY).

Sample	Mean ± SD	Spearman's ρ	P-value
Overall (n=325)	12.2 ± 8.8	-0.2953	<0.0001
Q1	17.2 ± 12.0	-0.2920	<0.0001
Q2	14.0 ± 8.8		
Q3	10.8 ± 6.5		
Q4	11.6 ± 11.3		
Q5	11.5 ± 7.9		
Q6	9.7 ± 4.6		
Q7	10.0 ± 6.5		
Without US (n=224)	11.5 ± 8.8	-0.3605	<0.0001
Q1	16.6 ± 13.2	-0.3547	<0.0001
Q2	13.6 ± 8.9		
Q3	9.1 ± 2.8		
Q4	8.9 ± 5.2		
Q5	10.3 ± 8.5		
Q6	8.3 ± 3.1		
Q7	10.5 ± 6.5		
With US (n=101)	13.8 ± 8.6	-0.3640	0.0002
Q1	19.8 ± 4.2	-0.3981	<0.0001
Q2	17.8 ± 7.5		
Q3	14.8 ± 10.0		
Q4	15.8 ± 16.4		
Q5	14.4 ± 5.4		
Q6	11.7 ± 5.6		
Q7	9.8 ± 6.6		

US, ultrasound; *SD,* standard deviation.

correlates with improved survival. This study demonstrated that CPR pulse check duration improved with our educational intervention and targeted feedback. With this in mind, providers may use similar methods to potentially improve patient survival by shortening pulse checks. Although all pulse checks improved over time, pulse checks using POCUS improved more than those without. Despite this, overall average of pulse check duration with POCUS was significantly longer than pulse checks without POCUS. During the last three months of study overall pulse checks were 10 seconds. To our knowledge, pulse check durations in this study were shorter than previous studies, both with and without POCUS.[17,21] Through our educational intervention we were able to achieve the goal pulse check duration of 10 seconds at the end of the study period. Thus, through the implementation of an educational intervention, we improved the pulse check duration as compared to other studies.

One of the major priorities of this study was the multidisciplinary approach, targeting education and feedback at all levels of the resuscitation team (nursing, technicians, physician assistants, and physicians). Previous studies have shown improved outcomes in cardiac arrest with an integrated team approach.[27] With integrated education at all levels of the resuscitation team, all members feel responsible for the resuscitation, not only the physician providers. Often the ultrasonographer, focused on performing the POCUS, may not pay as close attention to pulse check duration. With a multidisciplinary approach, any team member (especially team members primarily responsible for chest compression [in our setting ED technicians]) feels empowered to interrupt a POCUS to resume chest compressions; examples of this were witnessed on video review.

Video review is a low-cost, widely adopted method used for medical education.[28] Other academic hospitals may reproduce and adopt the methods of video review described in this study to improve key parameters in CPR. Weston et al first discussed videotaping cardiac arrest cases in 1992, when their results identified poor leadership and prolonged interruption of cardiac massage as deficiencies; however, most video use

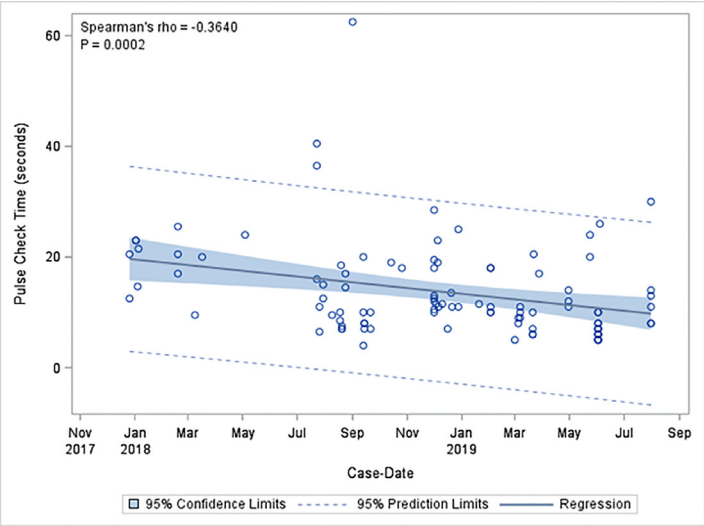

Figure 2. Correlation between pulse check length with ultrasound use throughout time of educational intervention.

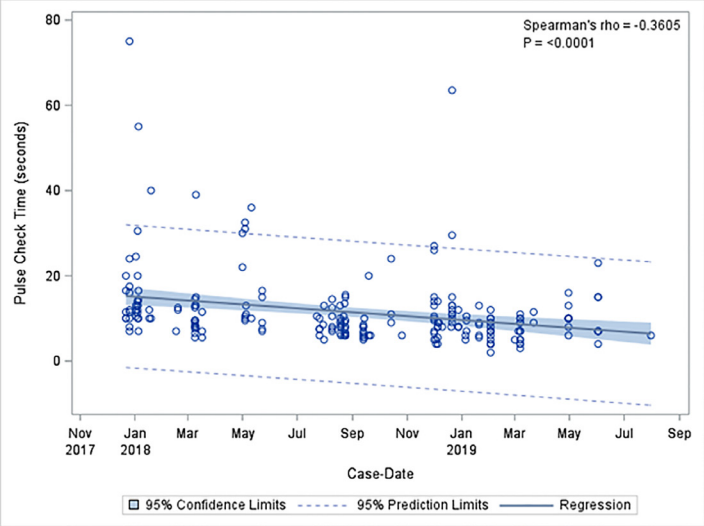

Figure 3. Correlation between pulse check length without ultrasound use throughout time of educational intervention.

remains in simulation settings due to many challenges to recording within clinical settings.[29-31] These challenges include the legality of videorecording patient care, patient privacy laws, and provider litigation. This study is innovative in its utilization of video review feedback to improve POCUS in cardiac arrest.

Another strategy to help minimize interruptions in CPR is the development of POCUS protocols.[32,33] These protocols alone did not reduce pulse check duration but could be used with video feedback review to further improve CPR quality. Another advancement in the use of POCUS has been the use of trans-esophageal echocardiography (TEE) as it does not interfere with compressions in the same way transthoracic ultrasound does. Recent studies have shown that emergency physicians can perform TEE to guide resuscitation; however, it is far from widespread adoption due to the need for specialized training and equipment.[34]

We demonstrated that focused individual feedback as well as conference case review decreased the duration of pulse checks. Across the entire study period, the mean length of POCUS-assisted pulse checks in our study was 13.8 seconds, and 11.8 seconds without the use of POCUS. Averaged by quarter, mean pulse check duration significantly decreased from study onset to the final study period with the final three-month period showing a pulse check duration without POCUS of 10.5 seconds, and with POCUS of 9.8 seconds. This demonstrates that the hesitancy to use ultrasound in pulse checks created by prior research should be taken with caution, as with proper education and protocols in place it is still possible to deliver high quality CPR. We encourage emergency physicians to integrate POCUS into CPR with a continuous quality improvement process to improve the metrics of cardiac arrest resuscitation, and ultimately to improve patient outcomes.

LIMITATIONS

The major limitations of this study include the cohort design, single-center sample size, sample bias, sonographer experience, and the use of mechanical compression devices. Our study had a relatively small sample size from only one hospital; however, to our knowledge this is the largest study in the EM literature addressing duration of pulse checks with POCUS during CPR. Although 18 patients survived to hospital admission, only three patients survived to hospital discharge; this sample size is too small to draw any meaningful conclusions about the effect of this intervention on mortality. Additionally, this was a convenience sample of patients placed into videorecorded resuscitation bays. We did not account for patients with OHCA who were placed in non-video rooms as we would not have been able to extract the same data from these cases. For example, nursing staff do not record pulse check times during a typical non-video resuscitation.

The significant improvement in pulse check duration when using POCUS demonstrated during this study may simply be correlation, related to some other factor other than the educational feedback, and not causation, as there was no comparison group not receiving the feedback. For example, providers may have experienced the Hawthorne effect, and may have aimed to improve pulse check times because they were aware of being videorecorded. This probable Hawthorne effect, or the fact that focusing attention on pulse check duration during CPR impacts CCF, is in some ways not a limitation, as it informs the practice of performance assessment during resuscitations to improve the quality of CPR.

The generalizability of this intervention presents a further limitation. With the decrease in financial cost of video review technology we anticipate that other institutions may adopt this

protocol to improve their practice; however, it is certainly time and resource intensive. These interventions at our hospital have continued after the study period ended, but time will tell if this proves sustainable. An additional limitation is that the experience of the sonographer obtaining cardiac views during arrest is a major factor in the length of the pulse checks.[34] However, we did not account for the sonographers' level of experience (eg, year of training; fellow or attending status; previous POCUS training) in our study. Therefore, we cannot further stratify pulse check lengths with the sonographer's experience.

Finally, our hospital and EMS system frequently used a mechanical chest compression device for continuous compressions (LUCAS, Stryker Medical, Portage, MI). In this study, 65 patients (92.9%) received compressions via LUCAS device. Due to the size and placement of the LUCAS, it impairs the use of the parasternal window, a useful view in cardiac arrest when gastric distension limits the subxiphoid view. Although in practice the most commonly obtained window is the subxiphoid view, we were not able to document the view used during each ultrasound check.

CONCLUSION

We have demonstrated that a targeted educational intervention improved pulse check times overall, and improved pulse checks with POCUS to an even greater degree. We anticipate that with further attention and intervention related to this important topic, we will continue to improve pulse check times both with and without POCUS. As our intervention is ongoing, our observation has led us to continue our study as we hope to further use this method to optimize cardiac resuscitations and minimize potential harm to our patients.

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Emergency Medicine Challenges in Ecuador

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Introduction: Emergency medicine (EM) was recognized as a specialty in Ecuador in 1993. Currently, there are two four-year EM residency programs and an estimated 300 residency-trained emergency physicians countrywide. This study describes the current challenges in EM in Ecuador.

Methods: We conducted 25 semi-structured, in-person interviews with residency-trained emergency physicians, general practitioners, public health specialists, prehospital personnel, and physicians from other specialties. The interviewer asked about challenges in the areas of emergency care, working conditions of emergency physicians, EM residency education, EM leadership, and prehospital care. We analyzed data for challenges and registered the number of interviewees who mentioned each challenge.

Results: Interviewees worked in the three largest cities in the country: Quito (60%); Guayaquil (20%); and Cuenca (20%). Interviewees included 16 (64%) residency-trained emergency physicians; six (24%) residency-trained physicians from other specialties working in or closely associated with the emergency department (ED); one (4%) general practitioner working in the ED; one (4%) specialist in disasters; and one (4%) paramedic. Shortage of medical supplies, need for better medico-legal protection, lack of EM residencies outside of Quito, and desire for more bedside teaching were the challenges mentioned with the highest frequency (each 44%). The next most frequently mentioned challenges (each 38%) were the need for better access to ultrasound equipment and the low presence of EM outside the capital city. Other challenges mentioned included the low demand for emergency physicians in private institutions, the lack of differential pay for night and weekends, need for more training in administration and leadership, need for a more effective EM national society, and lack of resources and experience in EM research.

Conclusion: Emergency medicine has a three-decade history in Ecuador, reaching important milestones such as the establishment of two EM residencies and a national EM society. Challenges remain in medical care, working conditions, residency education, leadership, and prehospital care. Stronger collaboration and advocacy among emergency physicians can help strengthen the specialty and improve emergency care. [West J Emerg Med. 2020;21(6)284-290.]

INTRODUCTION

Ecuador is a small, upper-middle income country located in northwestern South America. It has a population of approximately 17 million.[1] Quito, the capital, and Guayaquil are the most populous cities with approximately 2.7 million inhabitants each.[2] The country's gross domestic product per capita in United States dollars is $11,500; approximately 21% of the population lives beneath the poverty line.[1,3] Emergency medicine (EM) was recognized as a specialty in Ecuador in 1993 and has reached significant milestones since. This qualitative, descriptive statistical analysis presents the history and current state of EM in Ecuador and identifies current challenges with the goal of informing future EM development work in the country.

Population Health Research Capsule

What do we already know about this issue?
Emergency medicine (EM) has been recognized as a specialty in Ecuador for the last three decades, and there are two EM residency programs in the country.

What was the research question?
This study sought to identify current challenges in the specialty and the state of emergency care in Ecuador.

What was the major finding of the study?
Important challenges remain in delivering medical care, as well as in EM working conditions, residency education, leadership, and prehospital care.

How does this improve population health?
This qualitative study can serve as the starting point for future EM research and development of the specialty in Ecuador.

BACKGROUND

Healthcare System

Ecuador provides universal healthcare through a mixed public-private health system.[4] Overall, 30% of Ecuadorians have Social Security Insurance (employees working in the formal economy), 58% seek medical care in public facilities (individuals who have low income or work informal jobs), and 12% have private health insurance.[4] Healthcare resources vary greatly among medical facilities in Ecuador, from small outpatient facilities in rural areas with minimal resources to large tertiary-care hospitals in the larger cities. Private facilities are usually better resourced than public ones.

General practitioners still provide most emergency care in the country, either independently at lower acuity facilities, or under the supervision of emergency physicians (EP) or other specialists in tertiary-care centers. Most residency-trained EPs work in Quito, with fewer than 50 estimated to work in other cities, including Guayaquil, Cuenca, Ambato, Manta, and Portoviejo. By law, all emergency departments (ED) must care for patients with life-threatening emergencies, regardless of their insurance status or ability to pay but are not obligated to provide any additional care once the patient has been stabilized. The majority of EDs employ the Manchester triage system.[5]

Medical Education

Medical school education begins immediately after high school, and programs are offered by both public and private universities. All programs are six years in length, plus one year of social service in underserved areas after graduation. General practitioners may then work independently or under the supervision of specialists or apply to residency programs.*

*In Ecuador, physicians pursuing a medical specialty degree are referred to as *posgradistas* or "postgraduates," instead of "residents," the term more commonly used for these trainees in other countries. In contrast, in Ecuador the term "resident" is used for general practitioners working under the supervision of a specialist, without actively pursuing a specialty degree. Given that this article is aimed at an international audience the terms "resident" and "residency" will be used in their more common international usage, as opposed to their Ecuadorian meaning.

Emergency Medicine History in Ecuador

In 1986 the Ecuadorian Society of Emergency Medicine and Disasters (SEMED) was formed by general practitioners interested in emergency care. Shortly thereafter in 1989, author AM's interest in EM was piqued during a rotation in the ED while still early in his pulmonary medicine residency. Inspired by the US EM curricula, AM modified his residency curriculum and graduated in 1993 as the first residency-trained EM specialist in the country. He subsequently helped establish the first residency program in EM and Disasters at Universidad Central and later founded the residency program at Universidad Católica. A third program, affiliated with Universidad San Francisco de Quito only lasted a few years due to differences between the university and the main clinical site.

At the time of this study there were an estimated 300 EPs in Ecuador.[6] Most completed EM residency training, while a minority were grandfathered into the specialty after working in EDs for at least five consecutive years. This mechanism was also used in other specialties and was terminated by the government in 2000. At the time of this study, SEMED had 20 members, all of whom were EM specialists.

Emergency Medicine Residencies

There are two EM residency programs in Ecuador: Universidad Central and Universidad Católica, a private university (Table 1). Both programs are four years in length

and are located in Quito. Admission processes for each institution require a school-specific written exam, a certificate of intermediate English proficiency, and an in-person interview. Both residency programs charge tuition, but few residents pay the full amount. Instead, tuition and stipends for residents are sponsored by the government or hospitals where they rotate. In addition to clinical rotations (Table 2), both residencies have extensive didactic activities including several hours of lectures every week with mandatory attendance. Both programs use medical simulation and require residents to document medical procedures in a logbook. Ultrasound training curricula is the same for both residency programs.

Following residency, graduates who received government scholarships must repay their financial aid by working two years for every year of financial aid received in government-designated hospitals, often in other cities or rural locations. This method of repayment is referred to as *devengar* ("to earn") and applies to graduates of all specialties. There are no board exams for EM or any other specialty in Ecuador. Due to the relatively small number of residency-trained EPs in Ecuador, many graduates go on to be the first EPs hired by their institutions, and often find themselves in leadership roles.

Table 1. Emergency medicine residency program characteristics in Ecuador.

Program	Universidad Central	Universidad Católica
Year founded	1994	2004
City	Quito	Quito
Institution type	Public university	Private university
Duration	4 years	4 years
Tuition per year	USD $5,000*	USD $7,000*
Stipend	USD $1,600*	USD $900 - $1,600*
Class size	15-18	20-25
Total residents	35	65
EM faculty	50	30
Application requirements	Written exam English exam Interview	Written exam English exam Interview
Fellowships offered	None	None
Special Features	Oldest program in the country	ACLS and ATLS certifications included for residents

*Tuition and stipend usually paid by scholarship
EM, emergency medicine; *USD*, United States dollar; *ACLS*, Advanced Cardiovascular Life Support; *ATLS*, Advanced Trauma Life Support.

Table 2. Ecuadorian emergency medicine residency curricula: number of months spent in each clinical rotation.

Program	Universidad Central months in rotation	Universidad Católica months in rotation
Emergency Medicine	23 (12 in critical EM)	16
Pediatrics	3	2
ICU	6	12
Other rotations	EM Observation 4 Internal Med-Cardiology 4 Neurologic Emergencies 4 Pulmonology Emergencies 4 Ultrasound*	Anesthesia 2 Cardiology 2 Gastroenterology 2 Internal Med 4 Neurology 2 Prehospital 2 Ultrasound* International or Provincial Rotation 2-4

*Ultrasound training consists of 30 hours of lecture and 100 hours of supervised practice for both programs over four years.
EM, emergency medicine; *ICU*, intensive care unit.

Prehospital Care

The national emergency medical services (EMS) system is called Servicio Integrado de Seguridad ECU 911 (ECU-911 for short). The system is activated by dialing 911. ECU-911 is a mixed public-private system. Most ambulances are staffed with paramedics, while very few employ physicians.[7] Paramedic training is a four-year undergraduate degree. General practitioners provide medical control in call centers. No EPs were involved in medical control at the time of this study. Although ECU-911 is a nationwide initiative, prehospital capabilities vary widely among different regions. In 2018 Quito's ECU-911 response included 16 ambulances. Nationwide protocols published by the Public Health Ministry exist to guide EMS and prehospital emergency care.[7]

Pediatric Emergency Medicine

General practitioners and pediatricians provide most of the emergent health care to the pediatric population as there are no fellowship programs for pediatric EM in the country. Residents from both EM residencies rotate through Hospital Baca Ortiz, a large referral pediatric hospital in Quito, and are supervised by pediatricians and pediatric critical care specialists.

METHODS

In April 2018, 25 semi-structured, in-person interviews were conducted with EM specialists, general practitioners, prehospital personnel, public health specialists, and physicians from other specialties in 10 EDs across the three largest cities in Ecuador: Quito, Guayaquil, and Cuenca. All interviews

were performed by author AP and consisted of an initial list of 13 general questions and 23 questions related to EM training (see Online Supplement A). The questions were asked in an open-ended manner, with follow-up questions as needed. Non-EM specialists were included in the sample given their current role in the provision of emergency care in Ecuador and with the aim of including diverse points of view. Interview questions were developed based on prior experience with EM development research[8,9] and focused on the current challenges in the areas of emergency care, EM working conditions, EM education, EM leadership, and prehospital care.

Questions related to EM working conditions, EM leadership, and EM training were directed to EM specialists only. Only EM specialists were asked questions about residency training. This included individuals who were grandfathered into EM as well as those who were residency trained. The initial interviewees were identified by author AM based on personal and professional contacts. We used snowball chain-referral sampling to identify subsequent participants. The recruitment email included a study fact sheet, and informed consent was implied by voluntary completion of the interview. Challenges were identified and the number of interviewees who mentioned each challenge was recorded. Interviews and data analysis were conducted in Spanish. Challenges mentioned by three or more respondents were translated for inclusion in the manuscript. The authors performing the interviews and data analysis are fluent in both Spanish and English. Ethical approval was obtained from the Partners Healthcare Institutional Review Board (IRB), in Boston, MA, and the Hospital General Docente Calderón IRB, in Quito, Ecuador.

Table 3. Characteristics of subjects who were interviewed about the state of emergency care in Ecuador.

	Number	%
City (n = 25)		
Quito	15	60%
Guayaquil	5	20%
Cuenca	5	20%
Specialty (n = 25)		
Emergency medicine	16	64%
Surgery	2	8%
Pediatrics	2	8%
General practitioner	1	4%
Disasters	1	4%
Internal medicine	1	4%
Critical care	1	4%
Paramedic	1	4%
Work setting (n = 25)		
Only clinical	15	60%
Only administrative	3	12%
Both	7	28%
Sector (n = 25)		
Public	23	91%
Private	2	9%
ED director (n = 25)	9	36%

ED, emergency department.

RESULTS

Interviewee Characteristics

All 25 subjects approached participated in an interview (Table 3). Fifteen (60%) participants worked in Quito, and the majority (64%) were EPs. With respect to current employment, 60% of participants worked exclusively in the clinical setting, 12% in healthcare administration only, and 28% in both. Approximately one-third of the interviewees were directors of their EDs.

Challenges

Interviewees cited many challenges with respect to the provision of emergency care and EM as a specialty. Table 4 lists the challenges mentioned by at least three interviewees. Themes were divided into five categories: emergency care; EM working conditions; EM education; EM leadership; and prehospital care.

DISCUSSION

EM has reached important milestones in Ecuador over the last three decades. However, important challenges remain. The most frequently mentioned challenge in emergency care was the shortage of medical supplies. Some interviewees attributed this to a lack of expertise of managers, mismanagement of funds, and funding variability with political cycles. ED crowding and long wait times were also mentioned. ED crowding is not unique to Ecuador.[10] One potential strength of the Ecuadorian system is that the overwhelming majority of its healthcare facilities are public or part of the nation's Institute of Social Security, which could allow for easier implementation of reforms at a national level as compared to more decentralized systems. Interviewees also identified the need for better application of protocols for the management of time-sensitive pathologies, both in the hospital and the prehospital settings. Some EDs lack protocols. Others have them on paper but do not apply them, resulting in delays and inefficiencies.

With respect to working conditions, interviewees reported medical lawsuits are increasing in Ecuador and felt a lack of medico-legal protection was negatively affecting the specialty. EP compensation was also mentioned by interviewees as an issue. EPs work a disproportionate number of night and weekend shifts, caring for critically ill patients in a stressful environment, and balancing the needs of multiple patients at the same time.[11,12] However, all medical specialists working in government or Social Security hospitals are paid the same, regardless of specialty or shift distribution. Interviewees

Table 4. Emergency medicine challenges in Ecuador.

	Number of interviewees who mentioned challenge	% of interviewees who mentioned challenge
Emergency care (n = 25)		
Shortages of medical supplies	11	44%
Longer wait times	7	28%
Crowding and boarding	7	28%
Need for stronger application of institutional protocols for time-sensitive conditions (eg. stroke, MI, trauma)	6	24%
Emergency medicine working conditions (n = 16, emergency medicine specialists only)		
Need for better medico-legal protection	7	44%
Need for increased access to bedside ultrasound	6	38%
Low demand for emergency physicians in private institutions	5	31%
Lack of differential pay for night and weekend shifts	5	31%
Emergency medicine education (n =16, emergency medicine specialists only)		
Absence of postgraduate programs outside the capital city	7	44%
Desire for more bedside teaching and supervision during residency	7	44%
Interest in more training in administration and leadership	5	31%
Government scholarship repayment (Devengar)	3	19%
Lack of emergency medicine subspecialty fellowships (eg, ultrasound)	3	19%
Emergency medicine leadership (n = 16, emergency medicine specialists only)		
Low presence and recognition of EM outside of capital city	6	38%
Need for a more effective EM national society	5	31%
Few resources and lack of experience in EM research	5	31%
Prehospital care (n = 25)		
Lack of strong prehospital protocols for time-sensitive conditions	4	16%
Difficulties and delays in referrals to tertiary care medical centers	4	16%
Lack of involvement of emergency physicians in the prehospital system	3	12%

MI, myocardial infarction; *EM*, emergency medicine.

mentioned that few EPs are employed by private hospitals. In these institutions, the payment model favors multiple specialist consultations, encouraging general practitioners or EPs to consult other specialties for conditions within the EP's scope of practice. This results in inefficiencies, increased cost, and increased length of stay. Lack of access to bedside ultrasound equipment was also listed as a challenge under working conditions, as it is an important clinical tool for the specialty. It could have also been listed under the emergency care category as lack of bedside ultrasound access can affect the overall care of patients.

The two most frequently mentioned challenges in EM education were the absence of residency programs outside of Quito and an increased desire for bedside teaching and supervision during training. A new EM residency is planned in Cuenca, which could help expand the national visibility of EM. Bedside teaching is limited by EM specialists being only available part of the day in some training hospitals. Increased EM specialist coverage, increased senior resident teaching, additional time in the simulation center, or telemedicine initiatives could be potential alternatives to increase supervision.

The most salient challenge in EM leadership was the lack of EM presence outside of Quito. EM specialists are gradually starting to work in other cities. Another EM leadership challenge mentioned was the need for a stronger EM national society. At the time of data collection, SEMED had a small membership and limited involvement and advocacy in EM issues. Active recruitment of EM specialists and EM residents, programming that appeals to EPs, and allowing full voting rights and involvement in leadership for new members could increase transparency and participation. A strong EM society can advocate for its members and provide guidance to hospitals, government officials, and other healthcare entities about issues affecting emergency care and EPs.[13] Another challenge in EM leadership was the lack of EM research. While all EM residents are required to complete a research project, the quality of the projects is variable. Few EP-led projects are published in international medical journals.

Potential reasons for low research output mentioned by interviewees included heavy clinical and teaching loads of academic faculty, limited funding opportunities, and lack of role models and experience in EM research locally.

The challenges most frequently mentioned in prehospital care were the lack of strong protocols for time-sensitive conditions, difficulties and delays in transfer to tertiary hospitals, and lack of EP involvement. Prehospital care in Ecuador would benefit from further involvement of EM specialists to improve coordination between the prehospital and ED settings and to implement systemwide protocols for time-sensitive conditions. Despite the many challenges identified by this study, EM continues to grow in Ecuador. Addressing the issues identified here could help expedite the growth of the specialty and improve emergency care for Ecuadorians.

Future Directions

After completion of this study, the authors, SEMED, and the American College of Emergency Physicians (ACEP) co-sponsored the First Forum About the Future of Emergency Medicine in Ecuador in September 2019, in Quito. The conference drew over 80 participants from around the country, including many EM residents. The goals of the forum were as follows: 1) share the results of this research project; 2) bring together Ecuadorian EM specialists to further discuss current challenges in EM and identify possible solutions; and 3) to expose Ecuadorian EM specialists to international EM leaders to promote the transnational flow of ideas. Speakers included Ecuadorian EPs and international EM experts. SEMED presented a reform plan that included the following: active recruitment of new members with full voting rights for EM specialists; free membership for EM residents; and formal collaborations with international EM organizations. SEMED also proposed the formation of task forces to address multiple issues, including education and government relations. At the time of submission of this publication, SEMED's membership had increased to more than 80.

LIMITATIONS

An important limitation of this study is the small sample size, which was due to time constraints. However, as seen in Table 4, many themes were mentioned by multiple participants. The small sample size limited the ability to conduct subgroup analyses by city or by specialty. Similarly, not all respondents were able to answer questions for all topics (eg, only EM specialists answered questions about EM training, EM working conditions, and EM leadership). Additionally, only challenges that were mentioned by three or more respondents were included to increase reliability, which may have resulted in the exclusion of important minority opinions. Our findings are likely most limited for the prehospital care themes given that our sample was largely composed of EM specialists who currently have little involvement in the prehospital system in Ecuador.

The referral chain-sampling method may have inserted bias. A survey of all EPs in Ecuador could have allowed for more robust statistical analysis; however, there is no central repository of contact information for all EM specialists in Ecuador. Furthermore, little information exists about EM as a specialty or its challenges in Ecuador, which made it difficult to develop a detailed survey. Instead, a semi-structured interview approach was pursued to permit follow-up questions that could result in a deeper understanding of themes and context.

Despite these limitations, this study provides important details about the history and current challenges of EM in Ecuador and has already initiated conversations and reform among local EPs. The issues identified may not apply to every hospital in Ecuador, and local context must be considered. Ultimately, Ecuadorian EPs are best positioned to address these challenges.

CONCLUSION

Emergency medicine has a three-decade history in Ecuador, reaching important milestones such as the establishment of two EM residencies and a national EM society. Challenges remain in medical care, working conditions, residency education, leadership, and prehospital care. Increased involvement of emergency physicians in administrative and leadership roles and stronger advocacy on both a local and national level will help strengthen the specialty and improve emergency care.

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Patients Presenting with Bull-related Injuries to a Southern Indian Emergency Department

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Introduction: Bull-related injuries are commonly observed in rural areas of India as result of the animal's use in sporting events as well as for agricultural purposes. These patients need early resuscitation due to complications from severe injuries. Previous work examining the epidemiology of bull-related injuries is limited, with most studies focusing on injuries in Spain and Latin America. There is scant literature examining the prevalence of such injuries in India. The objective of this study was to evaluate the demographic and clinical characteristics of bull-related injuries at a hospital in Tamil Nadu, India.

Methods: This was a prospective, observational study of patients who presented to an emergency department (ED) in Madurai, India, with a reported history of bull-related injuries between June 2017 and March 2019. We recorded information about patient demographics, location of injury, disposition, initial Injury Severity Score (ISS), and transport time.

Results: Our sample included a total of 42 patients. Almost a third of patients who presented were between the ages of 20-30 years (31%, n = 13), and most were male (86%, n = 36). Approximately 59% of patients (n = 25) had provoked injuries, occurring as a result of active participation during sporting activities. Injuries to the trunk were most common (55%, n = 23), followed by injuries to the perineum (19%, n = 19). The majority of patients (59.5%) had penetrating injuries (n = 25), The mean ISS was 10.1 (standard deviation 6.3). Five (12%) patients had a complication after injury including intra-abdominal abscess formation, peritonitis, and sepsis. Two patients died as a result of septicemia from peritonitis.

Conclusion: Bull-related injuries may result in significant morbidity and mortality. Education of the population about the dangers of bull injuries from sporting events and the need for early transportation to the ED have the potential for significant reduction in morbidity and mortality. [West J Emerg Med. 2020;21(6)291-294.]

BACKGROUND

Bull-related injuries are commonly seen in Tamil Nadu, India, due to the frequent use of bulls in daily agricultural activities as well as in sporting events. Jallikattu, a popular sport in Madurai, Tamil Nadu, is practiced during the Mattu Pongal celebration, which honors the role of cattle in

supporting the livelihood of Indian farmers. As part of this event, the bull is released into a confined area and participants alternate attempts to stop its movement by embracing its hump.[1] Most of these events occur in rural areas, where emergency care is scarce. When care is available there may be prolonged transport times to reach acute care services, leading to adverse medical outcomes.[2]

Injuries sustained from bulls are extensive and often result in prolonged hospitalization. Most bull injuries are penetrating, occurring as a result of direct goring from the horn.[2,3] Blunt injuries can occur as a result of the force sustained from impact with the ground after being thrown from the bull.[2,3] The size and contamination of bull horns complicate penetrating injuries due to a higher incidence of wound infection and delayed healing.[3]

The majority of studies published about the epidemiology of bull-related injuries are from Spain and Latin America, focusing on trauma resulting from bull fights.[3-8] While there have been some reports from India,[3,9,10] less is known about the initial presentation to the emergency department (ED). In particular, little is known about complicating factors such as transport time that may lead to delays in care. This is a challenge that makes the presentation of bull injuries unique to low-resource settings such as India, compared to that of areas such as Spain, where there may be better access to emergency care.[1] Because bull-related injuries involve the need for aggressive and early resuscitation in the ED, it is important to understand the mechanism and consequences of such injuries in order to provide timely management.

METHODS

We collected data prospectively from all patients who presented with bull-related injuries to a South Indian ED in Madurai, Tamil Nadu, between June 2017–March 2019. The ED is one of the largest in Tamil Nadu and has a residency training program along with surgical specialty services. Using the ED health chart, we recorded information about patient demographics, location of injury, disposition, initial Injury Severity Score (ISS) and transport time. We examined the association between disposition and ISS and transport time for all patients in our sample. We calculated the mean, standard deviation, and p values between groups by disposition using chi-squared analysis for discrete variables and t test for continuous variables with SDSS software, version 20.0. A p value < 0.05 was considered significant. The study was approved by our hospital's institutional review board.

RESULTS

During our study time period 42 patients presented to the ED with a bull-related injury. Patient demographics are shown in Figure. Almost a third of patients who presented were between the ages of 20-30 years (31%, n = 13), and most were male (86%, n = 36). Approximately 59% of our patients (n = 25) had provoked injuries, occurring as a result of active participation during Jallikattu sporting activities. The remaining cases were unprovoked, sustained either as spectators during a sporting event or through domestic work. The average time between injury and presentation to the ED (transport time) was 2.88 hours (standard deviation [SD] 2.9 hours).

Injuries to the trunk were most common (55%, n = 23), followed by injuries to the perineum (19%, n = 19). The majority of patients (59.5%) had penetrating injuries (n = 25), approximately 31% (n = 13) had blunt injuries, and almost 9.5% (n = 4) had both blunt and penetrating injuries (See Figure 1).

Table 1 shows the injury type and disposition of patients in our sample. Of patients with abdominal injuries, eight had solid organ injuries including one with a grade 2 splenic laceration, three with liver lacerations (grades 1, 3 and 5), and one with a grade 4 renal injury. Three had small bowel perforations. Of patients with trunk injuries, seven required chest tubes for pneumothorax or hemothorax. Eighteen patients had fractures involving the cervical spine (n = 3, 7.1%), ribs (n = 6, 14.2%), extremities (n = 4, 9.6%), and maxillofacial bones (n = 1, 2.4%). The most common procedures performed were laceration repair either under local (n = 7, 16.7%) or general anesthesia (n = 9, 21.4%), laparotomy (n = 7, 16.7%), and chest tube placement (n = 6, 14.2%). The mean transport time to the hospital was 2.88 hours (SD 2.9 hours). Thirty-two patients (76%) were admitted to the intensive care unit (ICU); all other patients were admitted to the ward. The mean ISS was 10.1 (SD 6.3) with a mean hospital length of stay of 6.55 days (SD 4.9 days).

Table 2 shows differences between patients admitted to the ICU and the ward. Patients who had a trunk injury were more likely to require an ICU admission than those who

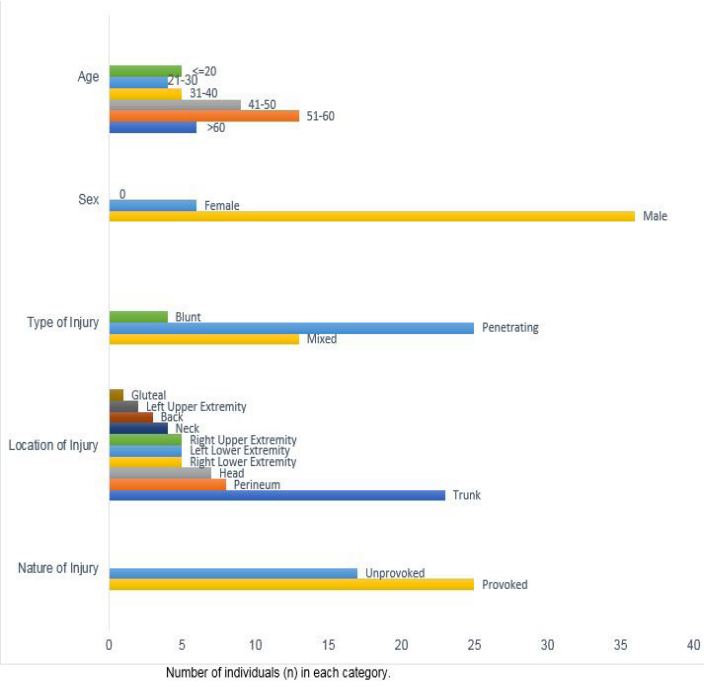

Figure 1. Sample demographics of patients presenting with bull-related injuries in the state of Tamil Nadu, India.

Table 1. Injury, procedures, and disposition (n = 42) in patients treated for bull-related injuries.

	n (%)
Injuries	
Contusion/abrasion	15 (35.7)
Laceration	
Superficial (< =1 cm)	5 (12.0)
Deep (>1 cm)	22 (52.4)
Closed head injury	2 (4.8)
Solid organ/bowel injury	
Liver laceration	3 (7.1)
Splenic laceration	1 (2.4)
Renal injury	1 (2.4)
Bowel perforation	3 (7.1)
Fractures	
Maxillofacial fracture	1 (2.4)
Extremity fractures	4 (9.6)
Spine fractures	3 (7.1)
Rib fracture	6 (14.2)
Clavicle	2 (4.8)
Procedures performed	
Conservative management	8 (19.2)
Laceration/wound closure local anesthesia	7 (16.7)
Kyphoplasty/cord decompression	2 (4.8)
Wound repair under general anesthesia/hematoma evacuation	9 (21.4)
Fracture reduction/fixation	4 (9.5)
Craniotomy	1 (2.4)
Laparotomy/peritoneal drain	7 (16.7)
Perineal wound exploration/repair general anesthesia	3 (7.1)
Chest tube	6 (14.2)
Wound debridement/closure	4 (9.5)
Disposition	
Admission to ICU	32 (76.2)
Admission to ward	10 (23.8)
Hospital length of stay (days)	6.55 (SD 4.9)
Mean Injury Severity Score	10.1 (SD 6.3)
Mean time between injury and ED presentation (transit time in hours)	2.88 (SD 2.9)

cm, centimeter; *ICU,* intensive care unit; *ED,* emergency department; *SD,* standard deviation.

Table 2. Relationship between characteristics of bull-related injury and disposition.

	Intensive Care Unit N = 32	Ward N = 10	P-value
Location of injury			
Trunk	21 (65.6%)	2 (20.0%)	0.01
Other	11 (34.4%)	8 (80.0%)	0.01
Transport time (hours)	3.02 hours (SD 3.1)	2.41 hours (SD 1.7)	0.56
Injury Severity Score	11.75 (SD 6.3)	4.8 (SD 1.8)	<0.001

SD, standard deviation.

sustained injuries to other locations of the body (65.5% vs 34.4%, p = 0.01). Patients with a higher ISS were more likely to require an ICU admission (mean ISS among ICU admitted patients was 11.75 vs 4.8 in ward patients [p<0.001]). Five (12%) patients had complications during their hospital stay including intra-abdominal abscess formation, peritonitis, and sepsis. Two (5%) patients died during hospitalization as a result of septicemia from peritonitis. The hospital course of all of the remaining patients in our sample was uneventful and no major complications were reported.

Patients who were admitted to the ICU had a longer mean transport time than those admitted to the ward, but this difference was not statistically significant. The mean transport time for patients who were admitted to the ICU was 3.02 hours (SD 3.1 hours) and that of patients admitted to the ward was 2.41 hours (SD 1.7 hours). The two patients who died had a much longer mean transport time (mean 14.2 hours, SD 0.2 hours) and a higher mean ISS (25, SD 0.1) as compared to survivors (mean transport time 2.3 hours, SD 1.4; and mean ISS 9.4, SD 4.4, p<0.001.)

DISCUSSION

Our sample shows similar patterns of injury as seen in other regions. Studies of injuries involving bulls for agricultural and sporting activities in the United States and India show the predominance of abdominal and perineal injuries.[8-11] In studies of professional bullfighters, injury patterns are somewhat different.[12] In a review of 68 cases of professional bullfighters in Mexico, upper and lower extremity injuries were most common (66%) followed by injuries of the perineum.[7] In a series from Spain and southern France, penetrating extremity injuries accounted for 75% of cases in 317 individuals.[5]

Patients who present to the ED with bull-related injuries are at significant risk for high morbidity and mortality. Although most patients in our sample survived their injuries, the two who died had a significantly longer mean transit time between the site of the occurrence of injury and the ED. In India, emergency medicine is still in its nascency and prehospital care services are limited, particularly in rural areas where bull-related injuries are most likely to occur.[8-11] This may have contributed to the long mean transport time observed in our sample.

Although bull-related injuries are a small proportion of all traumas in Southern India it is still a significant source of

morbidity. In one series from a Tamil Nadu ED, animal-related injuries accounted for less than 1% of traumas, compared to 65% from motor vehicle accidents (although that study did not specifically evaluate bull-related injuries).[13] More research is needed on a larger sample of patients to better understand the prevalence of bull-related injuries and to design strategies aimed at prevention and management of such injuries. This includes the training of specialists who treat these injuries as in Spain and Mexico.[7] In addition, while the Indian government has issued some regulations of the sport of Jallikattu, additional intervention may be needed to insure that safety measures are practiced.[1]

LIMITATIONS

There were a number of limitations to our study. This was a small sample at a single center in India. Results may not be generalizable to the rest of the population of India, particularly at hospitals that do not have emergency medical care. We did not have information on any interventions received prior to arriving to the ED or comorbid conditions that may have impacted outcomes. In addition, we did not follow patients for delayed adverse events that occurred after hospital discharge. We also did not have information about deaths occurring outside of the hospital setting or about patients who did not present to our ED; therefore, our results may have been skewed in favor of patients with greater or lower severity as compared to those who presented elsewhere or who did not present to any ED.

CONCLUSION

Despite the occurrence of bull-related injuries in India, there is little awareness about the dangers of using bulls for sport, offering opportunities for public health outreach about the prevention of such injuries and the need for early intervention. Because the sport of Jallikattu is an integral part of culture in Tamil Nadu, there are ample opportunities for community outreach in this population that have the potential for significant reduction in morbidity and mortality.

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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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This Article Corrects: "Identifying Patients at Greatest Risk of Mortality due to COVID-19: A New England Perspective"

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Identifying Patients at Greatest Risk of Mortality due to COVID-19: A New England Perspective
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Erratum in
West J Emerg Med. 2020 November;21(6):295. Author name misspellled. The third author, originally published as Danyal Ibhrahim, MD, MPH is revised to Danyal Ibrahim, MD, MPH.

Abstract

Introduction: Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has spread rapidly since December 2019, resulting in a pandemic that has, as of May 24, 2020, yielded over 5.3 million confirmed cases and over 340,000 deaths.[1] As businesses move to safely reopen and frontline healthcare workers (HCW) continue to face this crisis, it is essential that health officials know who in the population is at the greatest risk of mortality if hospitalized and, therefore, has the greatest need to protect themselves from being infected. We examined the factors that increase the risk of mortality among hospitalized COVID-19 patients.

Methods: This was a retrospective cohort study including confirmed COVID-19 patients admitted to the four Trinity Health of New England hospitals (THONE) in Connecticut and Massachusetts who either died or were discharged between March 1–April 22, 2020. Demographics, comorbidities, and outcomes of care were extracted from the electronic health record. A model of in-hospital mortality was made using a generalized linear model with binomial distribution and log link.

Results: The analysis included 346 patients: 229 discharged and 117 deceased. The likelihood of in-hospital mortality was increased for patients who were aged 60 or older (relative risk [RR] = 2.873; 95% confidence interval [CI], 1.733-4.764; p = <0.001), had diabetes (RR = 1.432; 95% CI,1.068-1.921; p = 0.016), or had chronic obstructive pulmonary disease (COPD) (RR = 1.410; 95% CI, 1.058-1.878; p = 0.019). Hyperlipidemia had a protective effect, reducing the likelihood of mortality (RR = 0.745; 95% CI, 0.568-0.975; p = 0.032). Sensitivity and specificity of the model were 51.4% and 88.4%, respectively.

Conclusions: Being age 60 or older or having a history of diabetes or COPD are the most useful risk factors associated with mortality in hospitalized COVID-19 patients. As states ease stay-at-home orders, risk factors of severe disease can be used to identify those more likely to have worse outcomes if infected and hospitalized and, therefore, who in particular should continue to follow public health guidelines for avoiding infection: stay home if possible; practice physical distancing; and wear a facemask.

PMCID: PMC7390549 [PubMed - indexed for MEDLINE]

Fall 2019 American College of Osteopathic Emergency Medicine (ACOEP) FOEM Competition Abstracts

The Foundation for Osteopathic Emergency Medicine (FOEM) promotes research and graduate medical education to advance the science of patient centric holistic emergency care consistent with the osteopathic philosophy. Each year the FOEM hosts a number of research competitions that are presented at the American College of Osteopathic Emergency Physicians (ACOEP) fall scientific assembly and spring seminar. The *Western Journal of Emergency Medicine* (*West*JEM) annually sponsors the research paper competition at the fall scientific assembly and is considered the premier research award at the competition. This *West*JEM issue highlights FOEM research presented at the 2019 ACOEP Fall Scientific Assembly.

John Ashurst, DO, MSc
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1 Examining Suicide Ideation and Opioid Use Disorder in Patients Presenting to the Emergency Department and Inpatient Settings

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Introduction: The rate of suicide has increased since 2005, while the mortality rates of other leading causes of death have declined. Suicide is an important factor in the mortality of opioid users. An association between the misuse of prescription opioids and suicidal ideation has emerged; however, research examining the relationship between opioid use disorders and suicide is limited, particularly in acute care settings. With improved screenings for suicidal ideation and risk of opioid use disorder, patients can be treated according to more accurate diagnoses, and the correlation between the two can be examined. The objectives of the study were to provide insight into the comorbidity of suicide risk and opioid use disorder and to identify the percentage of patients evaluated by mental health professionals during their emergency department (ED) or inpatient hospital visit.

Methods: Patients presenting to the ED and inpatient settings between February–June 2019 were screened with institutional review board approval for suicide risk and opioid use disorder using semi-structured interviews and a prospective chart review. The opioid use cohort (OUC) was comprised of patients with a chief complaint specific to opioids, including current intravenous drug use, opioid-related medical complaints (abscess, cellulitis, flu-like symptoms), and overdose. The suicide risk cohort (SRC) were patients who screened positive for suicide risk without a chief complaint specific to opioids. Sample size for specific measures was limited by patient compliance in structured interviews. We conducted Pearson's chi-square and Fisher's exact tests to analyze data from the interviews and chart reviews.

Results: We enrolled 78 patients in the study (30 OUC, 48 SRC). History of at least one opioid-related overdose was seen in 69% (n = 20/29; 95% confidence interval [Cl], 52.1%-85.8%) of the OUC, compared to 21% (n = 9/43; 95% Cl, 8.8%-33.1%) of the SRC ($p<0.0001$). At the time of overdose, 21% (n = 4/19; 95% Cl, 2.7%-39.4%) of opioid use patients reported they wanted to die, while 78% (n = 7/9; 95% Cl, 50.6%-100%) of suicide risk patients wanted to die ($p<0.01$). Patients in the SRC reported using opioids 37% (n = 7/19; 95% Cl, 15.2%-58.5%) of the time in an attempted suicide. At time of enrollment in the OUC, 53% (n = 16/30; 95% Cl, 35.5%-71.2%) of patients reported feeling down, depressed, or hopeless in the prior two weeks; 33% (n = 10/30; 95% Cl, 16.5%-50.2%) reported thoughts of killing themselves in the prior two weeks; and, 30% (n = 9/30; 95%Cl, 13.6%-46.4%) reported a suicide attempt within the previous six months. Patients in the SRC reported using drugs other than those required for medical reasons 54% (n = 25/46; 95% Cl, 40-68.7%) of the time. Evaluation by a mental health professional during visits to the ED or inpatient admission was completed for 94% (n = 45/48) of patients in the SRC and 93% percent (n = 28/30) of patients in the OUC.

Conclusion: A significant percent of patients in the present study are comorbid for suicide risk factors and opioid use disorder. An area for improvement is for mental health professionals to evaluate all patients positive for suicide risk or opioid use disorder during their hospital visit.

2 Emergency Department Utilization by Children of Somali Immigrants in Lewiston, Maine

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Introduction: Lewiston, Maine, a city of 36,000, is home to approximately 6000 immigrants, with the vast majority being of Somali origin. In some regions of the US, it is believed that immigrant populations use and/ or require emergency department (ED) services more frequently than other groups for various reasons. This study aimed to determine whether there were differences in the number of visits and visit acuity to the ED between children of Somali immigrants (COI) and children of non-immigrants.

Methods: We reviewed the charts of patients at the Pediatric

Associates of Lewiston from May 2018–June 2018. Patients in the electronic health record system were categorized as COI if their chart indicated that their parents spoke Somali. Patients whose parents spoke only English (as indicated in their chart) were classified as non-immigrants and served as the comparison cohort. Patients whose charts listed an ED visit between 2006–2018 were included in the study. Data (including immigrant status, gender, age, ED visit year, type of ED visit, and number of ED visits per patient) was recorded. We used five categories to classify the type of ED visit: 1) non-urgent; 2) urgent, unexpected injuries/accidents; 3) urgent due to acute disease process; 4) follow-up or complication of a chronic condition; and 5) non-medical emergency. We analyzed data using an independent samples t-test, non-equal variance (Welch) to determine which group had more visits and chi-square analysis to determine which cohort was more likely to use the ED for non-urgent issues.

Results: We analyzed the charts of 401 COI and 77 children of non-immigrants. It was found that patients classified as non-immigrant had a significantly higher number of visits per patient ($M = 4.0$, standard deviation [SD] 2.8) than COI ($M = 2.3$, SD 2.3) ($p < 0.001$). Chi-square analysis found no significant differences between COI and non-immigrant patients in their use of the ED for any reason, including non-urgent visits ($p = 0.47$).

Conclusion: It was found that children of non-immigrants had a higher mean number of ED visits per patient than the cohort of children of Somali immigrants. This does not support the belief that immigrant communities use ED services more than non-immigrants within the context of the Somali immigrant population of Lewiston, Maine. There was no difference between the two cohorts with respect to type of ED visit according to the categories of urgency as defined for the study. Further research should examine ED use in adult populations, additional geographic areas throughout the state of Maine, and different immigrant populations.

3 Emergency Department "Bounce-back" Rates as a Function of Emergency Medicine Training Year

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Introduction: Since the 1990s, the emergency department (ED) unscheduled return visit, or "bounce-back," has been used as a quality of care measurement. During that time, resident training was also scrutinized and the scrutiny uncovered a need for closer resident supervision, especially of second-year residents. Over the years, bounce-backs have continued to be analyzed with vigor, but research on residency training and supervision has lagged with few studies concurrently investigating residency supervision and bounce-backs. Other literature on resident supervision suggests that with adequate attending supervision, resident performance is equivalent to attending performance. With that in mind, it was hypothesized that resident bounce-back rates would be equivalent to attending bounce-back rates, and there would be no change among residency years. The primary objective of this study was to determine the rate at which patients are seen as a bounce-back visit within 72 hours of their initial visit to a community hospital ED during the study time frame. The secondary aims were to evaluate whether ED bounce-back rate was impacted by training level (residents or attending) and to describe bounce-back patient characteristics, including primary complaint/disease, age, comorbidities, and issues with compliance.

Methods: We conducted a retrospective chart review of 1000 charts from September 2015- September 2017. Charts were randomly selected by the OhioHealth Quality & Patient Safety team and, after inclusion/exclusion criteria, 732 charts were analyzed. Inclusion criteria included age ≥ 18 years, patients treated by an emergency medicine (EM) resident during their initial visit and patients with a "discharge" disposition. Exclusion criteria included patients seen as a scheduled return visit (eg, two-day return for blood pregnancy recheck, wound check, etc.). We collected demographics, initial visit variables, comorbidities and bounce-back data based on electronic record query or chart review. Data was analyzed using means, standard deviations, medians, and ranges for continuous variables. We used logistic regression modeling techniques to examine factors that affected whether the patient had a bounce-back visit.

Results: The rate of unscheduled return visits within 72 hours their initial visit was 4.65%. Postgraduate year (PGY) -1 and -2 residents' bounce-back rate was 3.8% and 3.6%, respectively, and PGY-3 and -4s' bounce-back rate was 5.7% and 5.6%, respectively (p-value = .63). There was no statistically significant change among residency years. Most bounce-back characteristics analyzed, including primary complaint, age, and comorbidities, demonstrated no statistical significance in increased rate of bounce-back except for patients with history of tobacco use, alcohol use, and chronic pain. Current smokers were 6.5 times more likely to bounce back than former smokers (odds ratio [OR] 6.485, 95% confidence interval [CI], 2.089 to 20.133, p-value = 0.0012); and those with chronic pain were 2.5 times more likely to bounce back than those without chronic pain (OR 2.518, 95% CI,1.029 to 6.164, p = 0.0431).

Conclusion: EM residency training year does not increase the frequency of bounce-backs in a community hospital ED. Patients with substance abuse disorders and chronic pain were more likely to bounce back.

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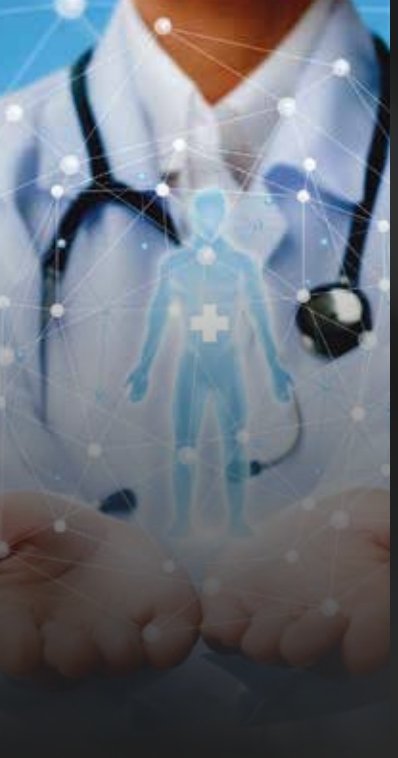

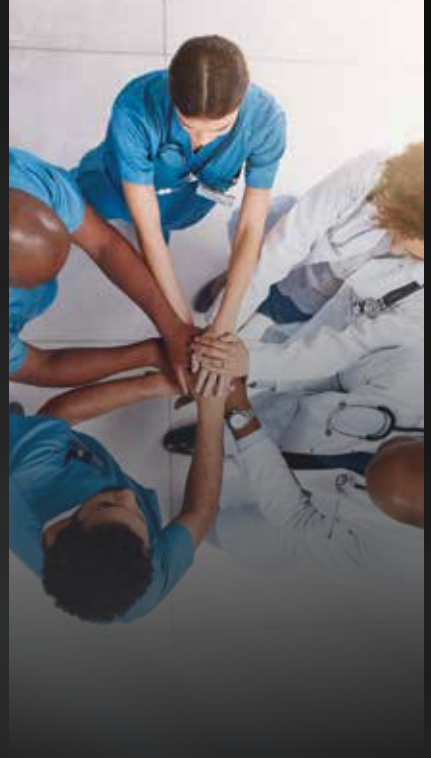


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