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Geospatial impacts on melanoma stage at initial diagnosis: a systematic review

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Abstract

Melanoma, an invasive and potentially fatal form of skin cancer, is projected to comprise 5% of new cancer cases and 1.4% of cancer-related deaths in 2024 alone.¹ Survival rates are closely linked to the stage at detection, with thicker tumors at initial diagnosis associated with reduced overall survival rate.^{2,3} Increased distance to healthcare providers creates barriers to early detection; disparities in sun exposure and healthcare access between rural and urban populations underscore the need for targeted interventions.

This review explores the relationship between rurality and distance to providers with melanoma staging at detection. A search was conducted of the PubMed and Embase databases, following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.⁴ The included studies examined melanoma staging and Breslow thickness in rural versus urban areas and the impact of distance to healthcare providers. Greater distance to healthcare providers was associated with more advanced tumor stages at diagnosis, while rurality status had largely insignificant effects. This review investigates the impact of rurality status and distance to a healthcare provider on melanoma detection. Ensuring equitable access is crucial for better melanoma management across different regions.

Introduction

Melanoma is a highly invasive and potentially lethal form of skin cancer, projected to account for 5% and 1.4% of all newly reported cancer cases and related deaths in 2024, respectively.¹ The prognosis of melanoma is largely dependent on the stage of discovery. As Breslow thickness increases, the overall survival rate decreases. Localized cases have a 5-year survival rate of 99%, whereas in cases with distant metastases that rate drops to merely 25%.^{2,3} Therefore, it is important to develop early detection strategies tailored to specific patient demographics to ensure accessibility to care for all at-risk populations.

Disparities in sun exposure and access to healthcare between rural and urban populations indicate the need for targeted interventions strategies.⁴ Individuals in rural areas tend to have higher levels of sun exposure owing to outdoor occupations and limited access to shaded areas compared to their urban counterparts.⁵ This heightened exposure increases the risk of melanoma and other forms of skin cancer in rural populations.⁶ Moreover, limited access to dermatological care in rural areas exacerbates barriers to a timely diagnosis and treatment of melanoma.^{7,8} Initiatives focused on raising awareness of sun exposure and enhancing access to dermatological care can be tailored to include individual-focused strategies targeting specific subpopulations, particularly those facing geographic barriers, to effectively mitigate the burden of melanoma.⁴

This review investigates a critical gap in understanding the impacts of geographic factors on melanoma staging at initial diagnosis. There is a necessity to identify barriers to early detection and treatment in rural commu-

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nities to inform healthcare policies and interventions aimed at reducing health disparities and improving outcomes for at-risk individuals.⁹ The overarching objective of this review is to contribute insight on how geospatial factors influence melanoma detection in rural versus urban populations, as well as in those living at increased distances from healthcare providers.

Methods

This systematic review was completed by following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.¹⁰ The PubMed and Embase databases were searched to identify studies comparing melanoma staging in rural versus urban areas, as well as those examining melanoma stage in relation to distance to healthcare providers. Inclusion criteria consisted of original research articles written in English, while excluding previous literature reviews, systematic reviews, meta-analyses, letters to the editor, commentaries, abstracts, and studies not addressing rurality or distance to providers. Keywords such as *rural*, *melanoma*, *skin cancer*, *dermatology*, and *distance* were employed for search optimization. Initially, 1,722 articles were found, and a reference manager program called Rayyan was used to identify and remove duplicate articles.¹¹ After the first round of screening, 1,314 articles were screened by two independent authors based on abstract and title, resulting in 42 articles for full-text evaluations. A final screening review included two independent authors' assessments, ultimately resulting in 13 articles for inclusion ([Figure 1](#)). There was over 90% interrater agreement on the initial screening; agreement conflicts were resolved through discussion and rereview of full-text articles. Quality was assessed by using the National Institutes of Health Study Quality Assessment Tools.¹² The authors individually extracted the data using Google Sheets, including information such as article title, authors' names, publication year, international publication status, sample size, staging and thickness of melanoma categorized by distance or rural versus urban, percentage of study participants with advanced stage, and any other staging differences, if applicable.

Results

Included studies

After three rounds of title, abstract, and full text reviews, 13 studies met the inclusion criteria outlined in the methods. The included studies are relatively recent, from 2000 to 2021, contributing to their relevance.

Quality assessment

The methodological quality of studies meeting the inclusion criteria was assessed by three investigators using the National Institutes of Health Study Quality Assessment Tools resource.¹² This resource provides assess-

ment tools grouped by study type and allowed investigators to produce ratings of good, fair, and poor for each paper based on outlined guidelines ([Table 1,2](#)). Interrater agreement was confirmed.

Owing to variation in study designs and statistical heterogeneity, meta-analytic pooling was deemed inappropriate. Therefore, data was detailed descriptively and qualitatively.

Study design of included articles

Six cross sectional and 7 retrospective cohort studies were included. Six studies were international whereas 7 were based in the United States. The international studies were conducted in Italy, Australia, Ireland, Scotland, France, and Canada. In terms of breadth of the studies, one was conducted countrywide, 6 were conducted state-wide, three were conducted region-wide, and three were conducted hospital-wide. Most studies used population-based cancer registry data whereas hospital wide studies used electronic health records. Sample sizes ranged from 30 to 37,234 individuals diagnosed with melanoma. In most of these studies, all patients diagnosed with melanoma within the specified region were analyzed. Bowles et al only included invasive melanoma.¹⁸ Murchie et al analyzed a subset of all the eligible patients.¹⁶

Five studies examined the relationship between rurality and Breslow thickness of patients diagnosed with melanoma.^{13,15-17,19} Four studies assessed the relationship between rurality and staging at diagnosis in terms of percentage of melanoma patient population.^{14,18,20, 21} Four studies examined the relationship between distance to provider and Breslow thickness.²²⁻²⁵ [Table 1](#) and [Table 2](#) present the summarized results found from each study.

Impact of rurality on Breslow thickness or clinical stage of melanoma at diagnosis

Two studies examining the relationship between rurality and Breslow depth found a statistical difference in melanoma thickness in patients living in rural areas as compared to urban areas ([Figure 2](#)). In a retrospective cohort study investigating tumor thickness among central city and rural hospitals from 1998 to 2012 in South Tyrol, Ambrosini-Spaltro et al determined that urban patients had a median Breslow thickness of 1.59mm, while rural residents had a median thickness of 1.22mm ($P=0.004$).¹³ Moreover, a population-based study examining regional clinical and pathological differences in melanomas found a higher proportion of melanomas >2mm (37.3% versus 27.1%, $P=0.02$) and melanomas classified as stage II (43.9% versus 30.2%, $P=0.004$) in Ardennes département, a predominantly rural region with a low geographic density of dermatologists, compared to urban areas.¹⁷

A total of three studies found no significant connection between rurality and Breslow thickness ([Figure 2](#)). Mannschreck et al conducted a cross-sectional study on

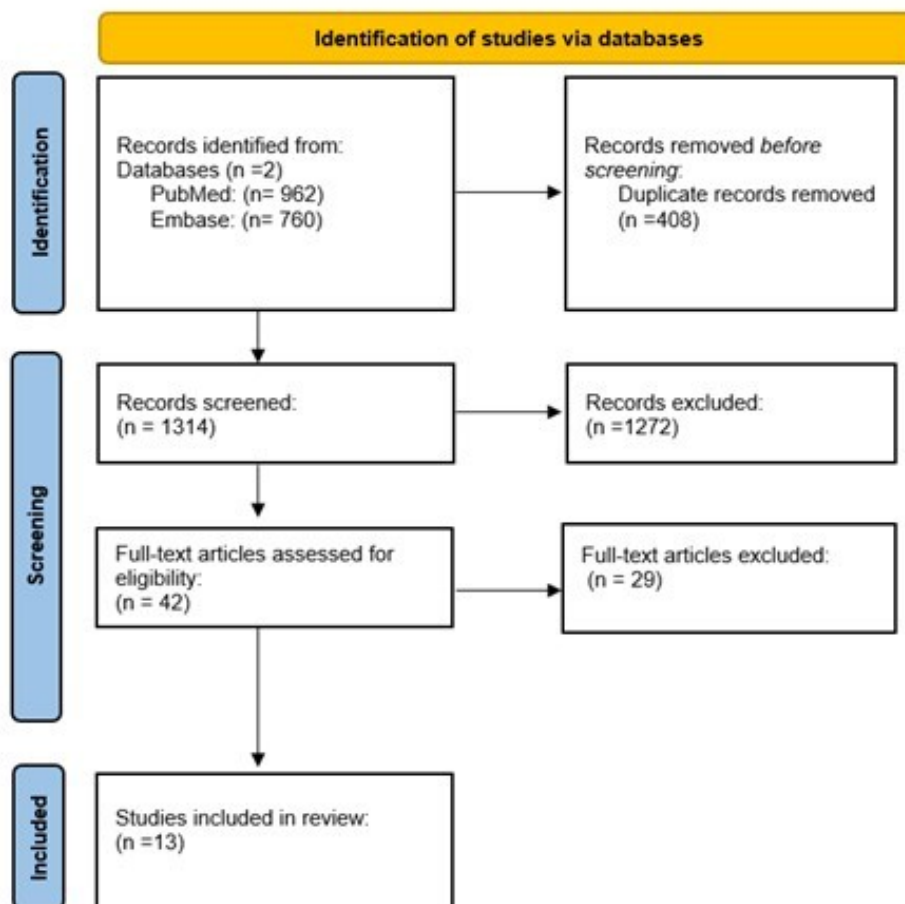


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram for this systematic review which included searches of databases only.¹⁰

the prevalence and severity of melanoma among 31,750 patients treated by the Johns Hopkins Department of Dermatology from January 2016 to June 2017. They found that despite traveling much greater distances to receive care (101.8 miles versus 17.7 miles, $P>0.001$), rural patients did not present with more advanced disease than their urban counterparts ($P=0.2566$).¹⁵ Murchie et al performed a population-based cohort study of every individual in Scotland who received a pathological diagnosis of cutaneous invasive melanoma from January 2005 to December 2013 ($n= 9519$). They found a median Breslow thickness of 0.9mm for rural regions and 1.0mm for rural regions ($P=0.390$).¹⁶ Using data from the population-based Queensland Cancer Registry from 1996 to 2001, Coory et al found that 5.3% of rural patients were diagnosed with melanomas >4.0 mm compared to 3.6% of urban patients ($P=0.107$).¹⁹

Among studies examining clinical staging and rurality, a total of one study found a statistically significant correlation, whereas three did not. Xue et al conducted a retrospective review of 347 patients diagnosed with melanoma at Indiana University between January 2017 and September 2022. They found that rural residents presented with more stage T3 melanomas (15.0% versus 3.5%, $P<0.001$) in contrast to their urban counterparts.¹⁴

Mavor et al conducted a retrospective population-based cohort study using data from patients' diagnoses in the Ontario healthcare system from 2007 to 2012 and found no significant differences in relative risk of advanced melanoma between urban and rural areas ($P=0.6$).²⁰ In a state-wide cohort study conducted by Bowles et al examining the incidence of melanoma in Utah from 2005 to 2013, it was found that melanoma stage at diagnosis did not differ between rural and urban patients ($P=0.71$).¹⁸ Van Durme et al did a cross-sectional study to examine the sociodemographic characteristics that could be potential predictors of late-stage melanoma diagnosis. They found that the odds of having a late-stage diagnosis and living in an urban residence were 0.93 the odds of that living in a rural residence, but findings were not significant ($P=0.63$).²¹ [Figure 3](#) includes studies assessing the difference of melanoma stage and demonstrates the percentage of patients diagnosed at each stage.

Impact of distance to provider on Breslow thickness or stage at melanoma diagnosis

Three studies examining the relationship between distance to provider and Breslow thickness or tumor stage found a significant association between increased dis-

Table 1. Included Papers Comparing Breslow Thickness and/or Staging between Rural versus Urban Areas with Corresponding Quality Rating and Summarized Results

Article Title	Author, Year	Study Type	Sample Size [n]	Study Location	Rating	Results
Melanoma Breslow tumor thickness development in South Tyrol: 1998-2012	Ambrosini-Spaltro et al, 2014 ¹³	Cross-sectional	2,447	South Tyrol	Good	Mean Breslow thickness of 1.22mm in rural areas and 1.59mm in urban areas (P=0.004)
The influence of rurality on melanoma diagnosis in Indiana: A retrospective cohort study	Xue GR et al, 2024 ¹⁴	Cohort	347	United States	Good	There were more stage T3 melanomas in rural versus urban areas (15.0% versus 3.5%, P<0.001). Rural area patients had fewer stage I melanomas (80.8% versus 89.3%) and more stage II melanomas (19.2% versus 8.1%), and no stage III melanomas, compared to urban area patients (P=0.028). There were no statistically significant differences found in Breslow thickness, Clark level, or tumor diameter.
Rural melanoma patients in Maryland do not present with more advanced disease than urban patients	Mannschreck DB et al, 2021 ¹⁵	Cross-sectional	37,234	United States	Good	Mean Breslow thickness of 0.953mm in rural areas and 1.652mm in urban areas (P=0.256). There were no significant differences in Breslow depth or clinical stage. Urban patients had Breslow depths 1.54 times greater than rural patients, although not statistically significant (P=0.16). Urban patients had 6.39 times greater odds of having a clinical stage ≥ 2 , although not statistically significant (P=0.08).
Impact of rurality on processes and outcomes in melanoma care: Results from a whole-Scotland melanoma cohort in primary and secondary care	Murchie P et al, 2018 ¹⁶	Cohort	9,519	Scotland	Good	Median Breslow thickness of 0.9mm for rural regions, and 1.0mm for remote small-town areas (P=0.390).

Article Title	Author, Year	Study Type	Sample Size [n]	Study Location	Rating	Results
Clinical and pathological characteristics of melanoma: A population-based study in a French regional population	Barbe C et al, 2012 ¹⁷	Cross-sectional	832	France	Fair	Mean Breslow thickness of 2.02mm in rural areas and 1.59mm in urban areas. A proportion of thick melanomas (Breslow thickness >2mm) was higher in the Ardennes département, a more rural area, compared to other areas (37.3% versus 27.1%, P=0.02)
Impact of rurality on melanoma diagnosis in Utah	Bowles TL et al, 2021 ¹⁸	Cohort	5,199	United States	Good	Clinical stage did not differ between rural and urban area patients (P=0.71).
Urban-rural differences in survival from cutaneous melanoma in Queensland	Coory M et al, 2006 ¹⁹	Cohort	12,827	United States	Good	5.3% of rural patients were diagnosed with melanomas >4.0mm compared to 3.6% of urban patients (P=0.107).
Disparities in diagnosis of advanced melanoma: A population-based cohort study	Mavor ME et al, 2018 ²⁰	Cohort	8,042	Canada	Good	No significant differences (P=0.6) in relative risk of advanced melanoma between urban and rural areas (RR 1.02, CI 0.91-1.16)
Demographic predictors of melanoma stage at diagnosis	Van Durme DJ et al, 2000 ²¹	Cross-sectional	1,884	United States	Fair	The odds of having a late-stage diagnosis and living in an urban residence was 0.93 the odds of that living in a rural residence, (P=0.6).

tance and more advanced tumor staging.²³⁻²⁵ These studies occurred in North America and utilized databases for melanoma patient information. Pitre et al, a study utilizing linked administrative databases from Ontario, Canada to identify a population-based cohort of melanoma patients, determined that distance from a cancer center was a significant prognostic factor for stage at diagnosis in the multivariable mode. This study found that 18.6% of patients living >50km from a cancer center were stage III or IV compared to 21.5% of patients living <10km away (P=0.01).²³ Synder et al using University of Colorado's outpatient dermatology clinic and its melanoma data bank demonstrated that patients traveling ≥50 miles had 58% greater odds of having an increased Breslow depth than those traveling less than 50 miles (P=<0.0001).²⁴ Stitzenberg et al published a study based on the North Carolina Central Cancer Registry, including 42 counties, found that for each additional mile the patient lived from the facility, Breslow thickness increased by 0.6% (P =.003).²⁵

Outside of those three studies, McCarthy et al found similar results in a low-access community hospital in Ireland where there is an average distance of 114.8km traveled by patients. Approximately 80% of invasive melanomas had a depth of 1.5mm or greater, compared to the national average of 33%.²² Furthermore, 45% of the hospital's patients had tumor depths greater than 4mm, compared to the national average of 12.9%.²³ However, this study did not test for statistical significance.

Discussion

Despite the inconclusive results regarding rurality, the clear correlation between increased distance and advanced melanoma staging suggests that proximity to healthcare facilities is a key determinant in patient outcomes. This review demonstrates that distance to a healthcare provider plays a more influential role than rurality in determining Breslow thickness and subsequent

Table 2. *Included Papers Examining Distance to Provider and Melanoma Stage at Diagnosis*

Article Title	Author, Year	Study Type	Sample Size [n]	Study Location	Rating	Results
Distance as a barrier to melanoma care	McCarthy S et al, 2019 ²²	Cross-sectional	30	United Kingdom	Fair	45% of rural patients presented with a depth greater than 4mm compared to the national average of 12.9% and the average for non-rural residents of 13%. Significance was not evaluated.
Is access to care associated with stage at presentation and survival for melanoma patients?	Pitre LD et al, 2019 ²³	Cohort	18,776	Canada	Good	No significant relationship between staging and rurality (P=0.19), RIO score (P=0.73), or distance to family physician (P=0.098) were observed. 18.6% of patients living >50km from a cancer center were stage III or IV compared to 21.5% of patients living <10km away (P=0.01).
Greater distance to an academic medical center is associated with poorer melanoma prognostic factors: The University of Colorado Experience	Snyder BM et al, 2017 ²⁴	Cohort	1,156	United States	Good	Subjects traveling ≥50 miles had 58% greater odds of having an increased Breslow depth than those traveling less than that distance (OR: 1.58; 95% CI: 1.24-2.01; P<0.0001) and had four times the odds of presenting with metastatic disease (OR: 4.04; 95% CI: 3.00-5.46; P=<0.0001).
Distance to diagnosing provider as a measure of access for patients with melanoma	Stitzenberg KB et al, 2007 ²⁵	Cross-sectional	615	United States	Good	For each 1-mile increase in distance to diagnosing provider, Breslow thickness increased by 0.6% (P=0.003).

tumor stage at initial melanoma diagnosis. Decreased distance to a provider can help facilitate earlier detection and appropriate management.

The limited number of studies examining the impact of provider distance can impact the generalizability of these findings. For example, the small sample size and the restricted geographical representation may introduce biases, potentially affecting these conclusions and one must note that some of the results were conflicting. Selective publication of manuscripts based on the significance and direction of study results could impact the interpretation of the results found in this review. Despite implementing quality assessment measures and a comprehensive literature search to mitigate publication bias, it remains a concern. Additionally, the mixed and statistically insignificant results regarding the impact of rurality

on melanoma staging suggest an unclear relationship between rural living and melanoma severity at diagnosis.

The inconsistency between rural living and melanoma emphasizes the necessity for additional research to better understand the determinants of distance to diagnosing providers and other barriers to melanoma diagnosis. Future research should aim to address the limitations of sample representation and potential biases, further clarifying the relationship between rurality, healthcare access, and melanoma detection.

By prioritizing equitable healthcare distribution, it is possible to mitigate the disparities in melanoma outcomes and ensure timely diagnosis and effective treatment for all populations. To address these disparities, a multifaceted approach is essential. Expanding telemedicine services, enhancing outreach efforts, providing sun

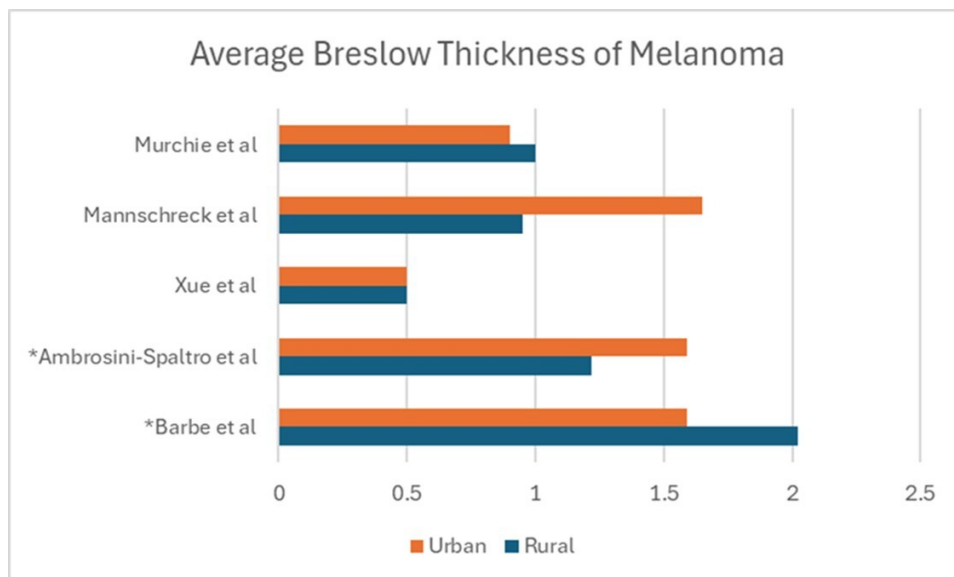


Figure 2. Average Breslow thickness of melanoma between urban and rural areas. Studies marked with an asterisk found a significant difference between groups.

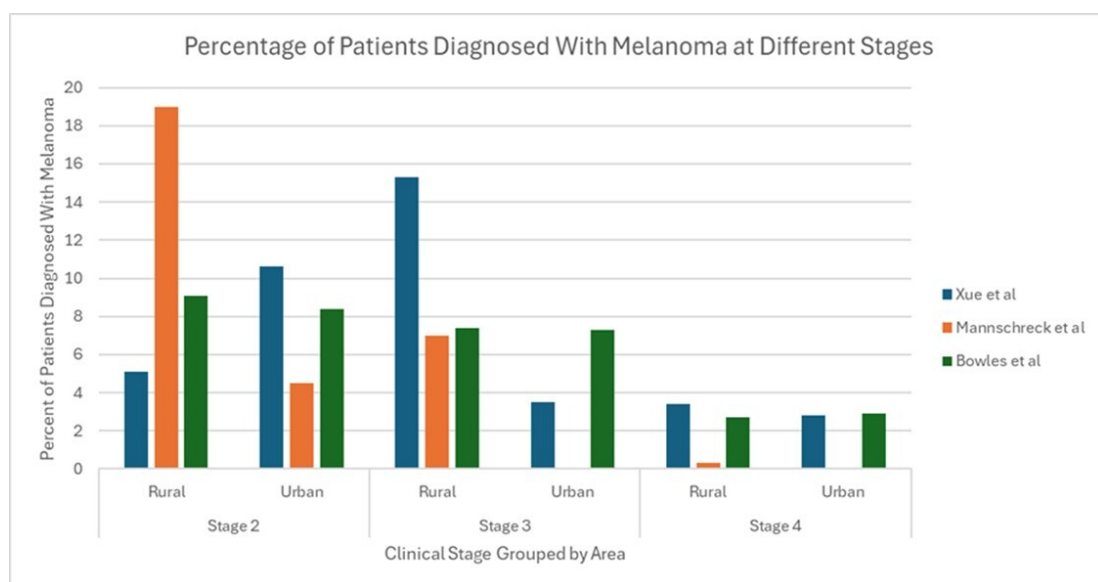


Figure 3. Percentage of patients diagnosed with melanoma at different stages grouped by rural and urban areas. The other four studies referenced in this section did not present data as percentages, therefore they are not included in this figure.

exposure education, and improving primary care provider follow-up in areas lacking dermatologists could significantly impact early melanoma detection and treatment. Additionally, increasing the number of dermatology residency programs or expanding the number of positions offered at current programs, as well as providing incentives for dermatologists to work in rural areas could help decrease travel distances for patients and reduce barriers to care. Overall, this review emphasizes the urgent need for targeted interventions and policies to ensure that all populations, irrespective of location, have access to timely and effective melanoma care.

Conclusion

Rurality has little effect on staging or Breslow thickness, whereas distance from provider correlates with increased staging and thickness. Proximity to a healthcare provider is a key determinant in melanoma thickness at initial diagnosis. Future intervention strategies should focus on prioritizing equitable healthcare distribution to address the disparities faced by those who live farther away from providers.

Potential conflicts of interest

The authors declare no conflicts of interest.

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