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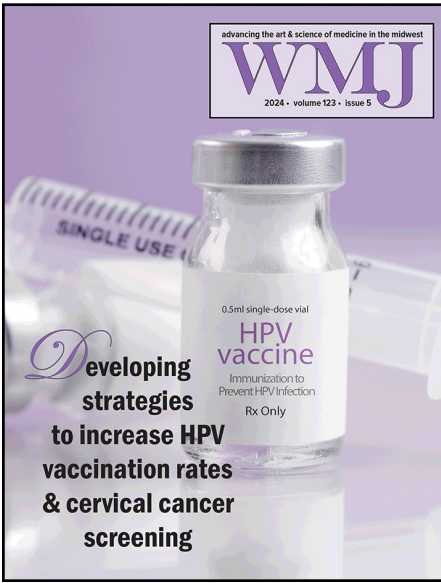
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**COVER THEME**

**Developing Strategies to Increase HPV Vaccination Rates and Cervical Cancer Screening**

*Human papillomavirus (HPV) infection poses significant public health concerns due to its prevalence and association with various cancers, including cervical cancer. In this issue of WMJ, researchers explore an intervention to improve HPV vaccination rates across various age groups and another to increase cervical cancer screening through a community-academic partnership.*

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The mission of WMJ is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues. WMJ is published through a partnership between the Medical College of Wisconsin and the University of Wisconsin School of Medicine and Public Health.

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## Olive Oil Consumption and Risk of Neurodegenerative Disease-Dementia

Dear Editor:

Dementia is a neurodegenerative ailment that impairs the proper functioning of neurons, resulting in memory and cognitive impairment and eventual inability to perform basic tasks.<sup>1</sup> It typically presents later in life and is the sixth leading cause of death in the United States. Notably, deaths from heart disease and prostate cancer have decreased over the past 2 decades, while deaths from Alzheimer's disease have increased.<sup>2</sup>

The Mediterranean diet has gained popularity due to its beneficial effects on cardiovascular health, particularly in reducing the risk of heart disease.<sup>3</sup> Olive oil, a key component of the Mediterranean diet, contains anti-inflammatory properties due to its high content of monounsaturated fatty acids, vitamin E, and polyphenols.<sup>4</sup> This suggests that olive oil has a positive effect on heart health. However, the relationship between olive oil consumption and cognitive health has only recently been studied by Tessier et al.<sup>5</sup>

This recent longitudinal study was undertaken to assess the correlation between olive oil consumption and the likelihood of succumbing to dementia. Spanning 28 years, the study enrolled 92 383 adults. During the course of the investigation, 47 510 deaths were documented, of which 4751 were attributed to dementia. The findings revealed that individuals who consumed at least 7 grams of olive oil per day exhibited a 28% lower risk of dying from dementia. Furthermore, replacing margarine and mayonnaise with an equivalent amount of olive oil was associated with an 8% to 14% lower risk of dementia-related deaths. However, there was no significant relationship observed when olive oil was substituted with butter or vegetable oil.<sup>5</sup> In a nutshell, olive oil can lessen the chances of dementia and has fewer adverse effects on cognitive health relative to substitutes.

These results align with dietary recommendations for maintaining cognitive health, as olive oil is beneficial not only for cardiovascular health but also for reducing the risk of dementia.

—Muhammad Ali, MBBS; Zain Afridi, MBBS

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## Perception and Experience of PA Students and Clinical Rotations

Dear Editor:

With an increase in physician assistant (PA) programs, demand for clinical rotations is increasing.<sup>1</sup> Clinicians are hesitant to precept students due to perceptions of decreased productivity and financial burden.<sup>2</sup> A study of PA program probation revealed 4 of the 7 most common violations were related to supervised clinical practice experience.<sup>3</sup> With expanding PA involvement in the growing hospitalist specialty, our goal is to prepare students for clinical work and for the Physician Assistant National Certifying Examination (PANCE).<sup>4</sup> To achieve an innovative, structured clinical rotation in the Section of Hospital Medicine at the Medical College of Wisconsin, each of our advanced practice providers implemented a daily lecture on various medicine topics. The PA students were provided a list of expectations, a “how-to guide,” and a documentation cheat sheet. Students are actively involved in seeing patients, writing notes, calling consults, and communicating with members of the health care team.

From June 2023 through May 2024, we surveyed 19 PA students before and after their internal medicine rotation using a Qualtrics survey. We received 19 pre-rotation and 17 post-rotation surveys. Per the pre-rotation survey, 74% had not participated in daily lectures at their clinical rotations, and 89% responded that they had received a document with rotation expectations. The post-rotation survey indicated that 1 student attended 0 to 5 lectures, 3 students attended 5 to 10 lectures, 7 students attended 10 to 15 lectures, and 6 students attended over 15 lectures. Of the respondents, 88% strongly agreed the lecture series prepared them for their end-of-rotation exam, and 100% said they felt prepared to apply the knowledge they learned from the lectures clinically. When asked to rate the lectures on a scale of 1 to 5, with 5 being the greatest, 76% rated the lectures a 5, and 24% rated them a 4. When asked if the rotation met expectations, 88% of respondents replied “strongly agree,” 12% replied “agree,” and 100% said they would recommend this rotation to others.

The survey results indicate PA students perceive benefits of a structured rotation. The daily lecture series helped prepare them for end-of-rotation exams and apply knowledge clinically. Passing the internal medicine exam is a strong indicator that the student will pass the PANCE.<sup>5</sup> As PA training programs expand, there is a need for similar initiatives and to retain students for clinical work within the organization. We can decrease the gap between increasing students and demand for preceptors by leveraging our existing PAs and developing and implementing structured clinical rotations to prepare our future workforce.

—Andrea Bequest, PA-C; Pinky Jha, MD, MPH; Paige Gioia, PA-C

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# Diary of an Orphaned Resident

Fallon Peplinski, DO

On what began as a random Monday in January, our worlds were thrown into chaos. Resident physicians, often buried under an ever-expanding mountain of tasks, rarely hop on the regularly occurring “all-staff” virtual meetings during the lunch hour, but something was different that day. I was in clinic, every appointment slot full, and I was on a roll. My notes from the morning were completed before lunch—an uncommon accomplishment—so I decided to join the virtual meeting to see what updates were coming to our organization. Unexpectedly, we learned our clinic (along with many others) and the main hospitals at which we rotate were closing. In one fell swoop, myriad emotions erupted—none of them good. Our knee-jerk concern was for the patients who desperately need medical homes and access to the services that would no longer be provided. The remaining hospitals in the community cannot possibly handle their current patient load AND ours.

*What will happen to them?* Then settled the sinking panic in the pits of our stomachs as we realized that as residents, we were soon to be without a program.

• • •

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*What will happen to us?* Family medicine fills my cup. Bringing a smile to a nervous patient, holding the hand of a patient struggling with loss, and meeting patients where they are in an

ally life-altering news by a patient—the roles of critical information delivery reversed—and fielding questions we don’t have answers for while still providing each patient with appro-

**This program was my number 1 rank for a reason; the education at this longstanding residency was matched by the collegial environment, allowing me to grow as a physician and person.**

effort to help them obtain and maintain health brings me immense vocational satisfaction. However, while I was initially glad to see a full schedule that morning, following the shocking news and unclear outlook, the thought of seeing patients that afternoon was daunting. Before entering each room, I consciously attempted to affix an unruffled smile to my face and ignore the anvil over my head. But some patients already knew about the situation and asked what my plans were, with each of my unsure responses creating increasingly deep cracks in my façade. By the end of my day, the smile had withered to a simple desire to not allow the stinging tears behind my eyes to fall in front of my patients.

I was one of the lucky residents. I was able to join the virtual all-staff meeting and heard the news then. Some residents were unable to do so, thus, did not have any warning before seeing patients in the afternoon who knew of the impending closure before the residents themselves did. Being blindsided with person-

appropriate attention and care is a level of compartmentalization we did not know ourselves capable of executing.

Our program director (PD) called a meeting for residents to confirm the bad news.

*We have to start over? Being the “new kid” is always a difficult transition, and I was just gaining confidence as a doctor here!*

*How will I tell my husband we have to move for my education... again?*

*I adore my co-residents. I wouldn’t have gotten through to this point without them. Now we won’t even get to graduate together?*

In the same breath as the heartbreaking report, our PD earnestly promised to do everything he could to facilitate our transfer to other residency programs with as few disruptions to our education as possible.

Residents hugged each other and wept. The comfortable (but challenging) lives we had created here with colleagues who had become friends, and friends who had become family,

would soon be over. The immediacy of the impending end was heavy.

Medical education is a predictably metamorphosing experience. First you transition from college student to medical student – surrounded by peers equally or more intelligent than you, learning how to learn and abandoning study techniques that no longer work at this level, and drinking from the proverbial firehose as you retain more than you thought possible. Then you transition from didactic learning to rotations, putting the book learning to practice and getting a taste of why you entered medicine, actually seeing patients, and clumsily navigating the hospital environment with the added weight of being graded on not only your knowledge base but also your disposition and professionalism. Next, you transition from medical school to intern year, where you figure out how to practice medicine, learn things you were never taught in medical school (what is a 25 modifier?), and work harder than ever. And then you transition from intern year to senior, taking on additional responsibility, mentoring interns, and finally hitting your stride—having a level of comfort and efficiency absent intern year that continually grows.

At long last, we were finally at a place in

our training where we thought we would get to remain in one spot for a while. The initial intimidation of being a doctor was offset by the comfort colleagues provided. Through frequent get-togethers, pet-sitting (and occasionally babysitting) for each other, sharing food regularly (some healthy, much of it not), supporting each other through professional and personal challenges, venting to each other, and laughing often, my co-residents and I grew close. In addition to resident camaraderie, I felt the teaching and encouragement I needed from faculty.

Through relationships I maintained with medical school friends, I know my experience of easily plopping down in my PD's or assistant PD's office without a prior appointment to openly discuss any concern, feedback, or simply to tell a joke without apprehension is not universal. This program was my number 1 rank for a reason; the education at this longstanding residency was matched by the collegial environment, allowing me to grow as a physician and person. And now, the peaceful and long-desired notion of settling in a location of my own choosing and not needing to nomadically relocate on a monthly or yearly basis like we did in the years prior to residency was gone with one press release.

Our PD kept his word. With dogged resolve, he manufactured opportunities from seemingly nothing. He spent hours on the phone, speaking with PDs from across the country. In addition to his efforts, co-residents utilized their networks to inform each other of positions they found, hoping to find a good fit for everyone. And fortunately, we all found programs with which we can finish our training with (relatively) minimal discontinuity.

Witnessing and receiving support from my favorite faculty members and classmates during these past months of upheaval reminded me that while it's easy to say it would have been better if I had matched the number 2, 3, or hell, even number 12 program on my rank list, the stress and worries of this ordeal revealed the loyalty and integrity of the people who drew me to this program in the first place. While "orphaned," I was not and am not abandoned. I am a better clinician and person for spending the first 1.5 years of my residency with these people, and wherever this journey takes me, the things I have learned at this sun-setting program will come with me.

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# Shaping the Future of Medicine Through Mentorship

Fahad Aziz, MD, FASN, *WMJ* Editor-in-Chief; Shefali N. Bhatt

Meet Dr Sarah Walker, a young physician beginning her residency, who is faced with the complexities of patient care, the challenges of clinical decision-making, and the significant responsibilities that each decision carries. She often finds herself questioning her choices and struggling with the pressures of her new role. Fortunately, she is supported by a mentor, an experienced clinician who offers their insights and guides her through these professional hurdles. Together, they share valuable medical insights and practical strategies for managing stress, balancing responsibilities, and building confidence in Dr Walker's skills. Their relationship goes beyond traditional teaching; it is a dynamic partnership that is integral to Dr Walker's development.

This scenario illustrates the transformative impact of mentorship in the medical field. It shapes career trajectories, enhances clinical competencies, influences approaches to patient care, and cultivates leadership skills

among early career physicians. As Sir William Osler aptly stated, "The good physician treats the disease; the great physician treats the patient who has the disease." Mentorship embodies this principle by providing support and assisting clinicians who are navigating the

young physicians, and Florence Nightingale, whose insights shaped nursing practices, exemplify the significant role mentors have had in shaping medical thought and practice. And over the years, these initially informal mentoring practices have been refined into structured

**“A mentor empowers a person to see a possible future and believe it can be obtained.”**

—Shawn Hitchcock

complexities of medical practice and career development. By fostering open communication, critical thinking, and a dedication to lifelong learning, mentorship preserves the legacy of medical excellence, improves patient care, and facilitates the professional growth of individual clinicians and the broader medical community.<sup>1</sup>

## Benefits of Mentorship

Mentorship in medicine has undergone a significant transformation from its traditional apprenticeship roots, where emerging physicians were trained carefully under the direct supervision of seasoned clinicians through hands-on, personalized guidance. This foundational approach was instrumental in facilitating the transfer of skills and professional development. Influential figures like Osler, who mentored countless

programs, complete with formal guidelines and robust support systems tailored to meet the demands of modern medicine.

Mentorship today offers valuable benefits that extend beyond conveying clinical knowledge. The guidance provided by mentors benefits patient care and teamwork by helping doctors communicate better, make more informed decisions, and develop leadership qualities, which, in turn, can speed up career growth and open doors to new opportunities.<sup>2</sup> It can also help boost one's confidence and emotional intelligence, providing a holistic strategy for cultivating new generations of health care professionals. By fostering both professional growth and personal development, mentoring helps create a culture of shared learning, where innovative ideas and knowledge grow. In short, mentorship helps shape skilled, com-

• • •

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passionate, and resilient doctors committed to providing the best care.

## Challenges and Solutions in Mentorship

While mentorship in medicine offers numerous advantages, there are also significant challenges that can hinder its effectiveness. A primary concern is the lack of structured programs within many institutions, where formal mentorship opportunities are not sufficiently developed or altogether absent.<sup>3,4</sup> This lack of structure forces early career physicians to navigate their professional development independently.

Further, the demanding schedules of both mentors and mentees can limit their ability to engage consistently and maintain meaningful interactions. It is also critical to acknowledge that differing goals and communication styles between mentors and mentees can lead to misunderstandings and frustration within these relationships.

Bias and inequity also present formidable obstacles—particularly for underrepresented groups who may encounter additional barriers to accessing quality mentorship. This, in turn, perpetuates disparities in opportunities for professional growth and advancement within the medical field, and affects diversity and inclusivity in health care leadership. Addressing these challenges is imperative for fostering a more supportive and equitable mentorship environment that promotes the development of all health care professionals.

## Strategies to Enhance Mentorship in Medicine

Creating well-organized mentorship programs begins with robust institutional backing and clear guidelines. When medical institutions invest in structured mentorship initiatives, they establish a strong foundation that outlines expectations and objectives for both mentors and mentees. This approach ensures that every trainee receives reliable guidance and support, regardless of their department or specialty. Thus, institutional support is crucial for standardizing the mentorship experience and, in turn, making it a fundamental element of professional development in the medical field.

Training for both mentors and mentees is critical in order to nurture effective mentoring relationships. Comprehensive skill-building workshops play a significant role in enhancing communication, goal setting, and feedback techniques, which are fundamental to fostering more productive collaboration.

Further, promoting diversity and inclusivity within mentorship programs is not just beneficial but essential. It ensures equitable access to opportunities for all individuals—irrespective of gender, ethnicity, or background—thus enriching representation and leadership within health care. An emphasis on diversity also helps to broaden the perspectives of those involved in mentoring, enhancing the learning experience for all parties.

Additionally, technology can further enhance these efforts. The use of digital platforms can facilitate seamless communication and support knowledge sharing, effectively bridging geographical gaps, increasing accessibility and flexibility, and enabling busy professionals to maintain impactful mentoring relationships despite schedule constraints. Such comprehensive approaches not only strengthen the mentorship experience but are also crucial in shaping well-rounded professionals equipped to manage the complexities of modern medical practice.

Mentorship in medicine is a transformative

force that shapes clinical skills, career paths, and leadership qualities. From traditional apprenticeships to modern programs, mentorship is essential for lifelong medical education and professional growth, affecting personal development and patient care. We encourage institutions, mentors, and aspiring and early career physicians to prioritize mentorship to create a more supportive and innovative health care environment. As famous drama director Shawn Hitchcock said, "A mentor empowers a person to see a possible future and believe it can be obtained."

Investing in mentorship is crucial for advancing careers and enhancing the medical field. In a future editorial, we will discuss finding a mentor, being an effective mentor, and fostering solid mentor-mentee relationships.

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# Value-based Care and Decarbonization Converge at Value

Rian J. Podein, MD, MBA; Michael T. Hernke, PhD

United States health care leaders, as in Robert Frost's famous poem *The Road Not Taken*,<sup>1</sup> face two existential paths: the paradigm shift toward value-based care and climate change mitigation through the decarbonization of operations. However, unlike Frost's dilemma of choice, health care leaders must successfully travel both paths simultaneously to the place where they converge in order to succeed in their organization's mission and planetary sustainability.

## Value-Based Care

Peering down one path, leaders see the sector's emergence from the historical fee-for-service model that has been plagued by unsustainable spending with low value achieved. As recent as 2021, US health care spending reached a staggering \$4.3 trillion, an amount equivalent to 18.3% of the total gross domestic product.<sup>2</sup> The value-based care paradigm aims to improve the quality of care and health outcomes for populations while controlling delivery costs. This is achieved by paying health care providers, including hospitals and physicians, for results based on quality, equity, and cost of care through a spectrum of pay-

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ment strategies known as alternative payment models. By aligning reimbursement with value, derived from measuring health outcomes against costs, health care leaders are freed from the fee-for-service constraints to deploy innovative evidence-based and cost-effective strategies to optimize disease prevention, man-

**For a more sustainable organization and planet, it will be incumbent on health care leaders to expand their concept of value.**

age chronic disease, and tackle the influential social determinants of health.

While value-based care models are increasingly prevalent, fee-for-service still remains the dominant form at 60%.<sup>3</sup> Unfortunately, due to unique challenges, safety-net health centers and rural organizations historically have been more hesitant to adopt alternative payment models, disproportionately excluding racial minorities, persons with disabilities, the uninsured, and lower socioeconomic status populations from the potential benefits of value-based care.<sup>4</sup>

Regardless of organization readiness for value-based care and payment adoption, progressive forces will continue to drive participation through financial rewards to successful participants, the imposition of negative financial impacts for nonparticipants, and the use of both voluntary and mandatory programs. Notably, the Center for Medicare and Medicaid Innovation (CMS Innovation Center) has proclaimed the goal to have every tradi-

tional Medicare beneficiary—and the majority of Medicaid beneficiaries—participating in a value-based care model by 2030.<sup>5</sup> Beyond the Centers for Medicare and Medicaid Services, the use of value-based care models has been projected to increase by both public and private payers alike.<sup>6</sup>

Along this path, value-based care offers health care organizations the potential for performance improvements. Accountable care organizations (ACOs), the most common model, have demonstrated the ability to outperform fee-for-service models across all quadruple aim goals with enhanced patient experience, improved population health, reduced costs, and improved work-life for health care staff.<sup>7</sup>

In response to stakeholders' drive to leverage equity goals within value-based payments, the CMS Innovation Center will deploy the new ACO Realizing Equity, Access, and Community Health (ACO REACH) model. ACO REACH provides additional support for clinicians who care for marginalized populations and increased delivery of benefits to low-income and disproportionately marginalized communities.<sup>8</sup>

## Decarbonization

Looking down the other path, leaders will see



a climate crisis described by the World Health Organization as “the single biggest health threat facing humanity.”<sup>9</sup> Of all the social determinants of health, climate change has garnered novel interest due to its profound direct impacts on population health and its overarching and progressive consequential effects on all other social determinants of health.<sup>10</sup> Although climate change will affect the health and well-being of all people, older populations, low-income communities, communities of color, children, people with underlying health problems, and rural environments will be disproportionately affected.

The health care sector is a major contributor to climate change, responsible for 8.5% of national carbon emissions.<sup>11</sup> While numerous voluntary efforts have responded to calls to decarbonize health care, mandates do not exist. One example is the Health Sector Climate Pledge, a voluntary commitment signed by many of the largest US hospitals, health systems, suppliers, pharmaceutical companies, and other industry stakeholders to cut their organization’s greenhouse gas emissions 50% by 2030, achieve net zero emissions by 2050, and to designate an executive lead for their decarbonizing work.<sup>12</sup> Toward this goal, the Inflation Reduction Act of 2022 provided significant federal tax credits to support proactive health care decarbonization efforts.<sup>13</sup>

Similar to value-based care models, decarbonization efforts can improve organization performance with more preventive and higher-quality care models that reduce overutilization and low value health care, while increasing population health.<sup>14</sup> The overarching business case for improved environmental sustainability performance has been made as a driver of competitive advantage through stakeholder engagement, improved risk management, innovation, customer loyalty, employee engagement and retention, and improved financial performance from all categories.<sup>15</sup> Health care organizations, specifically, have demonstrated positive returns on investments for decarbonization interventions, such as installation of on-site renewable energy, the purchase of renewable energy, and waste reduction.<sup>14</sup>

Because the health of individuals and populations depends on functioning ecosystems and

planetary health, quality of care and environmental sustainability with decarbonization are extensively linked.<sup>16</sup> Health care organizations should, therefore, consider decarbonization as part of ongoing quality improvement within value-based care. Due to the interconnectedness of these domains, environmental sustainability has been proposed for inclusion to the Institute of Medicine’s domains of quality: safe, effective, patient-centered, timely, efficient, and equitable.<sup>17</sup> Quality exists as one component of the more comprehensive goal of achieving value in health care.

### Convergence at Value

It is common for stakeholders to have divergent interpretations of value that can result in conflicting agendas to achieve it.<sup>18</sup> Since its earlier description as an equation with health outcomes achieved per dollar spent, the value definition has evolved. Value-based care models provide a platform for the decarbonization of health care delivery through integration of environmental and financial costs and clinical performance.<sup>19</sup> Together, their potential to enable performance improvement within multiple domains illuminates their convergence at the overarching goal of value in health care. For a more sustainable organization and planet, it will be incumbent on health care leaders to expand their concept of value. The sustainable value equation—Value = (outcomes for patients and populations)/(environmental + social + financial impacts)—provides a practical framework that integrates environmentally sustainable operations and clinical quality.<sup>17</sup>

### Tragedy of the Commons and Prisoner’s Dilemma

For systems thinkers, the shifts to value-based care and decarbonization are clear paths for organization and planetary success. However, the delay to fully engage these objectives by some leaders can be explained in part by the tragedy of the commons metaphor and the prisoner’s dilemma game theory construct. The former describes the tension between the responsibility to be stewards of public health and natural resources with the perceived self-benefit to neglect such responsibilities in the short term. The latter dilemma identifies how

hesitant leaders may delay needed action due to a lack of trust that their competitors will join in these pursuits while they continue to exploit the current fee-for-service paradigm and environmentally unsustainable operations for perceived short-term benefits.

Nevertheless, societal and financial forces will continue to nudge health care organizations toward value-based care models and decarbonization. . Health care leaders must heed sustainability science’s evidence-based conclusions that the tragedy of the commons and prisoner’s dilemma can mislead them, and proactive leaders will realize “the potential self-benefit of understanding the dynamics of major system change better than one’s competitors.”<sup>20</sup>

### Conclusion

Beyond the ethical imperative to do no harm, health care leaders and organizations are now called upon to expand and improve the value of care provided to patients and populations within planetary boundaries. As forces accumulate to drive value-based care and decarbonization, proactive leaders are needed to implement sustainable value-informed decision-making through a lens of health equity to drive performance success. To conclude in honor of Frost’s poem: *two roads converged in a wood, and I took both to where they met, and that has made all the difference.*

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## Examining the Relationship Between Obstructive Sleep Apnea During Pregnancy and Autistic Spectrum Disorder in Children

Dear Editor,

We recently reviewed the article "Are Symptoms of Obstructive Sleep Apnea During Pregnancy Associated With Autism Spectrum Disorder in Children: A Case-Control Study" by Nick et al<sup>1</sup> with great interest. Obstructive sleep apnea (OSA) is a common and serious condition. While treatments like continuous positive airway pressure (CPAP) and mandibular advancement splints are effective, many patients struggle with adherence.<sup>2</sup>

The study offers valuable insights into OSA but could be strengthened by exploring neuroinflammation in offspring due to gestational OSA and the sex-specific effects on children. These areas hold potential for uncovering new pathways and biomarkers, paving the way for more targeted treatments. Notably, a recent study revealed an increased soluble vascular endothelial growth factor receptor 1/PIGF ratio and reduced levels of pregnancy-associated plasma protein A in individuals with sleep

disorder breathing, after adjusting for key factors.<sup>3</sup>

The study by Nick et al relied on self-reported symptoms and medical history rather than objective sleep testing, which may have influenced the findings. Previous research shows that increased daytime drowsiness is common during pregnancy, so this factor could affect results.<sup>4</sup> While somnolence is not always a reliable indicator of severe sleep disorders in pregnancy, exploring more clinical markers could enhance the understanding of OSA's impact. Including confounding factors, such as maternal health and social circumstances, in future studies would provide a more comprehensive analysis.<sup>5</sup>

—Saim Mahmood Khan, MBBS; Jawairya Muhammad Hussain, MBBS; Iman Azam, MBBS

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# Development of Cervical Cancer Prevention Workshops for Hmong and Karenni Women Through a Community-Academic Partnership

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## ABSTRACT

**Background:** In the United States, Southeast Asian immigrant and refugee women face many barriers to cervical cancer screening. This work describes and evaluates the use of community health workers and community-based participatory research in providing community-level interventions through a community-academic partnership to address these barriers.

**Methods:** Community advisory board members and mother–daughter dyads were recruited to help develop and refine cervical cancer educational materials.

**Results:** Feedback from 9 community advisory board members and 5 mother-daughter dyads identified areas for improvement to increase cultural sensitivity of materials and ensure the equity of voices during discussions.

**Conclusions:** Through this community-academic partnership, we developed cervical cancer prevention educational materials and workshops for Southeast Asian immigrant and refugee communities to serve as a resource to future cervical cancer screening programs.

## BACKGROUND

Globally, cervical cancer is one of the most common female cancers for Asian women, likely due to barriers in access to health care services resulting in lower rates of vaccination and up-to-date screening compared to non-Hispanic White women.<sup>1</sup> Asian immigrant and refugee women in the United States face additional barriers to screening due to language, culturally discordant health beliefs, limited knowledge of host culture, modesty, fatalism, lack of access to health insurance, and social stigma

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due the association of HPV with sexually transmitted infection.<sup>2,3</sup>

Engaging community health workers (CHW) and community-academic partnerships are effective strategies to enhance health interventions for minoritized populations.<sup>4-6</sup> CHWs are typically representatives from the community and can serve as liaisons between community members and clinicians, promoting behavior change and increasing access to health services among ethnic minority women.<sup>5</sup> The use of community-based participatory research (CBPR) methods is essential in community-academic partnerships to ensure research is done in collaboration with those affected by the issue

being studied, amplifying the relevance and authenticity of the knowledge created and the potential for positive change.<sup>6</sup>

Our project consisted of the development of a community-academic partnership between the research team at the University of Wisconsin School of Medicine and Public Health (SMPH) and the community organization Milwaukee Consortium for Hmong Health (MCHH). Our objective is to promote cervical cancer prevention by offering (1) educational materials co-designed and delivered by CHWs in the native language and cultural context of the participants and (2) community-level screening options, such as pap smears and human papillomavirus (HPV) testing, which can be clinician-collection or self-collected.

This study had 2 primary components: formation of a community advisory board (CAB) and development of mock cervical cancer educational workshops. In this paper, we discuss the process of developing the community-academic partnership and materials for cervical cancer educational workshops through feedback obtained from Hmong and Karenni CHWs and mother-daughter dyads.



## METHODS

The study was conducted over 9 months spanning 2021 and 2022. Two types of participants were recruited: members for the CAB and community members (as mother-daughter dyads) to attend mock workshops. Throughout the study, CAB members and the research team met 5 times virtually. Four mock workshops were conducted at MCHH's community center with mother-daughter dyads: the initial workshop for each ethnic group (Hmong and Karenni) presented the initial draft of educational materials developed by the CAB. Notes and feedback obtained from these first workshops were then presented to the CAB to guide revisions. Revised workshop materials were then delivered during the second workshop to each group. (See Table 1 for a timeline of the study activities.)

Study approval was obtained from the Institutional Review Board at the University of Wisconsin School of Medicine and Public Health (Study ID# 2021-1003-CP002). Informed consent for both types of participants was obtained in English, Hmong, or Karenni, depending on participant preference.

### Community Advisory Board

The community-academic partnership between SMPH's research team and MCHH began in 2020. Two CHWs—one Hmong and one Karenni—were selected by MCHH's leadership to work with the research team on the development of workshop materials and assist in recruitment, consent, and data collection for the mock workshops. The CAB members included these 2 CHWs, 5 members from the MCHH board of directors, and 3 community members of Karenni or Hmong ethnicity. Community members were selected by the MCHH leadership to assist in representing the community.

Prior to the first CAB meeting, the research team and MCHH leadership set project goals, expectations, and responsibilities for each organization and had discussions regarding potential for future initiatives and the partnership's ability to address disparities in the community through sustainable innovations.

The academic team and the CHWs collaborated to develop the workshop materials and then brought them to the CAB for review. They also selected a self-collection device for HPV screening to be offered in future workshops. The Evalyn Brush (Rovers Medical Devices B.V., Oss, the Netherlands) was selected based on efficacy and acceptability.<sup>7</sup> The manufacturer's instructions were adapted for a lower literacy level, translated, and diagrams enlarged for clarity. Due to varying levels of health literacy and English profi-

**Table 1.** Study Timeline and Activities

| Activity                         | Month of Study                   |   |   |                                   |             |                  |                                   |             |                 |
|----------------------------------|----------------------------------|---|---|-----------------------------------|-------------|------------------|-----------------------------------|-------------|-----------------|
|                                  | 1                                | 2 | 3 | 4                                 | 5           | 6                | 7                                 | 8           | 9               |
| Community advisory board meeting | X                                | X | X |                                   |             | X                |                                   |             |                 |
| Mother-daughter mock workshop    |                                  |   |   | Karenni dyads                     | Hmong dyads |                  | Karenni dyads                     | Hmong dyads |                 |
| Workshop material development    | Development of initial materials |   |   | Presentation of initial materials |             | Review/Revisions | Presentation of revised materials |             | Review/finalize |

**Table 2.** Partnership Evaluation Survey Categories and Sample Questions

| Category        | Sample Questions  |
|-----------------|---|
| Communication   | I feel like the research team communicates with me in a way that best meets my schedule and personal preferences.         |
| Group Dynamics  | I feel like the research team values my expertise by actively listening to my ideas.                                      |
| Research Design | I feel like the research team considers the Southeast Asian community as a major role in guiding the project's direction. |
| Project Impact  | I feel like the project uses the community resources efficiently.   |

ciency, materials used mixed-modality approaches presenting content (1) in posters and flip charts with minimal written language and using images of families with physical features like the target ethnicities, (2) in videos in the native language with English subtitles, and (3) with hands-on materials, such as anatomical models and equipment used during cervical cancer screening procedures.

The full CAB met in 5 virtual meetings covering various topics, such as the following:

- a) the content, language, design, and delivery of educational materials
- b) options for a self-collection screening device
- c) feedback obtained from mother-daughter dyads attending mock workshops
- d) the community-academic partnership and expectations
- e) current and future collaborations

Iterative evaluation of the partnership was conducted through an anonymous online survey (Appendix A) after each CAB meeting. The survey was adapted and modified from toolkits and published CBPR methods.<sup>8,9</sup> Questions pertained to 4 categories: communication, group dynamics, research design, and impact (Table 2). Most questions included a 5-point Likert scale on level of agreement, and the survey concluded with 5 open-ended questions. Discussions during CAB meetings were recorded by a dedicated notetaker from the research team, and any written feedback obtained through email between CAB meetings was considered in the partnership evaluation.

A member from the research team independently analyzed the results 2 weeks following each CAB meeting. The summary results were then shared with the CAB team to open discussion for iterative adjustments to communication practices, CAB meeting structure, and the research design.

## Mock Workshops

Mother-daughter dyads were recruited by CHWs and were assigned to either the Hmong or Karenni group depending on their self-identified ethnicity. We included mother-daughter dyads because older immigrant and refugee mothers often involve their daughters or other family members during health care visits to assist in translation and health decision-making.<sup>10</sup> The age for inclusion was 15 years and above for the young women (“daughters”). This age cutoff was determined by the CHWs as the most appropriate level of maturity for the educational topics.

Workshops were led by the CHWs, and mother-daughter dyads were expected to attend both sets of mock workshops. At least 1 member of the research team attended to observe, take notes, and provide any needed clarification on educational materials. Participants were informed that the materials developed by the CAB and research team were all work-in-progress and were encouraged to provide feedback on how the materials may be received by the Hmong or Karenni communities. CHWs presented educational materials mimicking the format of a real workshop, with feedback collected by CHWs throughout the workshop through semistructured questions (Table 3).

## RESULTS

### Community Advisory Board

A total of 10 participants were recruited as CAB members. All participants self-identified as female, 6 identified as Hmong descent, 2 identified as Karenni descent, and 2 not of Asian descent. One Karenni community member withdrew from the project after the first CAB meeting, citing lack of time. At least 7 of the 10 members attended every meeting, and at least 5 participants completed the online survey after each meeting (Table 4).

All members responded positively to survey questions evaluating the partnership, and nearly 100% of responses were “strongly agree” or “somewhat agree” for all questions (complete responses to Likert questions included in Appendix B). The survey also evaluated CAB members’ overall willingness to collaborate with the research team in the future, with the average response being 9.3 on a 10-point scale (1 = never want to collaborate again and 10 = will enthusiastically collaborate again).

Open-ended feedback received raised some concerns in each of the 4 categories. These included scheduling challenges, CAB members feeling uninformed of the full study design, concerns regarding dynamics of the panel inhibiting equity in voices and desire for members who were Hmong or Karenni to be more front and center. Within the CAB meetings, active feedback and itera-

**Table 3.** Semistructured Questions for Mother-Daughter Dyads During Mock Workshops

| Category               | Sample Questions   |
|------------------------|--|
| Language               | Are there any phrases or words in Karenni/Hmong which are... new to you? ...do not make sense?   |
| Self-collection        | Do you feel like other members in the community would be receptive to the self-collection ... method? ...device?<br>Do you think that members in the community would prefer this method over the traditional clinician-collection method?<br>Are there any part of the instructions for the self-collection device which do not make sense or are confusing? |
| Comprehension          | Is any of this information new to you?<br>Is any of this information confusing?<br>Do you feel like any information on cervical cancer prevention is missing?  |
| Behavior change        | Does any of this information encourage or discourage you from getting recommended cervical cancer screening?   |
| Materials and delivery | What do you think about the delivery of the information? (ie, flip charts, hands-on models, video)<br>Do you feel comfortable receiving this information from community health workers?<br>Do you feel like having community health workers deliver this information provide more or less comfort to future participants?                                    |

**Table 4.** Community Advisory Board (CAB) Participation and Responses to Survey

| CAB Meeting   | Participants (n) | Survey Responses (n) |
|---------------|------------------|----------------------|
| November 2021 | 10               | 10                   |
| January 2022  | 9                | 7                    |
| February 2022 | 8                | 6                    |
| April 2022    | 7                | 5                    |
| June 2022     | 7                | 5                    |

tion was valued, and changes included logistical considerations, such as using online polling for scheduling preference, promoting inclusivity by ensuring all CAB participants were provided information equitably, and summarizing key points via email for those who missed a meeting. To increase opportunity for feedback, any questions needing more reflection during meetings were sent via email to accommodate those not comfortable sharing among the group. Additionally, to capture discussion from each individual CAB member, a “round robin” approach was used after the third CAB meeting.<sup>11</sup> Examples of the feedback received and subsequent changes are provided in Table 5.

### Mock Workshops

Three pairs of Karenni and 2 pairs of Hmong mother-daughter dyads participated in the mock workshops. A third Hmong pair was recruited but dropped out prior to the start of the study. Participants ages ranged from 17 to 48 years of age for Karenni participants and 15 to 43 years of age for Hmong participants. Dyads of the mock workshops (n=10) indicated that they liked the presentation and delivery of the materials and understood the content, with minor suggestions regarding language comprehension and suggested translation of words or phrases without a literal translation such as “handle,” “pink,” or “tampon.” All

**Table 5.** Feedback on Partnership and Subsequent Changes Made

| Category        | Feedback and Quotes  | Implemented Changes   |
|-----------------|--|---|
| Communication   | <ul style="list-style-type: none"><li>• Overall preference for online polling approach to scheduling for flexibility.</li><li>• In the first CAB meeting, members who were not involved in workshop development felt it was difficult to understand the scope of the project due to potentially missing information.</li></ul> | <ul style="list-style-type: none"><li>• Meeting dates and times scheduled through online polling.</li><li>• A summary project scope was sent to all CAB members and dedicated time at subsequent meeting to provide a more thorough introduction to the project for those newer to the conversations.</li></ul>   |
| Group dynamics  | <ul style="list-style-type: none"><li>• "...I am working on being mindful of my own level of participation to allow for others to speak. I think the team would benefit from hearing from more [quieter] team members during the meetings..."</li><li>• Suggest possible smaller breakout rooms if time allows.</li></ul>      | <ul style="list-style-type: none"><li>• Allowed more space during meetings for discussion, invitation of each member to share thoughts through "round robin" approach, and those who may not feel comfortable in the larger group setting were encouraged to provide feedback through the survey, email, or one-on-one with CHWs or research team members.</li></ul>            |
| Research design | <ul style="list-style-type: none"><li>• "...input – as a Caucasian cannot be front and center – and should not be made such."</li></ul>  | <ul style="list-style-type: none"><li>• Weighed input from those that were of Southeast Asian descent of higher value as closer representatives of the community.</li></ul>   |
| Impact          | <ul style="list-style-type: none"><li>• "...I cannot judge whether or not it will lead to changes. It is too early for that to be known."</li><li>• "...only hope that we will not have pushback from heads of family as this had been a past barrier and negatively impacted women's health options..."</li></ul>             | <ul style="list-style-type: none"><li>• Discussed topics such as patriarchal decision making and other potential barriers in more detail with mother-daughter dyads attending mock workshops.</li><li>• Determined it was difficult to determine impact based on survey questions and results therefore further evaluation of impact was saved for future directions.</li></ul> |

Abbreviations: CAB, community advisory board; CHW, community health worker.

participants agreed that feedback provided during CAB meetings and initial mock workshops were incorporated adequately into the revised materials and were inclusive of and culturally sensitive to Southeast Asian families.

Self-collection was well-received as a potential alternative for cervical cancer screening in the future. Some participants had concerns that this method might be confusing or undesired by older women who may have difficulty with manual dexterity, although they were hopeful that this new initiative would provide better access for the community.

## DISCUSSION

In this study, we developed a community-academic partnership between SMPH and MCHH focused on addressing barriers to cervical cancer screening among Southeast Asian immigrant and refugee women. Through this initial development phase, cervical cancer prevention workshops were able to be created for use in future implementation studies for the broader community. See examples of developed materials in Appendix C.

Community-based participatory research, which involves community members directly in all phases of project planning and execution, was a cornerstone of our approach. Through our close collaboration with leaders of MCHH, a trusted and respected community organization, we were able to engage with established community networks and incorporate cultural knowledge to better address the health needs of Hmong and Karenni women. The structure and content of our educational materials were informed by the knowledge gained in the culturally representative CAB. We adapted the structure of CAB meetings based on continuous feedback and iteration, ensuring that the voices and perspectives of all members were well represented. This collaboration enabled us to anticipate challenges that may arise during the next steps of con-

ducting these prevention workshops or similar collaborations and adjust our methods accordingly.

It is important to acknowledge limitations in this study—primarily the limited sample size and design. Evaluation of community-academic partnerships typically requires an unbiased third party through in-depth discussions, which we were unable to incorporate. While we did modify the survey used in this study based on numerous validated sources and results were beneficial to the partnership, no definitive conclusions regarding strengths or weaknesses of the partnership between SMPH and MCHH could be determined. Additionally, as this partnership is in its infancy, it is difficult to assess the potential impact of the study, including factors such as reach, adoption, and maintenance of the workshops.

The materials developed for cervical cancer educational workshops will be provided to the broader community through the community-academic partnership with the goal of increasing cervical cancer education and screening among Southeast Asian immigrant and refugee women. Future initiatives should assess if knowledge attainment and behavior change due to the workshops (ie, obtaining cervical cancer screening, receiving the HPV vaccination, modifying risk factors) are successful.

## CONCLUSIONS

This study provides an example of the use of community-academic partnerships to develop culturally tailored educational materials and workshops for cervical cancer prevention. The lessons learned from the partnership can serve as a resource for future collaborations by prioritizing community engagement, cultural relevance, and partnership, as we strive for more equitable health care interventions that effectively address disparities in underserved communities.



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# Improving HPV Vaccination Rates: A Comprehensive Evaluation of a Clinician-Centered Educational Initiative in a Wisconsin Health Care System

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## ABSTRACT

**Introduction:** Human papillomavirus (HPV) infection poses significant public health concerns due to its prevalence and association with various cancers. This study assesses a 2014 quality improvement initiative in Wisconsin's largest health care system. The intervention aimed to improve HPV vaccine initiation and completion among eligible patients and to reduce the gap in vaccination rates between males and females.

**Methods:** Educational sessions delivered to health care providers and staff at select clinics focused on current HPV vaccination recommendations and strategies for patient communication. Preintervention and postintervention surveys assessed changes in clinician knowledge and attitudes. Clinic-level data on HPV vaccination rates compared intervention and control clinics at 12 and 36 months following the intervention.

**Results:** Postintervention knowledge and attitudes regarding HPV vaccination improved, and intervention clinics demonstrated notable increases in HPV vaccine initiation and completion rates across various age and sex groups at 12- and 36-month follow-up. The gap between female and male HPV vaccination rates narrowed in some age groups in intervention clinics, but the effect was inconsistent.

**Conclusions:** This study highlights the potential effectiveness of an in-person educational intervention in improving HPV vaccination rates in a health care system. Clinicians' enhanced understanding of vaccination guidelines, coupled with real-time data feedback, contributed to sustained improvements. To address resource challenges, future interventions may explore cost-effective alternatives. These findings underscore the pivotal role of clinicians in increasing HPV vaccine uptake, emphasizing the importance of aligning interventions with evolving vaccination recommendations to combat HPV-related cancers more effectively.

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## INTRODUCTION

Human papillomavirus (HPV) accounts for more than 43 million new infections annually in the United States.<sup>1</sup> Selected HPV strains cause nearly all cervical and anal cancers and the majority of cancers of the vagina, vulva, and penis.<sup>2</sup> Each year between 2015 and 2019 in the US, an estimated 37 300 people were diagnosed with HPV-attributable cancer,<sup>2</sup> and about 4000 women died of cervical cancer.<sup>3</sup>

Since 2006, US Food and Drug Administration (FDA)-approved vaccines have effectively prevented infection from the HPV strains most closely linked to cervical cancer. Clinical trials of the first approved vaccine, Gardasil from Merck & Co, Inc (HPV4), demonstrated 90% to 100% reduction in infections for 4 target strains in both females and males.<sup>4</sup>

Recommendations for use of the HPV vaccines underwent gradual shifts in the first 5 years of licensure,<sup>5</sup> presenting challenges in adopting the vaccine as part of

routine immunization. Shortly after its 2006 FDA licensure, the Centers for Disease Control and Prevention (CDC) recommended HPV4 for routine administration as a 3-dose series for females ages 11 to 12 years, with catch-up vaccinations up to age 26.<sup>6</sup> In 2010, the CDC indicated that males ages 9 to 26 years could receive HPV4<sup>7</sup> and recommended it as a routine vaccine the following year.<sup>8</sup> (Note that a bivalent vaccine was licensed for use in the US in 2009. Cervarix [Glaxosmithkline] was included in updated recommendations from the Advisory Committee on Immunization Practices for vaccination of female patients in 2010. However, it

was never licensed for use in males in the United States, and use was uncommon in females. It was withdrawn from the US market in 2016 due to very low demand.)

In December 2014, the FDA approved Gardasil-9 (HPV9), with coverage for 9 high-risk strains of HPV.<sup>9</sup> HPV9 replaced HPV4 as the recommended vaccination for routine use in both male and female children.<sup>9</sup>

In December 2016, the CDC again modified the vaccine administration guidance based on emerging evidence of immunogenicity, recommending a 2-dose schedule for females and males who initiate the vaccination series before age 15 years.<sup>10</sup>

As of 2022, 66% of females and 63% of males ages 13 to 18 years had initiated the HPV series, while 53% and 50%, respectively, had completed the series.<sup>11</sup> In 2013, just before the intervention described here, 59% of females and 31% of males ages 13 to 18 years in Wisconsin had initiated the 3-dose vaccine series, while 37% and 14%, respectively, had completed the series.<sup>12</sup>

Wisconsin adolescents who were getting vaccinated also were doing so later than recommended. The average age of series completion was 16.5 for females and 15.7 for males, whereas the CDC's recommendation was for series completion by the 13th birthday. Although some evidence exists to suggest that vaccination can decrease HPV-related disease risk in people who have previously acquired HPV,<sup>13</sup> timing HPV vaccine administration before sexual debut is important because the vaccine is most effective at preventing HPV infection if it is given prior to exposure.<sup>14</sup>

This study evaluated a quality improvement initiative conducted in the summer of 2014 in Wisconsin's largest health care system, UW Health. The goals of this initiative were to (a) improve series initiation and completion of the HPV vaccine among eligible UW Health System patients; (b) improve series initiation in the recommended age window; and (c) reduce the male-to-female vaccination rate gap. We present results of a pre-/post-intervention survey of clinic staff, as well as the clinic-level rates of HPV vaccination for eligible patients before and after the intervention with 1-year and 3-year follow-up.

## **METHODS**

### **Intervention**

In 2013, a UW Health internal system-wide survey of clinical nurse managers suggested that clinicians did not fully understand the latest HPV vaccine recommendations and were unaware of the low immunization rates among their own patient panels. Confusion likely stemmed from rapidly evolving recommendations for routine HPV vaccination in this time period—particularly with respect to recommendations for male patients. To promote HPV vaccination, an Immunization Task Force designed an intervention intended to encourage UW Health clinicians to provide a strong HPV vaccine recommendation to eligible patients—both male and female—and ultimately to improve HPV vaccine series initiation and uptake system-wide. The intervention was imple-

mented in 2014 in UW Health's Division of General Pediatrics and Adolescent Medicine and Department of Family Medicine.

The intervention was delivered to clinicians and staff in selected UW Health clinics during an onsite "lunch and learn" session. Physicians, clinic managers, nurses, physician assistants, and medical assistants were invited and encouraged to attend via emails from department chairs, clinical nurse managers, and the Immunization Task Force. Attendees were offered complementary lunch and continuing medical education credit. The intervention was delivered in-person, onsite.

### **Education Session and Discussion**

A 40-minute didactic session led jointly by a UW Health pediatrician and obstetrician-gynecologist covered HPV virus facts, prevalence data, vaccine coverage, safety, and the contemporaneous CDC recommendations for vaccination series completion before age 13. Presenters emphasized the vaccine's role in cancer prevention and provided strategies for discussing it with adolescents and parents, addressing common questions and concerns. Attendees reviewed clinic-specific HPV vaccine rates, which were lower than rates for other recommended adolescent vaccines (meningococcal, Tdap, and influenza vaccines). The intervention goal was to emphasize the importance of HPV vaccination, aligning it with routine adolescent vaccines. Presenters encouraged questions and discussion throughout the session and included a 15-minute question-and-answer session at the end.

Over the course of 5 months in 2014, the intervention was presented at 17 clinic locations. Intervention clinics were selected non-randomly based on scheduling constraints and the size of the eligible patient populations, with the goal of maximizing system-wide impact.

This quality improvement intervention did not occur in isolation. According to an environmental scan of HPV vaccine promotion activities in Wisconsin around the time of this intervention, a variety of activities focused on educating clinical and health professionals, communities, and health systems regarding the importance of HPV immunization were concurrently in progress.<sup>15</sup>

### **Evaluation**

We conducted 2 separate evaluations of this intervention. First, we used preintervention and postintervention surveys to assess the knowledge, attitudes, and practices of clinicians and staff at the clinics where interventions took place. Second, we conducted a post-hoc comparison of HPV vaccine series completion rates at intervention clinics and nonintervention clinics in the same health care system.

### **Preintervention Survey**

Each educational session began with an anonymous, paper-and-pencil questionnaire assessing participants' knowledge about current age- and sex-specific recommendations for HPV vaccine, estimates of HPV vaccination rates among participants' own



patient panels, participants' perceptions of their patients' openness to HPV vaccination, and perceived barriers to vaccinating patients in their own practices. The survey was distributed and collected in person by the physicians leading the intervention. We did not collect information on the proportion of clinicians and staff who attended each session or completed the preintervention survey. In general, it was expected that clinicians and staff who were not engaged in patient care would attend the sessions. Clinic managers actively encouraged all present clinicians and staff to attend as each session began.

### Postintervention Survey

Three months after each session, all current clinicians and staff at each intervention clinic received an email invitation to complete a follow-up online questionnaire. This postintervention survey assessed the educational impact on participants' HPV vaccine knowledge and perceptions. It differed from the initial questionnaire in format and included additional questions about practice changes since the intervention. It also asked respondents to evaluate the intervention. Postintervention survey participants were asked to report whether they had attended the original educational session. We did not collect completion rate information on this survey.

### Electronic Health Record Review of HPV Vaccine Rates

More than 4 years following the delivery of the intervention, we obtained HPV vaccine series completion rates from the electronic health record (EHR) for all UW Health System clinics from January 2013 to December 2019. In this post-hoc evaluation, we used all pediatric clinics in the same health care system and not in the intervention as controls. We excluded clinics that did not have patients in relevant age groups or were not in operation at the time of the intervention, leaving us with 15 nonintervention clinics. We evaluated change in HPV vaccination rates, observing series initiation and completion rates in specific age and sex subgroups each month 12 months before through 36 months after the intervention.

### Statistical Analysis

To analyze data from both surveys, we used chi-squared tests and t tests to assess pre/post differences in survey respondents' understanding and perceptions of the HPV vaccine. Differences were assessed by comparing group means at time point A and B. We used SPSS Statistics version 26 (IBM Corp) for the comparative analyses.

**Table 1.** Descriptive Statistics for Intervention and Nonintervention Clinics at the Time of Intervention

|   | Female Patients             |                                | Male Patients               |                                |
|---|-----------------------------|--------------------------------|-----------------------------|--------------------------------|
|   | Intervention Clinics (n=17) | Nonintervention Clinics (n=15) | Intervention Clinics (n=17) | Nonintervention Clinics (n=15) |
| Mean (SD) clinic patient panel size                     |                             |                                |                             |                                |
| 9–10 year olds  | 177 (118)                   | 44 (25)                        | 184 (140) <sup>a</sup>      | 49 (26)                        |
| 11–12 year olds   | 170 (112)                   | 26 (24)                        | 179 (123) <sup>a</sup>      | 49 (24)                        |
| 13–18 year olds   | 495 (281)                   | 159 (79)                       | 514 (346)                   | 154 (71)                       |
| Mean (SD) HPV vaccine initiation rate                   |                             |                                |                             |                                |
| 9–10 year olds  | 1% (1%)                     | 2% (4%)                        | 0% (0%) <sup>a</sup>        | 0% (1%)                        |
| 11–12 year olds   | 37% (8%)                    | 37% (16%)                      | 30% (9%) <sup>a</sup>       | 27% (15%)                      |
| 13–18 year olds   | 73% (8%)*                   | 65% (15%) <sup>b</sup>         | 54% (15%) <sup>b</sup>      | 44% (22%) <sup>b</sup>         |
| Mean (SD) HPV vaccine series completion rate            |                             |                                |                             |                                |
| 9–10 year olds  | 0% (0%)                     | 1% (2%)                        | 0% (0%) <sup>a</sup>        | 0% (0%)                        |
| 11–12 year olds   | 11% (3%)                    | 9% (6%)                        | 7% (3%) <sup>a</sup>        | 5% (5%)                        |
| 13–18 year olds   | 54% (9%) <sup>b</sup>       | 46% (13%) <sup>b</sup>         | 27% (12%) <sup>b</sup>      | 17% (11%) <sup>b</sup>         |
| Mean (SD) sex difference in HPV vaccine initiation rate |                             |                                |                             |                                |
| 9–10 year olds  | 0.0% (1.0%) <sup>a</sup>    | 2.1% (4.0%)                    |                             |                                |
| 11–12 year olds   | 6.2% (7.2%) <sup>a</sup>    | 9.8% (10.6%)                   |                             |                                |
| 13–18 year olds   | 19.0% (10.1%)               | 21.3% (9.2%)                   |                             |                                |

<sup>a</sup>Note that one intervention clinic had no male patients in the 9- to 10-year-old or 11- to 12-year-old age groups. The n for these cells is 16.

<sup>b</sup>Intervention and nonintervention clinics were statistically different at the time of intervention, at  $\alpha = 0.05$ .

To analyze HPV vaccine data from the UW Health System EHR data, we calculated HPV vaccine series initiation and completion rate data at the clinic level. Vaccine rates were calculated separately for males and females in the 9- to 10-, 11- to 12-, and 13- to 18-year age ranges for each month from 12 months prior to and 36 months after the intervention. Series initiation rates were calculated as the number of patients who had 1 dose of HPV vaccine divided by the total number of patients in each age/sex subgroup. Series completion rates are similarly calculated, using 3 doses as the definition for "completion" prior to the December 2016 change in recommendations and 2 doses afterwards. We conducted a difference-in-difference regression analysis with clinic fixed effects to compare the preintervention and postintervention change in vaccination rates among intervention clinics to the change in vaccination rates in nonintervention clinics. We also analyzed the change in the gap between male and female patients' HPV vaccine series initiation rates. Intervention impact analysis was performed in Stata 17 (StataCorp LLC). The study received UW-Madison Institutional Review Board exemption as a quality improvement initiative.

### RESULTS

Table 1 describes baseline characteristics of both the intervention and nonintervention clinics. Intervention sites were selected non-randomly with a preference for larger sites and were predictably larger in terms of the number of patients. Both intervention and control sites had near-zero HPV vaccination among the youngest age group. Among 11 to 12 year olds, similar

HPV vaccination series initiation rates were observed at intervention sites (37% females, 30% males) and nonintervention sites (37% females, 27% males). For 13 to 18 year olds, intervention sites had higher HPV vaccine series initiation rates (73% females, 54% males) compared to nonintervention sites (65% females, 44% males).

Overall, similar patterns also were observed between intervention and nonintervention clinics for vaccine series completion rates (eg, 11% series completion for 11- to 12-year-old females in intervention clinics; 9% for the same group in nonintervention clinics). Sex differences in vaccination rates reported here always show

higher HPV vaccine administration for female patients compared to male patients. Intervention clinics had smaller sex differences in HPV vaccine series initiation rates at the time of intervention (eg,  $\Delta 6.2\%$  for 11 to 12 year olds in intervention clinics vs  $\Delta 9.8\%$  in nonintervention clinics).

### Preintervention Knowledge, Attitudes, and Practices

Before the intervention, many participants were unaware of the correct age range for HPV vaccination, and this varied by patient sex (Table 2). When asked about the earliest age for HPV vaccination, the majority incorrectly stated 11 to 12 years old. The second largest group correctly identified the youngest age range as 9 to 10 years. Few participants placed the lower age limit below 9 or above 12. Knowledge of upper age limits was also incomplete. Most correctly identified the upper age limit as 22 to 26 years. A few respondents thought it was over age 26, while a small number selected 18 to 21 years. A chi-square test confirmed a statistically significant difference in reported lower ( $\chi^2=491.68, P<0.001$ ) and upper ( $\chi^2=335.98, P<0.001$ ) age limits by sex.

Before the intervention, most participants recommended the HPV vaccine for females (91%) and males (88%), with a smaller group who said they recommended neither against nor in favor of the vaccine for females (8%) and males (9%). Only 1 participant said they recommended against the vaccine for females (1%), and a few more recommended against the vaccine for males (3%). A chi-square test confirmed a statistically significant difference in recommendation patterns between female and male patients ( $\chi^2=172.6, P<0.001$ ).

Prior to the intervention, most participants (57%) agreed or strongly agreed with the statement, "My patients (and/or their parents) react well to discussions about the HPV vaccine." About one-third (33%) neither agreed nor disagreed, while 10% indicated that patients/parents reacted negatively.

Respondents dramatically overestimated HPV vaccine series

**Table 2.** Preintervention and Postintervention Measures of Knowledge, Attitudes, and Practices With Respect to HPV Vaccination

|   | Preintervention |               | Postintervention |               |
|---|-----------------|---------------|------------------|---------------|
|   | Female Patients | Male Patients | Female Patients  | Male Patients |
| <b>Knowledge measures</b>   |                 |               |                  |               |
| Correct minimum age for HPV vaccination                                     | 38%             | 26%           | 41%              | 34%           |
| Correct maximum age for HPV vaccination                                     | 80%             | 87%           | 89%              | 73%           |
| Recommendations for HPV vaccination   |                 |               |                  |               |
| Recommend in favor  | 91%             | 88%           | 97%              | 96%           |
| Neither for nor against   | 8%              | 9%            | 3%               | 4%            |
| Recommend against   | 1%              | 3%            | 0%               | 0%            |
| <b>Attitude measures</b>  |                 |               |                  |               |
| Agree that patients react well to discussions about the HPV vaccine         | 57%             |               | 70%              |               |
| Respondent estimated percent of patients willing to receive HPV vaccination | 63%             |               | Not measured     |               |
| Respondent estimated percent of patients who had received the vaccine       | 59%             |               | Not measured     |               |

and completion rates in their own patient panels. On average, they believed that 63% of their patients were willing to receive the HPV vaccine and that 59% had received it. However, at the time of the intervention, the average initiation rate across the intervention clinics was just 38% (41% for females and 34% for males). The vaccine series completion rate was 18% (23% for female patients and 14% for males).

### Postintervention Knowledge, Attitudes, and Practices

Three months postintervention, most participants still incorrectly placed the lower age limit for HPV vaccination at 11 to 12 years (Table 2). A large minority correctly identified the range as to 10 years. A few inaccurately placed the lower age limit above the age of 12, while 1 participant said males could receive it before age 9.

Following the intervention, strong majorities placed the upper age limits between 22 and 26 years. One in 5 (21%) placed the upper limit for males in the 18- to 21-year range, while only 4% said the upper limit was 18 to 21 years for female patients. Small numbers of responders said that the upper limit for HPV vaccine was below the age of 18 years or above age 26 years for males. Differences in lower ( $\chi^2=129.8, P<0.001$ ) and upper ( $\chi^2=176.3, P<0.001$ ) age limits reported on the postintervention survey were significantly different by patient sex.

At 3 months postintervention, respondents almost universally indicated that they did recommend in favor of the HPV vaccine for females (97%) and males (96%). A few respondents said they neither recommended in favor nor against the HPV vaccine, and none reported recommending against the HPV vaccine for either sex. Differences in recommendations for females and males were not statistically significant.

Following the intervention, more than two-thirds (69%) of participants agreed or strongly agreed with the statement, "My patients (and/or their parents) react well to discussions about the HPV vaccine."

### Changes in Knowledge, Attitudes, and Practices

Postintervention knowledge improvements regarding HPV immunization age ranges were observed but did not reach statistical significance. After the intervention, participants showed stronger support for recommending the HPV vaccine to both female (pre mean=6.44, post mean=6.68) and male (pre mean=6.31, post mean=6.57) patients ( $P < 0.05$ ). Additionally, they reported better patient reactions to HPV vaccine discussions after the intervention (pre mean=4.73, post mean=5.05;  $P = 0.016$ ).

### Clinic-Level Change in HPV Vaccination Rates at 12- and 36-month Follow-up

Based on review of the electronic health records at the clinic level, intervention clinics showed increases in HPV vaccine initiation and completion rates for all age and sex groups at both 12- and 36-month follow-up, though not all changes were statistically significant. For example, at 12 months, female patients aged 11 to 12 years had 5.8% higher HPV series initiation rates and 1.2% higher completion rates as compared to baseline. Male patients aged 11 to 12 years had 10.1% higher series initiation and 3.2% higher series completion rates (results available from the authors).

Difference-in-difference regression models indicated that for most age and sex groups, intervention clinic gains were larger than the nonintervention gains at follow-up (Table 3). For example, at 12-month follow-up, intervention clinic female patients aged 11 to 12 years had 8.7% greater gains in HPV series initiation rates than in nonintervention clinics. Intervention clinic male patients in this age group had 8.4% greater gains in HPV series initiation rates than in nonintervention clinics. (Full results are available from the authors.)

To assess the change in the female-to-male gap in HPV vaccine rates between intervention and nonintervention clinics, we assessed sex differences in the change in HPV vaccination rates, comparing intervention to nonintervention clinics. Results showed that at the 12-month follow-up, the gap between females and males in HPV vaccine initiation rates decreased significantly in intervention clinics but only for 9- to 10-year-old patients. Completion rate gaps narrowed in intervention clinics only for 11 to 12 year olds and 13 to 18 year olds. Findings at the 36-month follow-up also were mixed. (Complete results are available from the authors.)

### DISCUSSION

Clinicians, being trusted information sources, play a pivotal role in influencing patient choices through strong clinical recommendations.<sup>16</sup> Considering the universal susceptibility to HPV and its association with various cancers in all sexes,<sup>17</sup> vaccination emerges as a vital preventive measure. In addition, widespread vaccination can reduce the risk that all individuals are exposed by producing herd immunity.<sup>18</sup>

Our study endeavored to bring clinicians current on rapidly

**Table 3.** Difference in HPV Series Initiation Rates Between Intervention and Nonintervention Clinics at 12-month Follow-up, by Sex and Age Group

|                 | Females            | Males              |
|-----------------|--------------------|--------------------|
| 9–10 year olds  | +2.0% <sup>a</sup> | -0.3% <sup>a</sup> |
| 11–12 year old  | +8.7% <sup>a</sup> | +8.4% <sup>a</sup> |
| 13–18 year olds | +2.5%              | +4.1%              |

<sup>a</sup>Statistically significant difference in difference at  $\alpha = 0.05$ .

Note: Positive numbers indicate that the preintervention/postintervention gain was greater in intervention clinics compared to nonintervention clinics. Negative number indicates that the pretreatment/posttreatment gain was greater in non-intervention clinics compared to intervention clinics.

shifting HPV vaccine guidance and offer them their own patient vaccination data, encouraging higher vaccination rates across patient demographics. Postintervention assessments illustrated an elevated understanding of the revised eligibility guidelines for male patients and fostered greater eagerness to recommend the vaccine to all individuals, complemented by positive shifts in perception regarding vaccine receptiveness from patients and parents.

Long-term follow-up revealed significantly greater improvements in intervention clinics over 12 and 36 months, showcasing sustained improvements. However, differences in changes in the gap between female and male HPV vaccination rates were inconsistent between intervention and nonintervention clinics. Future studies should further investigate whether improving clinicians' understanding of their performance on HPV vaccination rates can change their HPV vaccine practices, as well as whether such conversations can encourage collaboration among clinic staff through real-time data feedback.

### Limitations

This analysis has several limitations. Intervention clinics were selected based on patient panel size, not through random selection, potentially implicating other concurrent quality improvement endeavors in the observed results.<sup>15</sup> Further, the study uses a clinic-level analysis—a method that overlooks staff changes and multiclinic clinicians, making it difficult to rule out possible cross-contamination of the intervention in nonintervention clinics. Such cross-contamination, if it exists, likely weakened any observable effect of the intervention. Our analysis of knowledge, attitudes, and practices relies on self-reported attendance at the educational intervention, which we cannot verify independently. We also do not have any information on the completion rates—particularly for the postintervention survey among all staff at participating clinics. Low participation could affect how we interpret postintervention survey data. This is one reason we decided after the fact to conduct an analysis of HPV vaccine uptake data for all clinics.

### CONCLUSIONS

Our results suggest that in-person educational interventions that include elements of real-time data feedback and didactic



content may enhance HPV vaccination rates at the clinic level for extended periods. However, this intervention required substantial resources and intricate scheduling. Considering more cost-effective solutions, such as prerecorded or remote sessions despite potential compromises on customization, is advisable. Future studies should evaluate the tradeoffs of various intervention approaches.

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# The Legacy of Redlining and the Geography of Tobacco Retailers in Wisconsin

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## ABSTRACT

**Introduction:** Housing discrimination as one of the main mechanisms for reinforcing racial segregation has persisted historically in the United States through a process known as “redlining.” In recent years, researchers across different disciplines have utilized the iconic “residential security maps” created by the Home Owners’ Loan Corporation (HOLC) in the 1930s to analyze the structural roots of racial disparities. HOLC maps designated grading of “best” to “still desirable” to “definitely declining” and “hazardous” to urban areas where percentage of African American and foreigners were among the reordered measures.

**Objective:** Given that sales and marketing of tobacco products also present a historical connection to structural racism in the US, this study examines how historical redlining relates to current geographies of tobacco retailers in Wisconsin.

**Methods:** Analyses were conducted for 4 cities in Wisconsin with available HOLC maps. We used negative binomial models to account for spatial heterogeneity and overdispersion of retailers, and we controlled for present-day sociodemographic characteristics.

**Results:** Findings indicated that the hierarchy of HOLC grades are reflected in the present-day retailer density, and areas historically graded as “less desirable” have a higher present-day density of tobacco retailers. The result of the statistical model shows that poverty and percentage minority are also significant factors in distribution of tobacco retailers.

**Conclusions:** These results highlight that to address the structural roots of health disparities, we need intervention strategies that employ a comprehensive look at the historical legacies of discrimination.

## INTRODUCTION

It is estimated that 47.1 million adults in the United States currently use tobacco products.<sup>1</sup> Although there has been a substantial decrease in the prevalence of smoking in the US in the past decades, the disparities among specific subpopulations persist,<sup>2</sup> and

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Native American and non-Hispanic Black populations have the highest percentage of smokers.<sup>3</sup> Among the US Census regions, the Midwest has the highest percentage of smokers.<sup>3</sup> In 2020, 15.5% of Wisconsin adults smoked, which is the same as national average.<sup>4</sup> Annual health care costs directly caused by smoking in Wisconsin were estimated around \$2.66 billion.<sup>5</sup> In 2020, Wisconsin allocated \$5.3 million for tobacco use prevention.<sup>4</sup> However, Wisconsin is 1 of 19 states spending less than 10% of the amount recommended by the Centers for Disease Control and Prevention (CDC) for tobacco prevention programs, making the ratio of industry marketing to state tobacco prevention spending 31.1 to 1.5. Furthermore, research has shown that lower income and minority neighborhoods are disproportionately targeted by tobacco marketing,<sup>6</sup> and neighborhood characteristics (eg, poverty and segregation, density of tobacco retailers) play an important role in the prevalence of adolescent and teen smoking.<sup>7</sup>

The relationship between race, neighborhood characteristics, and health inequity in the US points to a historically persistent gap. There are many studies on the origins of the current disparities, with evidence of the role of residential segregation and geographies of concentrated disadvantage.<sup>8</sup> The extent to which these concentrated disadvantaged neighborhoods and the consequent existing disparities can be explained by previous racial housing policies has received growing attention in the last decade. One driving factor for this emerging interest is place-based causality and health outcomes. That is why understanding the patterns of residential segregation, their characteristics, and the underlying

contexts are important for health disparity research.

In the US, the major forces in shaping the cities and their residential patterns were the Great Migration and the appraisal practices of the Home Owners' Loan Corporation (HOLC) in the 20th century. As a product of the housing policies in the first half of the 20th century, HOLC maps were designed to systematically limit housing choices for African-American and other minority groups, while encouraging "white flight" to the suburbs.<sup>9</sup> The rating system employed by this program also affected future investments through assigned neighborhood grades (A=best, B=desirable, C=declining, and D=hazardous). Previous studies have shown the long-lasting legacy of redlining in American cities.<sup>10,11</sup> For example, contemporary racial and ethnic settlement patterns have been affected by previous housing policies and discriminatory practices.<sup>11</sup> A recent meta-analysis provided evidence of association between living in historically redlined areas with increased risk of multiple serious adverse health outcomes.<sup>10</sup> Recent studies also have speculated about the relationship between redlining designations and contemporary tobacco retailer disparities.<sup>12</sup> One pathway through which redlining might be associated with present day tobacco retailers' density is the long-lasting effects of redlining on current racial and ethnic settlement patterns across the country.<sup>11</sup>

Today, initiatives such as Mapping Inequality<sup>13</sup> have made historical HOLC data widely available for analysis. Building on previous research on residential segregation and geographies of tobacco retailers,<sup>12,14</sup> this study examines the inequity in the distribution of tobacco retailers, which has been shown as one of the determining factors for smoking risk disparities.<sup>15</sup> For example, a recent meta-analysis of 27 studies on the relationship between tobacco retailers' density and proximity and smoking behavior showed an estimated 2.48% reduction in risk of tobacco use from reductions in tobacco retailer density and proximity.<sup>15</sup> The research questions in this study included:

1. Is there a systematic disparity in contemporary geographies of tobacco retailers that corresponds with HOLC categories across Wisconsin? We hypothesized that HOLC grades are reflected in present-day tobacco retailers' density.

2. Is there a relationship between tobacco retailers' density and the current neighborhood level socioeconomic characteristics, including percentage minorities, percentage below poverty, and percentage below age 18 in Wisconsin? We hypothesized that areas with higher tobacco retailer density exhibit higher rates of concentrated poverty and minority populations.

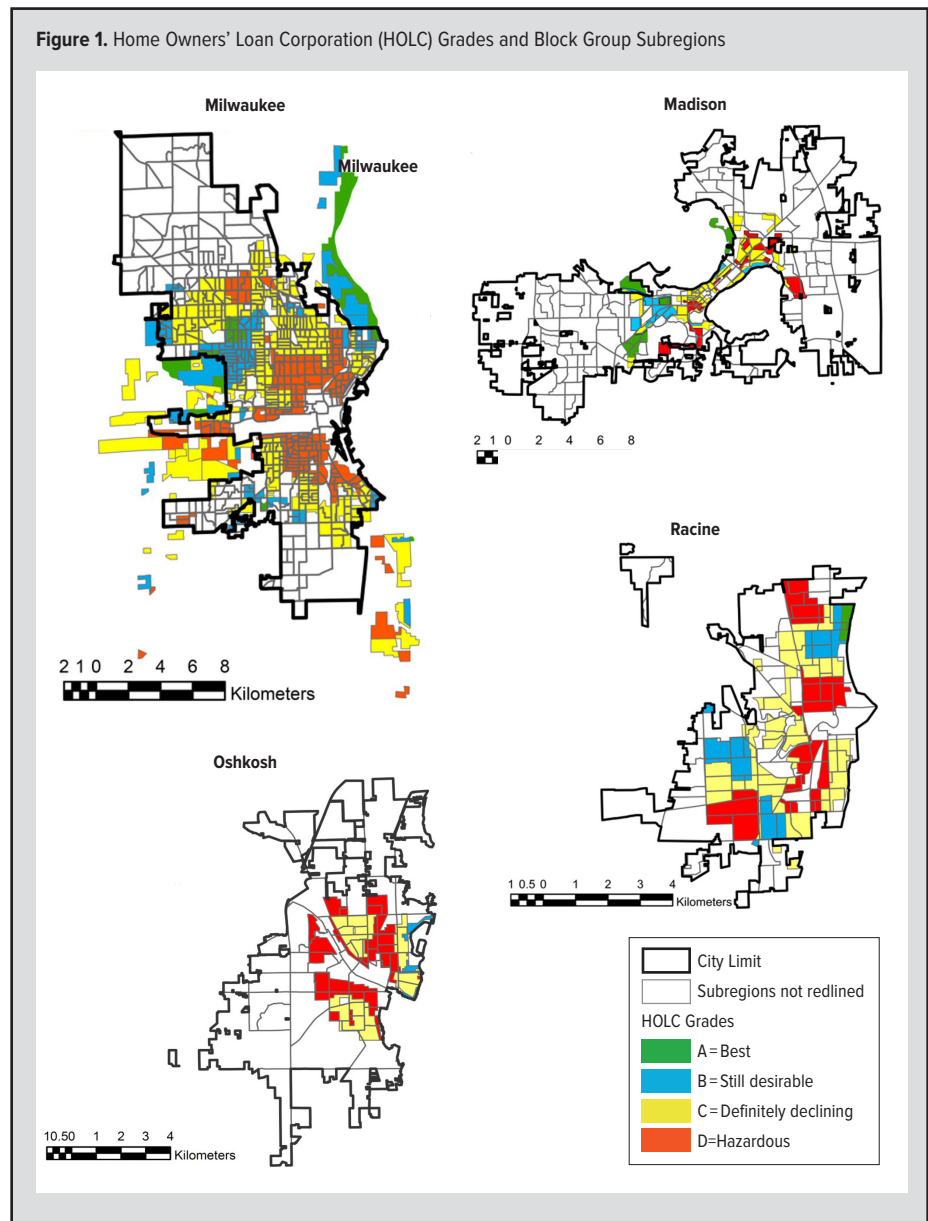
## METHODS

### Data Sources

We retrieved the HOLC boundary and grade data from Mapping Inequality.<sup>13</sup> At the time of this writing, the HOLC maps are available for 5 Wisconsin cities. We retrieved block group-level information about race/ethnicity, age, poverty, and total population from the 2016 American Community Survey 5-year estimates.

We were able to obtain the list of locations with tobacco sale licenses in 2020 from the city clerk's office from 4 cities

**Figure 1.** Home Owners' Loan Corporation (HOLC) Grades and Block Group Subregions





(Milwaukee, Madison, Oshkosh, and Racine). These retailers were then geocoded based on their street address.

### Analysis

#### Contemporary Sociodemographic Measures

We used the 2016 American Community Survey 5-year estimates to calculate the following measures for each block group: percentage of minority population, percentage in poverty, and percentage under age 18. Given that the percentage of African American (Black) population varies greatly across the cities studied and there are small percentages of Hispanic, Asian, and Native American population in most cities, the non-White population was categorized as minority population.

We used the Wisconsin state averages to define the cutoffs for “above average (high)” and “below average (low)” groups.<sup>12</sup> The average percentage of population living in poverty, the average percentage of minority population, and the average percentage of population under 18 in Wisconsin were 10.4, 19.1, and 21.8, respectively.<sup>16</sup> For example, block groups with percentage below poverty over 10.4 were coded as having above average prevalence of poverty; all other block groups were coded as low prevalence of poverty. Block groups with minority populations over 19.1% were coded as above average minority prevalence and the rest as low. Similarly, block groups with over 21.8% population under 18 were coded as above average prevalence of young people.

#### Historical Redlining Maps and Contemporary Measures

We overlaid the Shapefiles of the historical redlining maps for 4 Wisconsin cities with block group boundaries. We then defined smaller subregions for each HOLC-graded area that overlapped with a 2016 block group tract. These subregions as the unit of analysis were then assigned their respective HOLC grade. We marked areas that were not assigned a HOLC grade in the 1930s as “E.” We excluded the redlined areas that were outside of the city’s boundaries. Figure 1 shows the subregions and HOLC grades for these cities. We reallocated the total population and tobacco retailer counts to the subregions by reinterpolating by area size. This resulted in 1654 subregions with population and retailer counts.

**Table 1.** Summary of Four Regression Models on Associations Between Tobacco Retailer Counts in Subregions and Different Variables

| Variables                                 | Model 1:<br>HOLC                    | Model 2:<br>Socioeconomic<br>Variables | Model 3:<br>HOLC Grade and<br>Socioeconomic<br>Variables | Model 4:<br>HOLC Grade, Socio-<br>economic Variables<br>and City Effect |
|---|-------------------------------------|--|--|---|
|   | Estimate<br>95% CI                  | Estimate<br>95% CI                     | Estimate<br>95% CI                                       | Estimate<br>95% CI  |
| % Below age 18<br>Above avg vs below avg  |                                     | -0.32 <sup>a</sup><br>-0.499 to -0.146 | -0.30 <sup>a</sup><br>-0.472 to -0.119                   | -0.28 <sup>b</sup><br>-0.464 to -0.104                                  |
| % Below poverty<br>Above avg vs below avg |                                     | 0.73 <sup>a</sup><br>0.524 to 0.938    | 0.66 <sup>a</sup><br>0.447 to 0.866                      | 0.65 <sup>a</sup><br>0.439 to 0.861                                     |
| % Minority<br>Above avg vs below avg      |                                     | 0.61 <sup>a</sup><br>0.391, 0.837      | 0.60 <sup>a</sup><br>0.377 to 0.820                      | 0.63 <sup>a</sup><br>0.379 to 0.881                                     |
| HOLC Grade B vs A                         | 0.91 <sup>c</sup><br>0.030 to 1.933 |  | 0.77<br>-0.107 to 1.802                                  | 0.78 <sup>c</sup><br>-0.095 to 1.817                                    |
| HOLC Grade C vs A                         | 1.61 <sup>a</sup><br>0.773 to 2.602 |  | 1.28 <sup>b</sup><br>0.441 to 2.279                      | 1.29 <sup>b</sup><br>0.448 to 2.289                                     |
| HOLC Grade D vs A                         | 1.89 <sup>a</sup><br>1.048 to 2.890 |  | 1.54 <sup>a</sup><br>0.697 to 2.547                      | 1.55 <sup>a</sup><br>0.705 to 2.559                                     |
| HOLC Grade E vs A                         | 1.52 <sup>a</sup><br>0.697 to 2.519 |  | 1.30 <sup>b</sup><br>0.472 to 2.302                      | 1.31 <sup>b</sup><br>0.475 to 2.308                                     |
| Milwaukee vs Madison                      |                                     |  |  | -0.06<br>-0.305 to 0.191  |
| Racine vs Madison                         |                                     |  |  | -0.18<br>-0.520 to 0.149  |
| Oshkosh vs Madison                        |                                     |  |  | -0.00<br>-0.422 to 0.414  |
| Akaike information criterion              | 3669.8                              | 3579.6                                 | 3559   | 3563.8  |

Abbreviations: HOLC, Home Owners’ Loan Corporation; avg, average.  
<sup>a</sup> $P < 0.001$ , <sup>b</sup> $P < 0.01$ , <sup>c</sup> $P < 0.1$

**Table 2.** Summary Statistics of the Tobacco Retailers by Socioeconomic Factors and HOLC Grade

| City      | No. of<br>Subregions | Percentage With Above Average: |          |          | HOLC Grade (%) |       |       |       |       |
|-----------|----------------------|--------------------------------|----------|----------|----------------|-------|-------|-------|-------|
|           |                      | Poverty                        | Minority | Under 18 | A              | B     | C     | D     | E     |
| Madison   | 308                  | 49.35                          | 47.08    | 27.60    | 4.22           | 6.82  | 19.81 | 9.74  | 59.42 |
| Milwaukee | 1032                 | 71.80                          | 83.14    | 62.5     | 2.42           | 12.69 | 31.40 | 17.93 | 35.56 |
| Racine    | 194                  | 58.76                          | 84.02    | 65.46    | 2.06           | 12.37 | 27.83 | 15.46 | 42.27 |
| Oshkosh   | 120                  | 59.16                          | 7.5      | 43.34    | —              | 4.17  | 24.16 | 30.83 | 40.83 |
| Total     | 1654                 | 65.18                          | 71.04    | 54.96    | 2.54           | 10.94 | 28.30 | 17.05 | 41.17 |

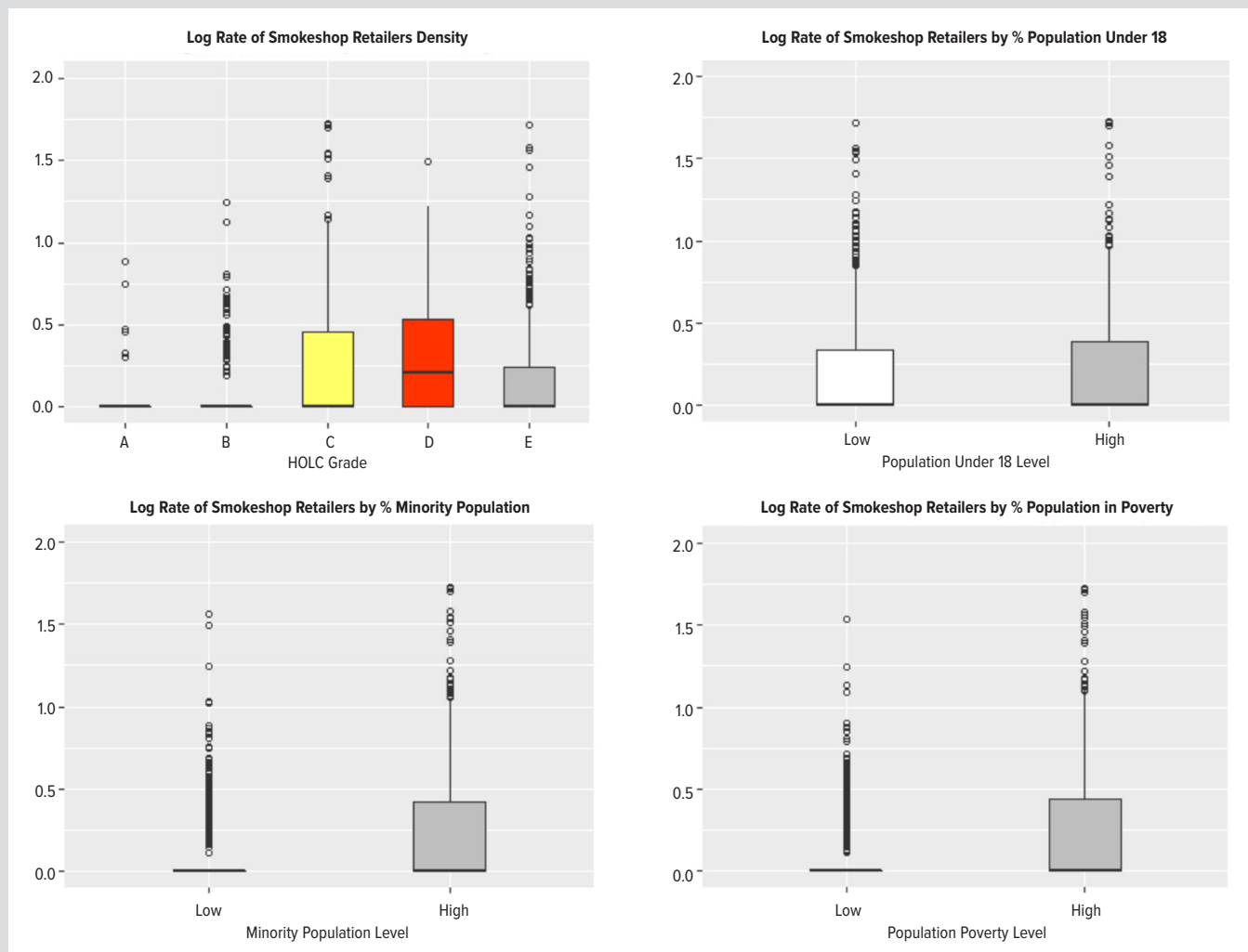
Abbreviations: HOLC, HOLC, Home Owners’ Loan Corporation.

### Statistical Analysis

First, we explored relationships between tobacco retailer density and sociodemographic factors and HOLC grade using boxplots and descriptive statistics. In examining the differences for tobacco retailer density and socioeconomic variables by HOLC grade, we used Mann-Whitney U test, a nonparametric test of the null hypothesis. We then used negative binomial regression models to examine the relationship between retailer density and sociodemographic factors. This method is used to model count (usually overdispersed) outcome variables and to account for overdispersion across subregions.<sup>17</sup>

In this study, the negative binomial statistical analysis included 4 models (Table 1). In the first model, we looked at the relation-

**Figure 2.** Boxplots of the Log Rate of Tobacco Retailers' Density, per 1000 People, by HOLC Grade and Socioeconomic Variables



Abbreviation: HOLC, Home Owners' Loan Corporation.

ship between density of retailers and HOLC grades. In the second model, we looked only at socioeconomic factors. In the third model, we looked at both socioeconomic variables and HOLC grades. In the fourth model, we also accounted for the effect of city. To compare the models, we used the Akaike information criterion (AIC), which is an estimator for relative quality of a statistical model. We used MASS and magrittr packages in R (R Core Team, 2022)

## RESULTS

The analysis resulted in 1117 retailers across 1654 subregions in 4 cities, with a total population of 1903254. Table 2 provides a summary of the distributions of socioeconomic factors and HOLC grades across the study cities. Most subregions (41.17%, 643235 people) were not historically graded (E). Of those subregions that were graded, the majority were grade C “definitely declining” (28.30% of subregions, 279037 people), followed by D: “hazardous” (17.05% of subregions, 164611 people), then B:

“still desirable” (10.94% of subregions, 88807 people), and A: “best” (2.54% of subregions, 17143 people). Table 2 also shows that the majority of the subregions have above average prevalences of poverty, minority populations, and population under 18.

Figure 2 displays summaries of the log retailer density and sociodemographic characteristics based on HOLC grades. The results show that retailer density mirrors the hierarchy of the HOLC grades. Also, the retailer density is higher in areas with above average percentage of minorities and prevalence of poverty. The retailer density seems slightly higher in areas with above average population under 18.

The results of the Kruskal-Wallis test for tobacco retailer density and the socioeconomic measures indicate that for all the measures, there were significant differences across HOLC grades. As illustrated in Table 3, Mann-Whitney U tests revealed that for retailer density, all of the differences were statistically significant, except for the difference between grades B and A and the difference between grades B and areas not redlined. For percent under

**Table 3.** Mann–Whitney U Test Results for Tobacco Retailer Density and Socioeconomic Characteristics Based on HOLC Grades

| HOLC Grade | Tobacco Retailers Density |                  | % Below Poverty      |                    | % Minority           |                   | % Under Age 18       |                 |
|------------|---------------------------|------------------|----------------------|--------------------|----------------------|-------------------|----------------------|-----------------|
|            | Difference in Median      | 95% CI           | Difference in Median | [95% CI]           | Difference in Median | 95% CI            | Difference in Median | 95% CI          |
| B–A        | -0.000                    | -0.000 to 0.000  | -3.208               | -7.318 to 0.063    | -9.226 <sup>a</sup>  | -17.905 to -1.780 | -1.588               | -4.762 to 1.463 |
| C–A        | -0.000 <sup>c</sup>       | -0.000 to -0.000 | -12.461 <sup>c</sup> | -17.920 to 7.514   | -17.456 <sup>c</sup> | -28.330 to -8.521 | -2.716               | -6.320 to 0.888 |
| D–A        | -0.000 <sup>c</sup>       | -0.283 to -0.000 | -15.894 <sup>c</sup> | -22.142 to -10.478 | -14.526 <sup>c</sup> | -25.385 to -6.028 | -2.540               | -6.418 to 1.459 |
| C–B        | -0.000 <sup>c</sup>       | -0.000 to -0.000 | -7.930 <sup>c</sup>  | -10.818 to -5.242  | -5.841 <sup>b</sup>  | -11.584 to -1.725 | -0.834               | -2.837 to 1.152 |
| D–B        | -0.000 <sup>c</sup>       | -0.047 to -0.000 | -11.310 <sup>c</sup> | -14.508 to -8.173  | -3.656               | -9.261 to 0.782   | -0.555               | -2.944 to 1.736 |
| D–C        | -0.000 <sup>a</sup>       | -0.000 to 0.000  | -3.115 <sup>a</sup>  | -5.802 to -0.455   | 2.114                | -0.842 to 5.374   | 0.181                | -1.703 to 2.185 |
| A–E        | -0.000 <sup>a</sup>       | -0.000 to -0.000 | -3.663 <sup>a</sup>  | -7.350 to -0.540   | -5.580               | -12.837 to 1.285  | 0.426                | -2.826 to 3.521 |
| B–E        | -0.000                    | -0.000 to 0.000  | -0.245               | -2.094 to 1.589    | 3.643                | -0.017 to 7.722   | 2.082 <sup>a</sup>   | 0.389 to 3.751  |
| C–E        | 0.000 <sup>c</sup>        | 0.000 to 0.000   | 7.857 <sup>c</sup>   | 5.985 to 9.819     | 12.153 <sup>c</sup>  | 8.460 to 16.376   | 2.805 <sup>c</sup>   | 1.374 to 4.212  |
| D–E        | 0.000 <sup>c</sup>        | 0.000 to 0.000   | 11.270 <sup>c</sup>  | 8.934 to 13.625    | 9.363 <sup>c</sup>   | 5.316 to 14.159   | 2.503 <sup>b</sup>   | 0.737 to 4.293  |

Abbreviation: HOLC, Home Owners' Loan Corporation.

<sup>a</sup> $P < 0.05$ , <sup>b</sup> $P < 0.01$ , <sup>c</sup> $P < 0.001$

poverty, all were statistically significant, except for the difference between grades B and A and the difference between grades B and areas not redlined. For minority populations, all differences are significant except for D and B, D and C, A and E, and B and E.

Table 1 shows the results of different models for the negative binomial regression. Model 3, including both HOLC grades and socioeconomic variables, is a better fit compared to the others. For example, the expected log count for subregion with above average percent of minority population is 1.822 higher than areas with below average percentage of minority population. The expected log count for subregions with above average percentage of poverty is 1.934 higher than subregions with low prevalence of poverty. Additionally, with the exception of grade B, the geography of retailer locations mirrors that of HOLC grades hierarchy. For example, in grade D areas, the expected log count is 4.664 higher than the expected log count in grade A areas. The part of the cities that were not graded also has higher tobacco retailers than grade A. The results also show that areas with an above average percentage of the population under 18 have fewer tobacco retailers.

For sensitivity analysis, we also ran the models with different cutoffs for percentage below poverty, minority percentage, and percentage under 18. We ran the models for top quarter and 80th and 90th and 3rd percentiles. While HOLC levels remained significant in all of these variations, other variables were not consistently significant. For example, in models using 90th percentile, 80th percentile, and top quarter cutoff, percentage minority was statistically significant, while in models with 3rd percentile cut off, percentage below poverty was significant.

We also ran the models stratifying by city. And while the results remain significant for Milwaukee and Madison, for Oshkosh and Racine, which had smaller numbers of subregions, the models were not significant. In Racine, only percentage of poverty was statistically significant, and in Oshkosh, none of the variables were statistically significant. Also, looking at minority groups separately would result in statistically significant associa-

tion with tobacco retailer count for African American population only.

## DISCUSSION

This study examined the association between historical redlining and disparities in the distribution of present-day tobacco retailers in 4 Wisconsin cities. The first research question was whether there is a systematic disparity in contemporary geographies of tobacco retailers that corresponds with HOLC categories across Wisconsin. Our findings showed that there is a statistically significant association between previous housing policies and the current geographies of tobacco retailers across the Wisconsin cities. The analysis showed that lower HOLC grades were associated with higher number of present-day tobacco retailers, such that areas historically graded as “best” had lower exposure to tobacco retailers than lower graded areas.

The second question was whether there is a relationship between tobacco retailers' density and the current neighborhood-level socioeconomic characteristics, including percentage minorities, percentage below poverty, and percentage under age 18 population in Wisconsin. Our findings also showed that socioeconomic factors including percentage in poverty and percentage of minority population were associated with a higher number of tobacco retailers. Areas with a higher percentage of the population under 18 had a slightly lower number of tobacco retailers.

In recent years, many studies have pointed to the legacies of redlining across the United States and its association with disparate health outcomes.<sup>18</sup> The results of this study add to previous findings regarding the relationship between redlining and health-related behavioral factors,<sup>21</sup> as well as previous research indicating an association between redlining and the geographical distribution of tobacco retailers in Ohio.<sup>12</sup>

Reducing health inequalities requires an understanding of the systematic patterns of discrimination perpetuated through housing policies and neighborhood environments. It is important to

note that while the results do not prove causality, they highlight the long-lasting effects of structural racism and housing discrimination on exposure to tobacco products. And although historical redlining is not a proxy for current-day neighborhood characteristics,<sup>11</sup> the results indicate that understanding the historical context is important for tobacco use prevention and control policy, as well as education-based interventions in Wisconsin. Licensing and zoning are effective strategies to impact the density of tobacco retailers across neighborhoods.<sup>20</sup> In Wisconsin, a license is required to sell tobacco products other than e-cigarettes.<sup>4</sup> A statewide Tobacco Retailer Licensing Program to regulate access to all tobacco products is the most effective policy approach for monitoring and restricting businesses that sell tobacco products. Regulating the density of tobacco retailers through zoning provisions has been adopted as a tobacco control policy by many local governments across the country; examples include restriction of new retailers in residential areas or in proximity of some land uses (eg, places where youth frequent) and limiting the number or density of tobacco retailers in certain zones through zoning ordinances.<sup>21</sup>

Educational initiatives are also particularly important in raising awareness of the adolescents and youth living in concentrated disadvantaged neighborhoods as they are exposed to higher rates of secondhand smoking and other inequities that can increase the chances of smoking both during adolescence and later adult life.<sup>22</sup> Interventions to target disparate exposure to tobacco products—especially in cities with a long history of racial segregation—should draw on the historical context of structural racism to advance political will to alleviate the consequent health disparities.

### Strengths and Limitations

We used a comprehensive list of tobacco retailers' locations in these cities. The study covers the most populated urban areas in the state. The analysis also uses block group units to provide more detailed results but inherits the limitations associated with small area estimations. However, this study only examined 4 cities due to data availability. Further research is needed to include the entire State of Wisconsin and other cities across the US. The population estimates for subregions were calculated based on area interpolations and are subject to the limitations of this method.

### CONCLUSIONS

The results of this study suggest that to address the structural roots of health disparities, intervention strategies that take into account a comprehensive look at the historical legacies of discrimination are needed.

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# Aim More Toward the Bed than the Head: A Proof-of-Concept Pilot Study on a Simple Technique for Keeping Trauma Thoracostomy Tubes Out of Lung Fissures

Jacob R. Peschman, MD; Alec J. Fitzsimmons, MPH; Andrew J. Borgert, PhD; Carley S. Buisman, CHSE; Christine J. Waller, MD; Faraz A. Khan, MD

## ABSTRACT

**Introduction:** Tube thoracostomy (TT) is used to drain the pleural cavity in the setting of both traumatic and nontraumatic pathologies. Literature has shown that inappropriate tube positioning occurs in 30% of patients, including TTs placed within the fissure, which may result in further interventions in these patients. Our goal was to compare the rates of TT placed into a lung fissure in a controlled model using a simple approach to direct the tube more toward the bed than the patient's head at the time of placement to validate further investigations of the clinical applicability of this technique.

**Methods:** We performed 650 tube thoracostomies in 3 separate cadaver torsos with tracheal intubation and bag valve mask approximating a 50% pneumothorax. TTs were performed by experienced clinicians using a "more toward the head" direction and a "more toward the bed" direction while varying other factors, including side of the chest, tube size, and location on the chest wall, followed by lung re-expansion to better evaluate each approach in different common clinical scenarios. A power analysis was performed for our primary outcome of tube placement in a lung fissure by direction, not for any additional variables. Multivariate analysis was used to determine whether the "head" or "bed" direction was more likely to result in tube placement in a fissure when controlling for other changes.

**Results:** A total of 650 TTs were placed in 3 cadavers by 2 experienced performers. The overall rate of tube placement in a fissure was 41% using the "head" direction and 13% using the "bed" direction. On multivariate analysis, the "bed" direction also was shown to have significantly decreased tube placement in a lung fissure when controlling for side, tube size, and location ( $P < 0.01$ ; odds ratio 0.22; 95% CI, 0.14–0.33).

**Conclusions:** Aiming more toward the bed than toward the head during TT placement is associated with a significantly decreased chance of placing the TT within a lung fissure in this highly controlled cadaveric proof-of-concept model. This technique requires no changes to standard TT placement set-up, time, cost, or equipment. We propose that it warrants further investigation as a potential intervention to decrease malpositioned tubes.

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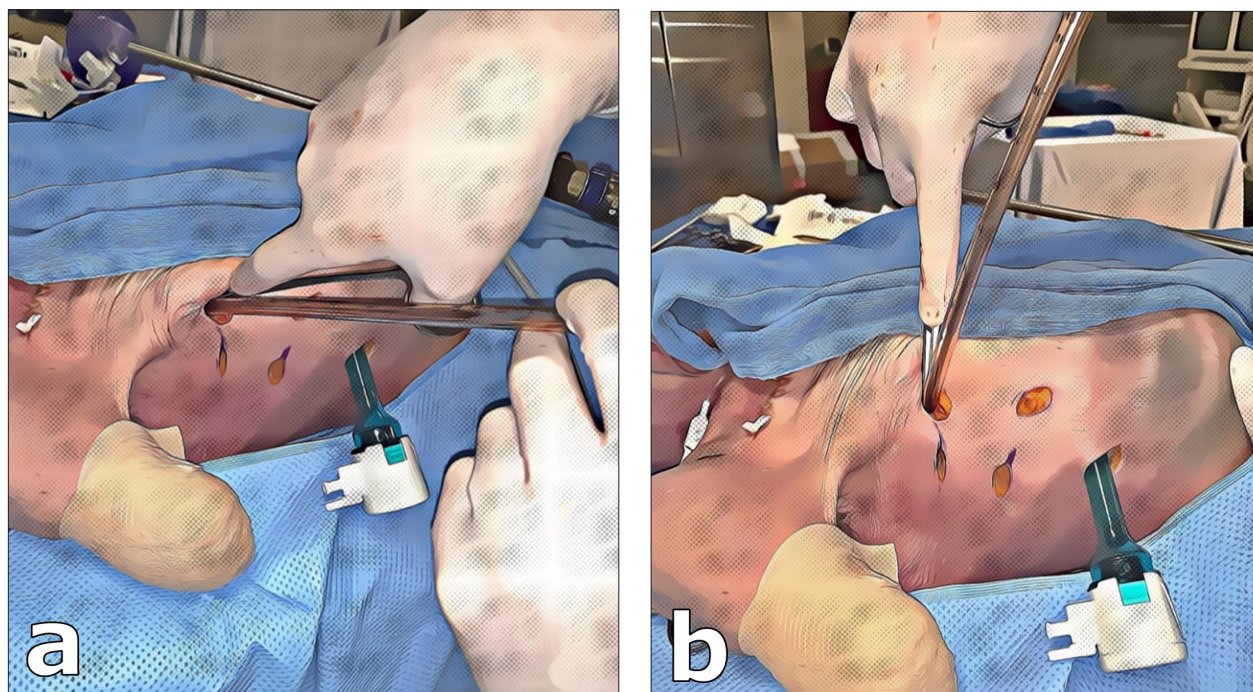
## INTRODUCTION

Placement of a thoracostomy tube (TT), also referred to as a chest tube, is a technique used to drain the pleural cavity of blood or air following traumatic injuries, as well as fluid in other nontraumatic pathologies. While it is considered a fairly basic and common procedure with well-described and consistent steps, it also can be lifesaving for those with traumatic injuries. As such, it is a required procedural skill in the American College of Surgeon's Advanced Trauma Life Support (ATLS) training course.<sup>1</sup> This course is required of all physicians, nurse practitioners, and physician assistants who care for trauma patients in many states as it is expected that any clinician may be in a position to place a lifesaving TT in a trauma patient. The clinicians taking this course often are not experts in trauma care or TT placement. Therefore, ATLS focuses on safety during placement and outlines specific steps expected of all learners. By following these steps, ATLS teaches 1 way to perform a TT, which emphasizes directing the TT

toward the patient's head.

Complications associated with TT placement, such as empyema, retained hemothorax, and intraparenchymal tube placement, continue to be reported in 20% to 40% of cases.<sup>2,3</sup> Multiple factors have been thought to increase the chance of complications, including but not limited to clinician experience, malposition of the tube, and placement location.<sup>3,4</sup> Incorrect pleural cavity positioning is believed to occur in approximately 30% of all TT pro-

**Figure 1.** (A) Tube Thoracostomy Aimed “More Toward the Head” and (B) Tube Thoracostomy Aimed “More Toward the Bed”



cedures, which can lead to an increased need for reintervention, a longer hospital stay, and increased cost.<sup>5,6</sup> One type of tube malposition is placement within a lung fissure. Although tubes that rest within a lung fissure can function similarly to tubes placed in the more ideal posterior, apically directed position within the pleural space, several studies have suggested that their poorer function increases the need for reintervention.<sup>7,8</sup>

The purpose of our proof-of-concept pilot study was to determine whether the direction of insertion of a TT aimed more toward the bed than toward the head would decrease the likelihood of a tube being placed in a fissure in a cadaver model compared with the standard apex-directed (head) insertion technique. This was based on the experience of one of the practicing trauma surgeons at our institution who regularly taught trainees using a bed-directed placement angle in order to best position the tube within the pleural space. The bed-directed insertion differed from most insertions by having the individual placing the tube bring their elbow over the patient's chest to ensure the clamp holding the tube was directed in a more posterior than apical direction (Figure). Placement across the patient's torso from the patient's contralateral side also was discussed though considered less practical. We hypothesized that this simple change in insertion technique could impact the end position of the tube in the pleural cavity in a way that has the potential to have better function and could be included easily as part of future standard teaching to clinicians who place TTs in the setting of trauma.

## METHODS

To determine the number of TT attempts utilizing the toward the head and bed approaches required to determine a difference in this study, the rates of TTs most commonly malpositioned into a lung fissure in the published literature were reviewed. In 5 selected publications, the reported malpositioned rates were 3%, 19%, 22%, 34% and 53%, yielding a median rate of 22% and a mean rate of approximately 26%, which was selected for our power calculation.<sup>4,5,7,9,10</sup> It was determined that a minimum of 320 TT placements would be needed (160 bed and 160 head placements) to detect a 50% decrease in the likelihood of fissure tubes at 80% power with  $\alpha = 0.05$ . To better simulate clinical TT placement variability, the authors elected to increase the sample size to 640 total insertions to provide sufficient power to control for the effects of additional relevant variables, including side of chest (right vs left), intercostal space (4th to 5th vs 6th to 8th), location (anterior vs mid-axillary), and tube size (28 French [Fr] vs 36 Fr). Chi-square tests were used to compare the rate of tube placement in a fissure by placement approach. A multivariate logistic regression model was constructed to control for the effects of other relevant clinical factors. All analyses were performed using version 9.4 of the SAS software suite (SAS Foundation, Cary, North Carolina).

Two experienced performers—1 faculty trauma surgeon and 1 postgraduate year 4 (PGY4) general surgery resident—performed the TTs in 3 separate cadaver models following the same steps for each TT placement. Tracheal intubation was performed on each

cadaver model. A sternotomy was completed so that the placement/location of each TT could be identified with direct visualization/palpation. The sternum was reapproximated after each performance to ensure a more normal chest wall structure before the next attempt. A bag valve was connected to the endotracheal tube, and for each individual placement attempt, the lung was inflated to approximate a 50% pneumothorax based on visual estimates of the observed lung filling the pleural cavity with the bag valve inflation. A 50% pneumothorax equivalent was selected to reflect a traumatic pneumothorax in a clinical setting that would warrant intervention as opposed to potential observation.

Two approaches to placement were employed: placement using the traditional approach, in which the tube was inserted from the ipsilateral side of the body (the more towards the head approach), and using the alternative approach, in which the tube was inserted with care taken to direct it more laterally than apically (the more towards the bed approach) (Figure). These placement techniques were utilized in series via the same skin incision and chest wall tract at each of our varied locations to imitate different potential clinical situations (ie, an incision placed lower or more anteriorly than ideal). After the tube was placed, the lung was reinflated with the bag valve mask from 50% to 100% expanded to simulate re-expansion of the lung for final determination of how the tube would rest with an expanded lung. The final tube position was then assessed via the sternotomy, with direct visualization/palpation of each tube as a binary outcome; the tube was either within a fissure or not and resting between lung parenchyma and chest wall. An anterior or posterior position was not differentiated for the purposes of this end point. The performers were not blinded to the tube placement results.

## RESULTS

A total of 650 tube thoracostomies were completed in 3 separate cadavers by 2 experienced physicians individually. These were completed on each side of the cadaver, varying the placement direction (head vs bed), side, tube size, and location. The number of attempts made were 160, 170, and 320 in cadavers 1, 2, and 3, respectively. The overall rate of tubes placed in the fissure was 27%. Using the “bed” direction, 13% of TTs were placed in a fissure, and while using the “head” direction, 41% of tubes were placed in a fissure ( $P < 0.01$ ). All “bed” attempts yielded tubes directed either within the fissure or between the posterior chest wall and the lung. During 1 “head” attempt, a tube was placed intraparenchymal.

A multivariate analysis was completed to better identify the effect of placement direction in the context of separate clinical scenarios. Variables in the model included direction of placement (head vs bed), cadaver, side of chest (right vs left), intercostal space (4th to 5th vs 6th to 8th), location (anterior vs mid-axillary), and tube size (28 Fr vs 36 Fr). In the multivariate regression, placement direction was found to significantly affect the rate of a TT

**Table 1.** Multivariate Regression Results

| Variable               | Comparison                        | OR (95% CI)      | P value |
|------------------------|-----------------------------------|------------------|---------|
| Direction of placement | Head vs bed                       | 0.20 (0.13–0.30) | <0.0001 |
| Cadaver                | 1 vs 3                            | 0.20 (0.11–0.39) | <0.0001 |
| Cadaver                | 2 vs 3                            | 0.99 (0.62–1.60) | 0.97    |
| Side                   | Left vs right                     | 0.70 (0.43–1.11) | 0.13    |
| Tube size, Fr          | 28 vs 36                          | 0.75 (0.51–1.10) | 0.14    |
| Intercostal space      | 4-5 vs 6-8                        | 1.28 (0.87–1.89) | 0.21    |
| Location               | Anterior axillary vs mid axillary | 0.98 (0.67–1.45) | 0.94    |

Abbreviations: OR, odds ratio.

**Table 2.** Multivariate Regression Results Excluding Cadaver 1

| Variable               | Comparison                        | OR (95% CI)      | P value |
|------------------------|-----------------------------------|------------------|---------|
| Direction of placement | Head vs bed                       | 0.22 (0.14–0.33) | <0.0001 |
| Cadaver                | 2 vs 3                            | 1.05 (0.65–1.71) | 0.83    |
| Side                   | left vs right                     | 0.82 (0.50–1.33) | 0.40    |
| Tube size, Fr          | 28 vs 36                          | 0.84 (0.56–1.27) | 0.40    |
| Intercostal space      | 4-5 vs 6-8                        | 1.18 (0.78–1.79) | 0.42    |
| Location               | Anterior axillary vs mid-axillary | 0.92 (0.61–1.39) | 0.69    |

Abbreviations: OR, odds ratio.

being placed in a fissure (Table 1) ( $P < 0.01$ ; OR 0.22; 95% CI, 0.13–0.30). The cadaver itself also seemed to affect the initial regression model, with cadaver 1 being associated with a decreased chance of placement within a fissure ( $P < 0.01$ ; OR 0.2; 95% CI, 0.11–0.39). Cadaver 1 had an incomplete fissure on 1 side, which likely resulted in a significantly decreased chance of placement within a fissure. When excluding cadaver 1 data, only placement direction still significantly affected the rate of placement in a fissure (Table 2) ( $P < 0.01$ ; OR 0.22; 95% CI, 0.14–0.33). The side of the chest, tube size, intercostal space, and location on the chest did not affect the ultimate positioning of a TT.

## DISCUSSION

Using cadaver models, we found that the rate of TT placement in a fissure was lower using the more toward the bed direction when controlling for multiple factors, including tube size, location, and intercostal space. While these results are promising, the impact of implementing this technique in training and practice remains to be determined. While we also saw no significant complications with this technique and expect that training will not add any complexity to the procedure, a primary question remains: how much a tube placed in a lung fissure even matters. Batchelder and Morris established that TT placement within a fissure is considered non-ideal; however, data remain mixed about the true clinical impact.<sup>11</sup> In a retrospective radiographic evaluation following TT placement, Maurer and colleagues recognized that tubes placed in the minor or major fissure required replacement in certain cases with potential for inadequate drainage of the pleural space.<sup>12</sup> More recently, Kim et al also noted retrospectively that tubes placed within the



fissure have a higher chance of need for reintervention.<sup>8</sup> However, one concern is a clinician hindsight bias that having identified the tube as within the fissure, a lower threshold for replacement or another secondary intervention was maintained due to the expectation it was less likely to work. Conversely, Kugler et al completed a retrospective review evaluating whether tube position or function affected the need for reintervention after TT. They found that if TTs were not kinked, there was no increased risk of reintervention.<sup>9</sup> In a prospective trial, Curtin and colleagues found that placement in a fissure had no significant effect on patient outcomes.<sup>3</sup>

While our study was not powered to specifically examine other variables, including tube size or location (intercostal space, mid vs anterior axillary line) and their impact on tubes placed into a fissure, we did feel it was necessary to evaluate these variables as they are common variations seen when tubes are placed clinically—especially in emergent trauma situations. The data also would suggest they do not have significant clinical impact. Maybauer et al performed an extensive retrospective review of 1065 patient records and evaluated TT placement based on location. The authors found no difference in complication rate based on position in the 4th to 5th intercostal space at the midaxillary line or in the 2nd to 3rd intercostal space at the midclavicular line.<sup>10</sup> Hernandez et al reviewed adult trauma patients requiring TT over 1 year and evaluated whether the angle of placement increased the rate of complications. They radiographically reviewed the angle of insertion and noted that an increased angle ( $>45^\circ$ ) was associated with increased complications.<sup>7</sup>

Although questions remain regarding the clinical impact of a TT resting in a fissure, the goal for placement remains an optimally positioned tube—one that is posterior and superiorly directed and not in a fissure. Therefore, there seems to be little reason not to adopt a technique more likely to achieve this goal if there is no associated increase in cost, time, equipment or complications. Etoch et al completed a retrospective review and found increased complications in TT completed by nonsurgeon physicians.<sup>5</sup> They postulated that further training in the TT placement would improve outcomes. Aiming more toward the bed than the head is a simple, free, easily replicated, and easily taught technique that can be utilized at the time of TT placement.

Using a highly controlled cadaver model to assess the issue of malpositioned tubes placed in a clinical setting does have limitations. We attempted to recreate reinflation with tracheal intubation and bag-valve-mask; however, this may not adequately model reinflation after TT placement and would only be for pneumothorax drainage versus drainage for a hemothorax or effusion. Presence of a pleural fluid density itself also could alter the path the tube travels in the chest cavity, which was not part of this model. We also looked at the binary outcome of in the fissure or not in the fissure. As previously discussed, “malpositioned” is inconsistently

defined in the literature, making ultimate attribution of function to location a challenge. A tube along the diaphragm or in the fissure may very well function adequately for the patient’s pathology but radiographically be defined as malpositioned. For this proof-of-concept pilot, we focused specifically on tubes within the fissure for our outcome based on our interpretation of the available literature of this position more likely affecting function and the suspected overall physiologic impact of the tube’s drainage holes being opposed on all sides by lung parenchyma versus tubes not in the apex but in the space between lung and posterior, which would communicate with more contiguously with the pleural space. Debate on the validity of this assumption is very reasonable and can be assessed in future models that include more details on other positions (ie, along the diaphragm), and when the presence of fluid or coagulated blood is part of the pathology, the tube must evacuate to be considered successful.

Anatomic variants were also limited in this pilot. One cadaver had an incomplete fissure, which highlights the anatomic variability that may affect the ultimate tube position but is outside of the clinician’s control. Other patient factors that could impact the direction a tube takes once in the pleural cavity, such as presence of adhesions from previous thoracic pathology, presence of traumatic injuries such as rib fractures or hemothorax with clot, and patient body mass index (BMI) (all of the cadavers’ BMIs were  $<25$ ) impacting the length of the subcutaneous tract, could not be assessed. In this model, we were limited to 1 skin and chest wall tract at each location due to the limited number of cadavers available. Tract likely has a significant impact in direction of a TT, particularly in larger BMI patients; therefore, we were not able to identify if tract-specific factors including length affected the rate of tubes within a lung fissure. Additionally, after placing over 100 TTs in each cadaver, it is possible that tracts along the lung parenchyma or directed toward the fissure led to recurrent placement in the same position, which would not occur in a clinical scenario where a single tube is placed in a single attempt. Muscle memory of the performers with immediate unblinded feedback on tube location also could have affected placement in or out of a fissure and could not be controlled for within the design of this study. This may have been further amplified by the fact we only had two performers available to participate in the TT placements for the study. More performers with various experience could have limited the possible muscle memory component but would have added additional variables in what was meant to be a highly controlled proof-of-concept trial.

## CONCLUSIONS

Using a highly controlled cadaver model and experienced performers, we varied the approach to TT placement from the classic “more toward the head” direction to the “more toward the bed” direction and reduced our rates of TT placement within lung fissures. This functioned as a proof-of-concept pilot model to sup-



port next steps in investigation in both the training and patient outcomes for this simple technique. When controlling for multiple clinical scenarios, including tube size, location on the chest, side, and intercostal space, only the proposed placement technique significantly decreased the likelihood of a TT being placed within a fissure. Implementation of an “aim more toward the bed than toward the head” mantra during TT skills training could very easily be incorporated in standard TT placement steps without adding any significant complexity to the procedure for learners.

The next steps in the evaluation of this approach will include training of more novice performers and adding additional pathology, including fluid or coagulated blood models, to compare the “head” and “bed” directions. However, this further investigation appears warranted given this simple change adds no cost, time, or equipment to current TT placement standards and has the potential to reduce the need for reintervention due to tube malfunction.

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# Qualitative Evaluation of Incorporating Ultrasound Education Into an Undergraduate Medical Education Clinical Human Anatomy Course

Jared R. Muench, MD; Michael A. Schellpfeffer, MD, MS

## ABSTRACT

**Introduction:** Ultrasound use as a procedural guide and diagnostic tool has led many to herald it as the “new stethoscope.” Thus, medical schools are seeking to integrate ultrasound training into their longitudinal curricula. While various methods have been trialed, incorporating ultrasound into basic science courses as a supplementary learning tool often offers students their first exposure. This study seeks to identify factors that affected student excitement and perceived value of ultrasound training as part of an anatomy course.

**Materials and Methods:** A brief survey was distributed to first-year medical students after completing ultrasound education in a clinical human anatomy course. This survey gauged student excitement and perceived value of the ultrasound sessions. Through free-response, students expounded on factors that affected their ratings. Qualitative student feedback was organized, coded, and associated with student excitement and perceived value ratings using thematic analysis.

**Results:** Responses were returned from 26.2% of the surveyed group. Ten and 6 themes were identified in response to students’ excitement and perceived value ratings of the sessions, respectively. Clinical relevance/utility was identified consistently as the most influential factor affecting student engagement. In addition, students’ personal motivation and incentive, as well as the structure and learning environment of the sessions, were found to impact student engagement.

**Conclusions:** We identified multiple factors that may impact student engagement with ultrasound sessions that are included as part of an anatomy course. Medical schools seeking to incorporate ultrasound sessions in a similar fashion could consider these factors when designing their own curricula.

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## INTRODUCTION

Ultrasound’s proven use as a procedural guide and powerful diagnostic tool has led to its utilization across nearly all medical specialties. Incorporating point-of-care ultrasound (POCUS) into practice has been shown to improve diagnosis,<sup>1</sup> efficiency,<sup>2,3</sup> patient satisfaction,<sup>2,3</sup> and procedural success rates<sup>3,4</sup> as well as to decrease procedural complication rates,<sup>4,5</sup> hospital length of stay,<sup>5,6</sup> and hospitalization costs.<sup>5</sup> When performed with a targeted question, bedside ultrasound enhances and augments the physical exam to improve diagnostic accuracy and expediency.<sup>7,8</sup> The age of POCUS has been heralded as the “new stethoscope” or the “5th pillar of physical diagnosis,” where all clinicians will be required to have a strong foundation in ultrasound use and image interpretation.<sup>9-11</sup> Indeed, current hospitalists and advanced practice providers desire this training.<sup>12</sup>

Given ultrasound’s emerging clinical utility, many medical schools are seeking to integrate hands-on ultrasound training into their curricula in an effort to improve the readiness of future physicians. Based on a 2012 self-report survey of 134 US medical institutions, 62.2% reported ultrasound education was incorporated into their undergraduate medical education (UME) curriculum.<sup>13</sup> In just under 10 years, this percentage increased to 72.6% among a similar survey of 200 institutions,<sup>14</sup> reflecting the urgency with which medical institutions are pursuing ultrasound education in UME. However, multiple methods have been employed, including vary ing tim-

ing of implementation, course length, number of sessions offered, and staffing.<sup>15</sup> Because ultrasound training has been integrated to varying degrees and through a wide variety of curriculum innovations, educators are often left wondering the best approach for their program.

Despite myriad curriculum changes being trialed,<sup>15,16</sup> medical school anatomy courses consistently have provided the opportunity for the incorporation of ultrasound into UME. Ultrasound provides the ability to combine surface anatomy with cross-sectional anatomy to better supplement students' learning. Furthermore, the dynamic, real-time aspect of ultrasound imaging offers additional learning opportunities in anatomy that conventional diagnostic imaging, anatomy atlases, and cadaver dissections cannot. Nicholas et al found that nearly 75% of those medical schools with integrated ultrasound curricula used basic science courses to introduce ultrasound.<sup>14</sup> Using ultrasound as an innovative learning modality in anatomy courses has been well-received by students who perceive ultrasound training as valuable to their understanding of human anatomy and other basic science topics.<sup>16,17</sup>

The aim of this study was to gauge first-year medical students' overall engagement with ultrasound sessions as part of a clinical human anatomy course. While previous studies have demonstrated overall success in integrating ultrasound into medical school curricula, this study specifically used thematic analysis to further identify factors that contributed to students' excitement and perceived value of the sessions. It is unlikely that any single ultrasound curriculum will be effective for every UME program. Instead, with a thorough understanding of the various factors influencing students' level of engagement, educators can employ strategies that will allow for more effective ultrasound initiatives and curricular efforts at the UME level.

## **MATERIALS AND METHODS**

This study was performed at the Medical College of Wisconsin during the first-year medical student Clinical Human Anatomy (CHA) course of the 2019-2020 academic year. This course taught students the structural aspects of the human body and clinical correlations to regional anatomy using both didactic lectures and cadaveric dissections. During cadaver dissection lab, all students were invited to participate in a scanning session in groups of 5 or 6, with 1 or 2 being asked to serve as a "peer model" for the group. If consent was given, a faculty facilitator used ultrasound to identify anatomical structures relevant to the current anatomy unit (ie, Back and Upper Limb, Thorax and Abdomen, Pelvis and Lower Limb, Head and Neck) and highlighted clinical implications of these structures. After an initial demonstration activity by the facilitator, each student was given the opportunity for hands-on scanning. Each session was 30 minutes long, and 4 sessions were offered throughout the course. In addition, 3 informational 30-minute webcasts were created

by a course instructor with extensive clinical ultrasound use and also offered online for students' optional viewing. These webcasts covered basic ultrasound physics (eg, acoustic waves, frequency), instrumentation and "knobology" (eg, freezing the frame, measuring tools), modalities and techniques (eg, B-mode, M-mode, Doppler), and ultrasound applications in specific specialties, such as obstetrics, cardiology, and anesthesiology.

Ultrasound sessions were developed strictly as a value-added component of the course, rather than a mandatory component of the curriculum on which students were assessed. While participation was entirely voluntary and did not affect students' grades in the course, nearly all – if not all – students chose to participate. Facilitators included radiologists, physiatrists, obstetricians and gynecologists, anesthesiologists, emergency medicine physicians, and cardiologists. In addition to allowing for built-in hands-on ultrasound probe time for the students, facilitators were instructed on specific images to capture during the session related to the current anatomy unit (eg, Thorax: 4-chamber view of the heart, great vessels; Abdomen: liver, gallbladder, kidneys; Head and Neck: thyroid, neck vessels). Throughout the sessions, facilitators also highlighted the utility of various probes (eg, linear, curvilinear, phased array) and explained different ultrasound modalities (eg, B-mode, Doppler, M-mode).

A brief Qualtrics survey (Provo, Utah) was created and distributed in coordination with the first-year CHA course. This survey was constructed by a single study investigator as a novel means to evaluate the ultrasound education sessions, prior to being reviewed by the remainder of the study team. The survey was released on May 13, 2020, with the end-of-course evaluation to 206 first-year medical students, all of whom had been invited (but not required) to participate in the ultrasound sessions. Anonymous responses were collected for 1 week until May 20, 2020. Participants were first asked to rate on a numerical scale of 1 to 10 their answers to the following questions: "How excited were you to participate in the ultrasound education sessions when they were available in lab?" and "How valuable was the information covered during ultrasound education sessions toward your clinical training as a physician?" A rating of 1 equated to "not excited" or "not valuable," and a rating of 10 equated to "extremely excited" or "extremely valuable." Participants were then asked to expound on factors that affected their ratings through the following open-ended prompts: "Please explain what would have made you more excited to participate in these sessions," and "Please explain why you did or did not find this information valuable." Excitement and perceived value ratings were chosen as intermediaries for assessing students' level of engagement with the sessions.

Data collected from the student survey included numerical ratings for students' excitement and perceived value of the ultrasound sessions, as well as qualitative feedback on factors that affected these ratings. When analyzing qualitative feedback, thematic analysis was performed. Thematic analysis has been shown

to be a powerful research method used for analyzing qualitative data when the relationships and patterns within a data set are instrumental to answering the research question.<sup>18</sup> Using Kiger and Varpio<sup>19</sup> as a guide to thematic analysis, free-response answers were organized, coded, and separated into distinct themes to reflect on students' experiences, as described below. Coding was performed initially by a single investigator before subsequent validation by a doctorate-level statistician, neither of whom held a teaching role within the anatomy course. The statistician had prior experience in thematic analysis and debriefed the study team on the iterative process using prior studies and referencing Kiger and Varpio.<sup>19</sup>

After becoming familiar with the entire data set of student responses, "codes" were generated within each individual's free-response answer. Each code contained a basic, unique element that influenced the participant's experience during the ultrasound sessions and affected their rating. As a result, each individual's response could have multiple codes.<sup>19</sup> After all students' free-response extracts were coded, patterns and connections between codes were identified to help develop "themes" of broader significance. Each theme was independently meaningful and added perspective to the overall question. An inductive approach was used when developing all codes and themes, meaning that determination of codes and themes was data-driven as there were no set preexisting codes or themes prior to reviewing the free responses.<sup>20</sup> The entire thematic analysis was an iterative process to discern appropriate fit of codes into refined themes. When there was disagreement among the team in the significance of a theme or in the distinction between themes, the reviewers discussed whether the codes within a theme formed a coherent pattern, whether the themes were valid in relation to the entire data set of codes, and, when reviewed together, whether the themes were an accurate representation of the data set as a whole. This resulted in some candidate themes being collapsed to form a single theme, while other themes were too diverse and were separated into multiple themes.

Finally, students' numerical ratings for excitement and perceived value were grouped by theme in order to determine which themes were associated with higher or lower ratings. For example, if any of an individual student's codes fit in the "Aided Learning of Anatomy/Structures" theme, the student's numerical rating was grouped with other students' ratings who also made related statements. Descriptive statistics of ratings were then calculated by theme to assess which factors had the greatest impact on students' excitement and perceived value of the sessions.

## RESULTS

Sixty-three surveys were returned from the 206 individuals included in the survey group. However, while all 63 participants provided a numerical rating for both excitement and perceived value, only 54 of these responses included answers to 1 or both

**Table 1.** Themes Identified for Student Excitement and Perceived Value

|  | No. of Codes (%) |
|--|------------------|
| <b>Feedback Theme: Excitement (n = 65)</b>   |                  |
| Poor timing of sessions/not scheduled  | 17 (26.2)        |
| Applicable to clinical setting   | 9 (13.8)         |
| Desired more time/opportunities  | 8 (12.3)         |
| Active clinical demonstrations (positive)  | 7 (10.8)         |
| Lacked understanding of ultrasound basics  | 7 (10.8)         |
| No incentive to learn/not tested   | 5 (7.7)          |
| Environment not conducive to learning  | 4 (6.1)          |
| Instructors (positive)   | 3 (4.6)          |
| Instructors (negative)   | 3 (4.6)          |
| Student unprepared for session   | 2 (3.1)          |
| <b>Feedback Theme: Perceived Value (n = 66)</b>  |                  |
| Clinical utility (positive)  | 27 (40.9)        |
| Aided learning of anatomy/structures   | 12 (18.2)        |
| Provided basic ultrasound appreciation   | 12 (18.2)        |
| No incentive to learn/not tested   | 10 (15.2)        |
| Lack of session structure/adequate time  | 3 (4.5)          |
| Clinical utility (negative)  | 2 (3.0)          |
| Ten themes were identified for Student Excitement, with the number of codes per theme ranging from 2 to 17. Six themes were identified for Student Perceived Value, with the number of codes per theme ranging from 2 to 27. |                  |

of the free-response prompts. Because free-response answers were needed in order to be incorporated into the study's thematic analysis, in accordance with the consensus statement of the American Association of Public Opinion Research,<sup>21</sup> the adjusted response rate was 26.2%." Of the 54 returned surveys that included free-response answers, there were 40 fully completed responses, including ratings for both questions as well as free-response answers to both prompts.

Sixty-five unique codes were generated from 45 students' responses regarding factors influencing their excitement. After reviewing the codes, 10 themes were established, with the number of individual codes in each theme ranging from 2 to 17 (see Table 1). Themes relating to the overall organization of ultrasound sessions (eg, session structure, scheduling/frequency, scanning volume) were among the themes that contained the most feedback data. In addition to session organization, several students reported that session content influenced their excitement—particularly the clinically focused demonstrations and clinical applications. Students also reflected on how both the instructors and learning format affected their engagement level. Finally, students stated the lack of incentive to engage in or prepare for the sessions affected their enthusiasm, as these sessions were optional. Taken together, themes reflected several factors influencing students' excitement or lack of excitement for the sessions, including both the organization and content of the sessions, the environment in which students learned, and students' personal motivation toward the sessions. Representative extracts from each theme can be seen in Table 2, and the overall



**Table 2.** Student Excitement for Ultrasound Sessions

| Theme                                     | Representative Excerpts  |
|---|--|
| Poor timing of sessions/not scheduled     | "I loved the sessions but always felt like when I was at them, I was getting behind on lab but maybe if they were explicitly on the schedule, it would feel less like that" ... "It's hard to switch from elbows deep in the dissection to going to the radiology room" ... "I think having a more set schedule for when we were going to be having our ultrasound lesson would help, as I often felt like we were pulled away in the middle of a specific lab task" |
| Applicable to clinical setting            | "I enjoyed seeing structures from a point of view that we will be using as clinicians" ... "ultrasound was something I knew we as medical students would have to understand for the future and so something that seemed like it would be useful for clinic sounded awesome"  |
| Desired more time/opportunities           | "I wish there were more sessions!" ... "allocating more time to each session would be helpful as I felt rushed at times"   |
| Active clinical demonstrations            | "Demonstrations where the 'patient' would do something (eg, flex a muscle to see the tendon slide) were very intuitive to me and aided my understanding" ... "I liked that we got to practice on each other and be able to handle the machine ourselves"   |
| Lacked understanding of ultrasound basics | "I believe most people were excited or at least somewhat interested to learn about ultrasound but had no knowledge whatsoever about the field or its fundamentals, which made it confusing"  |
| No incentive to learn/not tested          | "The sessions were very helpful and informative, but not on the test and thus took lower priority" ... "while I was very interested in ultrasound, it didn't feel necessary for me to master the course" ... "maybe having ultrasound images on the exam would make me more interested"  |
| Environment not conducive to learning     | "I think sometimes the overzealousness of other classmates hindered my learning, and I didn't want to take too long learning if I was orienting the probe wrong because my classmates still needed to learn, too" ... "what would have made me more excited to participate would have been less cadaver smell and less dirty scrubs"   |
| Instructors (positive)                    | "I had a great time interacting with the radiology team and anesthesiologists"   |
| Instructors (negative)                    | "The instructors would sometimes go on tangents rather than helping us find structures" ... "if the faculty were more enthusiastic about ultrasound, I would be more interested"   |
| Student unprepared for session            | "Sometimes it was hard to follow along when the topic covered in the ultrasound lab was what we had just talked about in lecture — in those cases, I hadn't yet studied that specific material and wasn't very comfortable with it yet"  |

**Table 3.** Student Perceived Value of Ultrasound Sessions

| Theme                                   | Representative Excerpts  |
|---|--|
| Clinical utility (positive)             | "Any exposure we have to clinical tools is extremely beneficial" ... "even if we may not be directly involved in conducting ultrasounds ourselves in the future, we may find ourselves in situations where we need to interpret findings from ultrasounds" ... "ultrasound is increasingly used in majority of medical specialties today" ... "the radiologist had a clinical story for each part, which really made me appreciate the skills we were learning" ... "I was able to better understand what my preceptor was showing me in clinic on the ultrasound" |
| Aided learning of anatomy/structures    | "Sessions provided another dimension to learning and remembering anatomy" ... "ultrasound helped me to build a better mental map of the human body"  |
| Provided basic ultrasound appreciation  | "Having no prior experience with ultrasound, I think it was important to learn at least a basic understanding of ultrasound, how it works, and how to use it effectively" ... "I think it was helpful for learning the very basics of how to use an ultrasound" ... "while I definitely do not feel like I have a solid understanding of ultrasound yet, having these lab sessions gave me an important first look, appreciation, and more knowledge than I had prior to lab"  |
| No incentive to learn/not tested        | "Most likely because we weren't being tested on ultrasound in any form, I noticed that several of my group members didn't go to the sessions" ... "it was such a limited scope of practice that I feel I've already forgotten most of what I learned about ultrasound and will need to relearn it to make it valuable as a clinician"  |
| Lack of session structure/adequate time | "This part of lab needs to be more structured and have more defined goals" ... "I wish we had access to this outside of lab hours, because I sometimes felt like my group was in a hurry to get back to our dissection because we still had a lot to finish"   |
| Clinical utility (negative)             | "Sessions seemed to be very isolated cases of trying to identify structures and there weren't many explicit applications to understanding how physicians actually use this in clinic"  |

interpretation for each theme can be seen in Appendix A.

Sixty-six unique codes were generated from 46 students' responses regarding factors influencing their perceived value of the sessions. After reviewing the codes, 6 themes were established, with the number of individual codes in each theme ranging from 2 to 27 (see Table 1). Students again specifically addressed the role of session content in their perceived value and its effects on learning – for the clinical setting, for the anatomy course directly, and in their understanding of ultrasound.

Feedback data also acknowledged that the voluntary nature of the sessions, as well as how the sessions were structured, affected how students viewed the sessions. Broadly, these themes again reflected the impact of session content and organization—as well as personal motivation—on the value that students derived from the sessions. Representative extracts from each theme can be seen in Table 3, and the overall interpretation for each theme can be seen in Appendix B.

Students' numerical ratings for excitement and perceived value

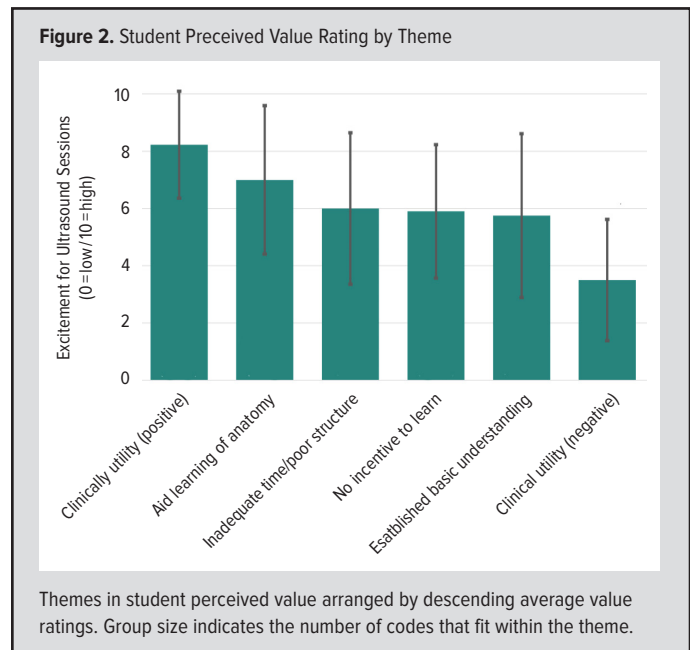
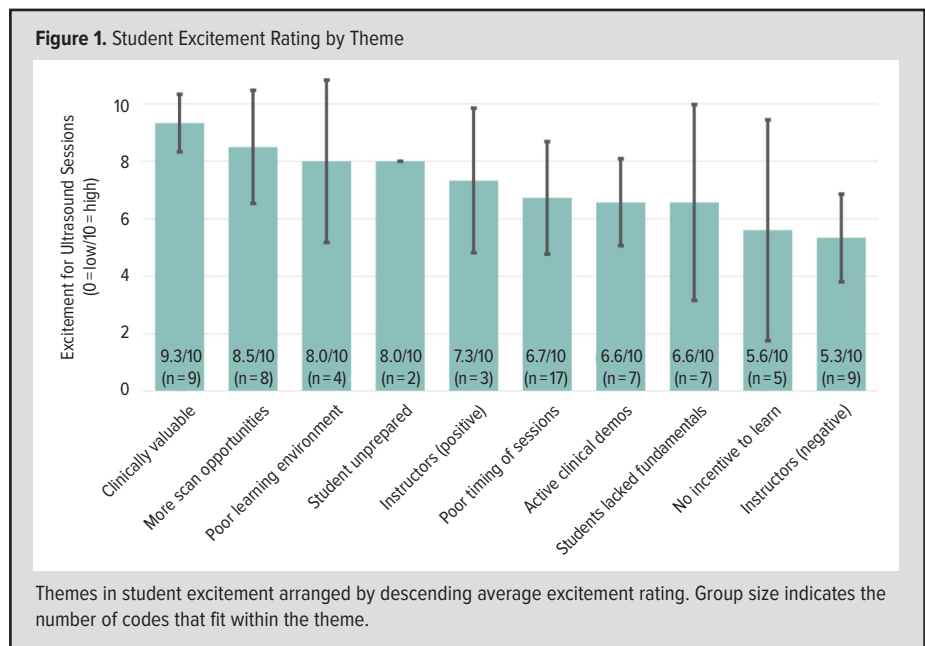
of the sessions were then plotted by theme. (See Figures 3 and 4.) Ratings varied by theme; however, clinical relevance/utility consistently was identified as the most important factor in generating student engagement. Students who found the sessions clinically valuable reported the highest excitement rating among all themes (9.33/10). Similar results were reflected in perceived value ratings, as students who identified the ultrasound sessions as clinically relevant and essential to their future in medicine found the sessions to be the most valuable (8.22/10), while students who stated the sessions were not clinically relevant reported the lowest perceived value rating (3.50/10). In fact, students who found the sessions valuable because of their clinical utility reported higher perceived value ratings than students who identified the sessions as helping them learn anatomy course content (8.22/10 vs 7.00/10, respectively).

As expected, ratings from students who cited no motivation or incentive to engage as an impacting factor were among the lowest excitement (5.60/10, second-lowest excitement rating) and lowest perceived value (5.90/10, third-lowest value rating) ratings. However, there were some themes that generated higher ratings than expected. Students who desired more opportunities and time for scanning reported the second-highest excitement rating among all themes (8.50/10), and students who commented that the environment was not conducive to learning reported the third-highest excitement rating (8.00/10).

Mixed results were seen from themes relating to instructors. Students who made negative remarks regarding instructors had the lowest excitement scores among all themes (5.33/10), while students who made positive remarks regarding instructors rated their excitement 2 points higher (7.33/10). However, this theme was still ranked as only the fifth-highest student excitement rating.

## DISCUSSION

Using thematic analysis, this study identified several factors affecting medical students' engagement with ultrasound education in a human anatomy course. Clearly, the content of ultrasound sessions is critically important for engaging learners, both in preparing them for clinical responsibilities and for learning anatomy. However, there must first be either personal motivation or incentive to engage on the student's behalf if sessions are scheduled during competing academic activities or course components. In addition, it is important to consider the overall learning environment, structure, and timing of sessions as having an impact on students' excitement and perceived value.



Educators may improve student engagement and ultimately better prepare student-doctors in their ultrasound education efforts and across UME more broadly by addressing these factors.

Clinical relevance/utility was identified consistently as the single most important factor influencing students' excitement and perceived value. Students' examples of clinical benefits gained during the sessions included understanding when ultrasound could be used to determine a medical diagnosis, supplementing their physical exam skills, early exploration of medical specialties that utilize ultrasound, and becoming familiar with terminology and images that are seen in students' clinical learning environments (eg, student-run clinic, early-exposure preceptorships, etc). Moving

forward, these ultrasound sessions could be approached from a more clinical perspective by including mock patient cases where students must brainstorm appropriate uses of ultrasound imaging to determine a diagnosis instead of seeking only to capture specific views of relevant organs during the sessions. While incorporating ultrasound into anatomy courses certainly aids students' learning of anatomy, it undoubtedly has further-reaching, secondary outcomes of enhancing students' career exploration and clinical skillset as well.

One factor that played a greater role than expected in affecting engagement in this cohort of students was the fact that sessions were not mandatory, and thus, students were not tested on ultrasound material. The reason these sessions were not mandatory was to avoid review by the medical school's curriculum and evaluation committee, which would result in more standardized objectives and testing requirements. These sessions were strictly meant to be a value-added component of the curriculum. However, because students were not tested on the material, their engagement suffered as a result. In addition, while this ultrasound program was used as a supplementary resource to the anatomy course alone, the ideal ultrasound curriculum may be one in which ultrasound training in anatomy courses provides just the initial component of a more robust, longitudinally integrated ultrasound program. Findings from this study suggest that ultrasound also could be incorporated into courses such as physical exam courses or clinical clerkships, as students were most engaged when material was presented from a clinical perspective. While opportunities for increased scanning time may be limited in the medical school curriculum itself, hosting voluntary "office hours" apart from dissection lab or establishing an Ultrasound Interest Group may be feasible extracurricular methods to further promote ultrasound education among medical students.<sup>22</sup>

The primary strength of this study was in its use of thematic analysis. By translating students' free-response prompts into overall themes, this method captured data that would not be available through numerical ratings alone. Furthermore, this method identified important factors to consider when targeting improved student engagement that are appropriate not only for the intended CHA course, but also among other basic science courses and in medical education more broadly.

Although the results of the study were informative regarding medical student engagement, the current study had the following limitations. The survey could have benefited from a pilot distribution to a subset of students. This would have allowed for changes to be made prior to the larger distribution in order to better justify the survey as a valid assessment tool. Additionally, just over 25% of those surveyed returned responses that were usable for this study's analysis, which resulted in some themes having low code volumes. Receiving limited responses to the survey may introduce bias into the analysis and limit its gen-

eralizability, as it is commonly individuals with the strongest opinions – both positive and negative – who respond, while the more moderate voices may be underrepresented. Despite this, with greater than 50 respondents, numerous codes were identified that still generated several strong themes. One additional limitation included the fact that this was a purely observational, subjective study, as responses reflected students' own assessment of their excitement and perceived value.

## CONCLUSIONS

This study used thematic analysis to evaluate qualitative feedback from medical students regarding their level of engagement in ultrasound education sessions in an UME anatomy course. Multiple factors were identified that may impact their excitement and perceived value of the sessions, including clinically relevant content, personal motivation, learning environment, and session organization.

Moving forward, next steps will include putting interventions into place in ultrasound sessions to explore how direct, student-driven improvements may translate into greater student engagement. Additionally, evaluating objective measures for students' interest, information retention, and subsequent use of ultrasound in clinical settings would offer enhanced insight into the role of ultrasound education on higher-level outcomes.

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# The Impact of Early Exposure to Microsurgery Training on Undergraduates, A Pilot Course

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## ABSTRACT

**Introduction:** This case study aimed to investigate a disparity in the medical education pipeline by investigating the impact of fundamental microsurgical training on interest and desire to pursue a career in medicine. This research introduces a method to attract undergraduate students from various backgrounds to the field of microsurgery through a hands-on microsurgical training course.

**Methods:** Microsurgical training took place 6 hours a week for 6 weeks. Techniques included knot-tying and anastomoses on 1-, 2- and 3-mm synthetic vessels using both end-to-end and back-wall techniques. Participant's knowledge and confidence in microsurgical skills were evaluated using a presurvey, postsurvey, and vessel patency. One undergraduate student with no prior surgical knowledge completed one-on-one microsurgical training designed for integrated plastic surgery residents and was supervised by a microsurgical educator.

**Results:** The undergraduate student achieved the microsurgery level equivalent to a third-year surgical resident in the same training program and could complete patent anastomoses using end-to-end and back-wall methods on a 1-mm, 2-mm, and 3-mm synthetic vessel. The student's timing for different skills decreased over time while their confidence level increased. Their time for tying 3 knots decreased from 2.53 minutes to 19 seconds, while their time for a 3-mm end-to-end anastomosis decreased by 5.13 minutes.

**Conclusions:** Medical knowledge may not be necessary before starting microsurgery training. Early, hands-on exposure may make a medical career less intimidating.

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## INTRODUCTION

Medical career paths typically begin at the premedical level, with residency selection representing a critical juncture in specialty choice. Critical factors influencing medical students' specialty choice include personality fit, specialty content, and role model influence, but less is known about what drives students to attend medical school.<sup>1</sup> An increasing body of literature is emerging in support of early exposure and mentorship as a means of attracting motivated trainees of increasingly diverse backgrounds.<sup>2-4</sup>

Different subspecialties within the broader field of surgery utilize different methods to attract a more diverse population to their field since surgery is a field in medicine that is not as diverse as other medical fields in regard to gender and race.<sup>5</sup> Surgery programs may provide exposure to the field through hands-on experience and shadowing opportunities for pre-

medical students interested in pursuing a career in medicine from the undergraduate and high school levels. This allows students an opportunity to gauge if surgery may be a suitable field for them.<sup>6</sup> It also gives them an awareness of what actually will be involved in the day-to-day activities of a surgeon, enabling them to have realistic expectations for their future if they choose to pursue a career in surgery.<sup>7</sup> Realistic expectations could lead a student to commit to a field early, which allows them to explore different pathways to becoming a specialist in that field. The most common path for surgical specialties is the traditional (independent) path, in which a formal residency is completed before a fellowship in the target

n which a residency in the target specialty is completed simultaneously.<sup>8</sup> Some popular integrated programs are for the specialties of cardiothoracic surgery, vascular surgery, and plastic surgery. Additional training can be completed for a person to become a microsurgeon, which is a popular subspecialty among plastic and reconstructive surgeons.

Academic microsurgery is a highly competitive surgical subspecialty that is typically introduced to medical students during their plastic surgery rotations through observation—not participation—with formal training beginning at residency. Microsurgery is a crucial skill set for a well-rounded reconstructive surgeon and an increasing number of surgical fields—such as vascular and ear, nose and throat—though there is limited exposure prior to residency and a lack of standardized curriculum. It has been demonstrated recently that new medical students are capable of learning microsurgical techniques and that such an experience influenced their career trajectory toward specialties that include microsurgery.<sup>9,10</sup>

### **Diversity in Training Practices**

An added benefit to providing early, hands-on exposure to microsurgery is the potential to influence a more diverse population. As evidenced by numerous studies, applicant pools for many medical specialties, including plastic surgery, have a less diverse applicant pool concerning gender and race when compared to medical school demographics.<sup>2,11,12</sup> Early premedical exposure to surgery directed explicitly at women without prior exposure to surgery was shown to directly affirm their decision to attend medical school and positively influenced their interest in pursuing a surgical career.<sup>4</sup> Newly admitted medical students who received hands-on training in surgical skills were more confident in their ability to become a surgeon and viewed the field of surgery more positively.<sup>13,14</sup> Early exposure to specialty training can provide positive experiences with potential role models and an improved understanding of key skills, roles, and responsibilities required for a career in academic medicine.<sup>15</sup> Mentorship relationships can be established at this point, providing premedical students with a positive role model who can offer professional guidance and advice.<sup>16</sup> Early mentorship can be used strategically to help increase the level of diversity within the surgical field.<sup>6,17-19</sup>

### **Establishing a Curriculum**

One way to increase the general level of interest in microsurgery is to have a microsurgical curriculum available at medical schools, as an established curriculum provides an opportunity that was previously unavailable for medical students.<sup>20</sup> Proficiency in microsurgical procedures within the operating room would require the completion of a surgical residency, but due to the importance of acquiring and maintaining a microsurgical skillset, medical students—especially those pursuing surgi-

cal specialties—may benefit from earlier exposure. This would likely increase the number of medical students interested in microsurgery, as observed in a comparative study between surgical residents who had completed microsurgical cases during at least 1 rotation and medical students undergoing microsurgery training.<sup>10</sup> The medical students within the study showed more engagement in the microsurgical training than the surgical residents. This may be because medical students often have more free time and a less routine schedule than surgeons.<sup>10</sup> This level of engagement and free time is more extensive among premedical undergraduate students, more specifically, students who are pursuing careers as physicians but are not yet in medical school. Medical schools may leverage a student's premedical years to expose more diverse cohorts of students open to the exploration of different career paths, including within the medical field.

Microsurgery training for premedical undergraduate students and medical students is an effective way to increase students' level of interest in joining a surgical field that involves and requires the expertise of microsurgery since it gives the students direct, hands-on experience. Additionally, a student's completion of a surgical skills workshop before obtaining their medical degree has been shown to increase the student's confidence level and competence in surgical skills.<sup>9,14</sup> Even if a student chooses not to pursue a career involving microsurgery in the future, that student may be more likely to choose a specialty that involves surgery or procedural and hands-on skills more generally, which is beneficial as surgery is a realm that still struggles with diversification in terms of gender and race/ethnicity.<sup>21</sup> Early mentorship, at the high school or undergraduate levels, is a method that many institutions are leaning toward to increase the diversity within certain fields, including surgical fields.<sup>19,22</sup>

The objectives of this case study were to retrospectively review how exposure to basic microsurgical concepts and techniques increased the student's level of interest in pursuing a surgical career involving microsurgery in the future. We sought to: (1) report the capacity of a premedical student with no prior knowledge of the field of microsurgery to learn basic microsurgical techniques, and (2) to explore the impact of early exposure to a microsurgical curriculum on medical career interests.

### **METHODS**

This case study consisted of a single, visiting premedical student (MF) paired with a microsurgical mentor/educator (WZ) during summer 2022 as part of an internship funded by the Doris Duke Charitable Foundation (grant #2020221). Data reported in this manuscript were collected as standard operating procedure for this training. The manuscript was conceived after the fact by lead author (MF) and supported by the senior author (AD). Following communications with our institutional ethics committee, it was determined that review/approval was not needed for this study as learning experience was not designed to develop generalized

knowledge and there was no systematic investigation, only information collected as per usual for training purposes.

Microsurgical training took place for 3 hours twice a week over 6 weeks. The training program was based on a series of 15 lessons from a previously established training program for integrated surgical residents. The materials were altered in accordance with grant requirements. Synthetic vessels were used in place of animal products. The premedical student completed one-on-one microsurgical training with a microsurgical educator.<sup>20</sup> Techniques were guided by the free microsurgery education website (<https://microsurgeryeducation.org/>) and consisted of naming and proper use of microsurgical instruments; management of the microscope; placement of sutures; manipulation of the needle; placement and manipulation of a stitch on the glove and sponge model; tying a knot on glove and sponge model; handling a synthetic vessel; placing a stitch on a synthetic vessel; tying a knot on a synthetic vessel; completing end-to-end anastomosis using two-stay method on 1-mm, 2-mm, and 3-mm synthetic vessels; completing an anastomosis using the back-wall-first anastomosis technique on 1-mm, 2-mm, and 3-mm synthetic vessels; and overall hand dexterity.

### Lesson Plans

Lesson 1 focused on the management of the microscope and instrument used for microsurgery, as well as the acquisition of basic microsurgical techniques, including how to tie a square knot and a surgeon's knot. Lesson 2 focused on proper needle and suture management and a non-crossing knot-tying technique. Lesson 3 focused on learning to use the two-stay method to perform an end-to-end anastomosis on a biomedical synthetic vessel. Lesson 4 focused on using the back-wall-first method to complete an end-to-end anastomosis. (Beginning here the lessons deviated from the original online curriculum, substituting animal tissues for synthetic vessels to follow the guidelines set by the grant). Lesson 5 focused on performing anastomoses on decreasingly small synthetic vessels (3 mm, 2 mm, and 1 mm).

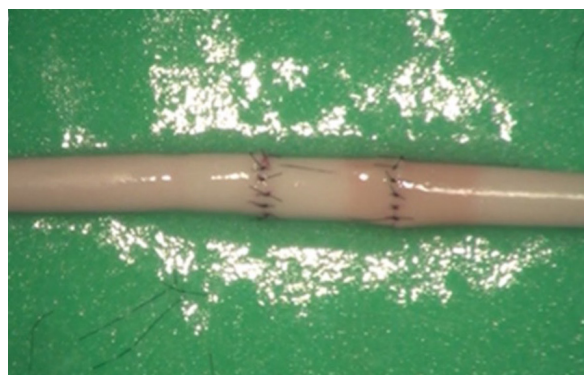
### Evaluation

The microsurgical educator was present to assist, observe, and evaluate the student's progress in real time. Each session was recorded. The microscope was connected to a camera, so the microsurgical educator could record the student's technique, which enabled comparison of the technique and monitorization of the student's progress throughout the training period. The microsurgical educator used the videos to evaluate the student's timing and proficiency, with direct comparison to the microsurgical educator's time and proficiency. The student was evaluated using a Likert scale based on surveys of knowledge and confidence level before and after training (see Appendix).

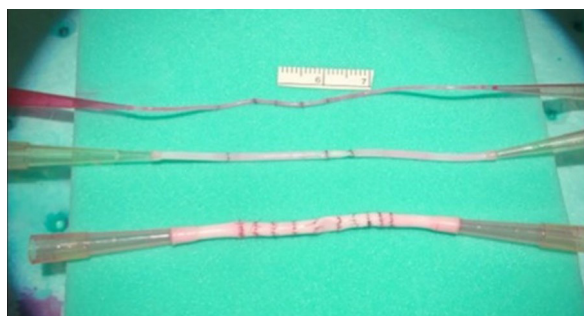
### RESULTS

Over the 6-week period, the premedical student achieved the

**Figure 1.** Image of 3-mm Vessel After Student's Traditional Anastomosis Approach



**Figure 2.** Image of 1-mm, 2-mm and 3-mm (top to bottom) Vessels Following the Student's Back Wall First Method of Anastomosis



microsurgery level equivalent of a third-year surgical resident undertaking the same training at our institution. The student completed an anastomosis using both the traditional approach, where the sides of the vessels are connected first, as well as the back-wall-first method (Figures 1 and 2). All anastomoses were patent as demonstrated by perfusion of blue dye in water with no through-stitch catching the back-wall or obvious leaking.

The student's timing for different skills decreased over time, while their confidence level for each skill increased over time. Their time for tying 3 knots decreased from 2 minutes 32 seconds during their first attempt to 19 seconds, which is only 3 seconds longer than the instructor's best time (Figure 3).

The student's time for an end-to-end anastomosis started at 46 minutes and 32 seconds and decreased to 41 minutes and 24 seconds (Figure 3). Confidence levels demonstrated an inverse relationship to time, increasing confidence after each lesson (Figure 3).

### DISCUSSION

Many factors contribute to a student deciding to pursue a specific career, especially in medicine. The premedical student in

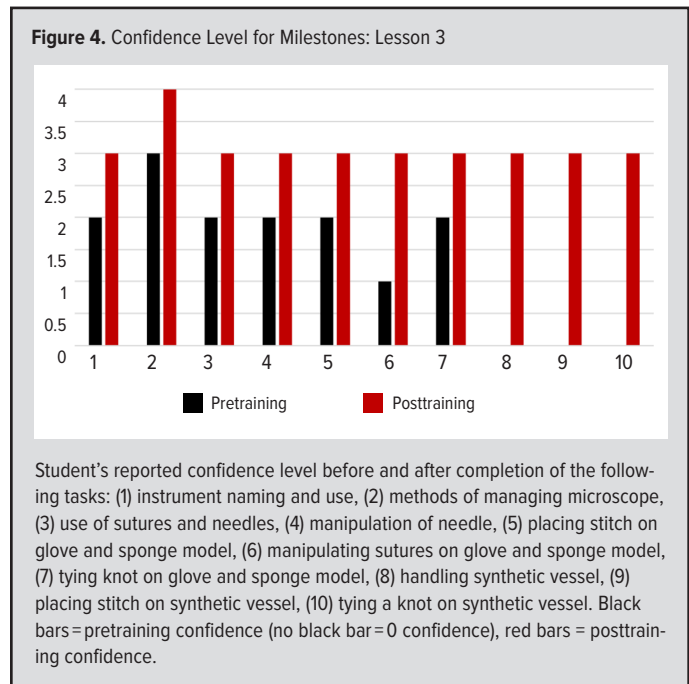
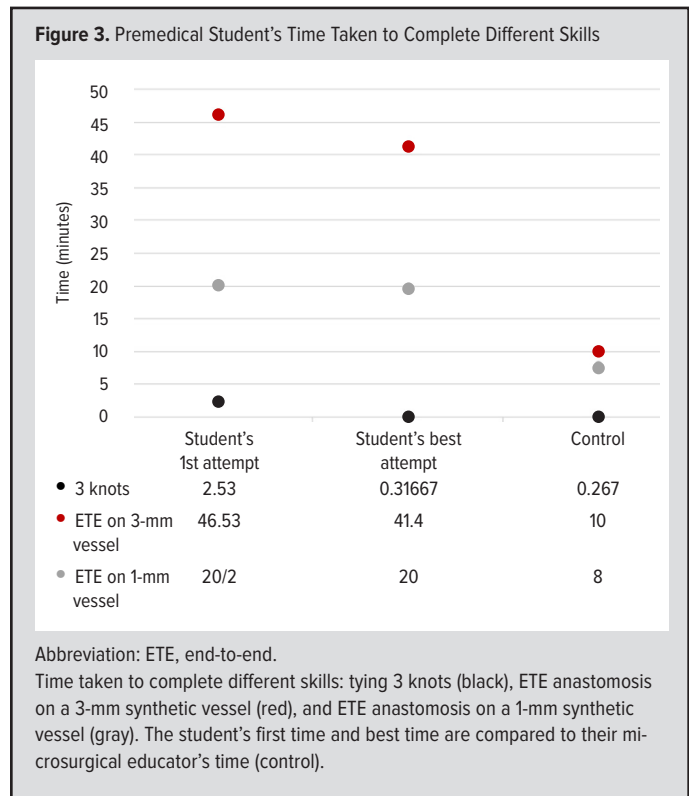
this study was already intent on pursuing medical school with an interest in surgery but was unaware of microsurgery before starting the microsurgical course. Receiving hands-on experience within the program led the student consider pursuing a career in microsurgery. Over the 6-week period, the student was able to learn about and become proficient in several critical microsurgical skills (Figures 1-3). This, in turn, improved the student's confidence with each lesson and was recorded to have had a direct impact on their career path (Figure 4). Additionally, the student appreciated that they could go through the same training as a surgical resident at our institution and develop similar skills, though some aspects of the training were altered in accordance with the specific funding requirements. The student was able to get a genuine feel for what is required to succeed within this field.

The student noted that though they were successful with the microsurgery training, that does not guarantee that others will mirror the same enjoyment or success in microsurgery training. Both positive and negative experiences in microsurgery—or any specialty—may help adjust one's career trajectory prior to medical school or residency training.<sup>9,10</sup>

One study displayed a correlation between microsurgical course performance and surgical career paths, with interns and junior residents who performed poorly less likely to pursue surgical residency than those who performed well.<sup>23</sup> If students who do well with the training are more likely to pursue surgical careers, early exposure to specialties like microsurgery may benefit, given the large learning curve with microsurgery.<sup>24</sup> Figure 3 shows how regular practice in microsurgical skills can significantly decrease the amount of time needed to complete a specific microsurgical skill, despite no prior knowledge or experience with surgery. The student's best time to complete specific microsurgical skills was comparable to that of the microsurgical educator, which also has been displayed in another study.<sup>10</sup>

Early exposure to surgery is important because even if the student does not enjoy their experience, they would be free to explore other career options before mentally and professionally committing to becoming a surgeon. But if a student enjoys their experience, they will have opportunities to arrive at their desired career in a shorter time period through an integrated pathway, which can save a year or two versus traditional pathways to arrive at the same career.<sup>8</sup>

Studies already have confirmed that medical students and interns are capable of excelling in microsurgery training,<sup>9,10</sup> but since this training is not extended to premedical students, much has not been studied on the microsurgical capabilities of premedical students and the long-term professional impact of early microsurgical training. This case study exemplifies that microsurgery is a great hands-on experience for premedical students that could encourage more students to consider a career in microsurgery as its stature as a subspecialty becomes visible. The acquisition of



microsurgical skills has been hypothesized to benefit most surgical residents since these skills could lead to better control of surgical instruments and the ability to handle tissues on the macroscopic level more gently.<sup>9</sup>

Experiences similar to this also could help address disparities in health care if these opportunities are open to and directly targeted to students within underrepresented populations in medicine.<sup>25</sup> The student in this case study, who identifies as an individual with



a background historically underrepresented in medicine, stated that their early, hands-on training in a medical specialty reaffirmed their commitment to becoming a doctor. The student was interested specifically in joining the surgical field due to their increased level of confidence in surgical and procedural skills following their microsurgical training (Figure 4). Early medical students who had taken an introductory surgical skills course acquired basic surgical skills, had an increased level of interest in becoming a surgeon, and increased confidence in their technical abilities.<sup>13,14</sup> If more students from underrepresented populations were given opportunities to complete basic surgical skills, it would likely lead to more individuals within underrepresented communities becoming surgeons.<sup>21</sup> This idea also can be applied to attracting more women to the surgical field—especially through programs directly involving female surgeons.<sup>4</sup> When used in combination with each other, medical schools may be able to attract a larger number of non-White females to their surgical programs since members of this demographic are currently considered rare in the surgical realm.<sup>17</sup> This could slowly improve the demographics of surgeons to better mirror and represent the general population in the United States, which, in turn, could lead to improved health care outcomes due to better patient-clinician communication, since being a part of a historically underrepresented group is associated with poor patient-clinician communication.

The undergraduate student also built a mentorship relationship with their microsurgical educator, which provided the student continuous opportunities to ask questions about the field, a source of professional advice and encouragement, and a good role model. The importance of a committed mentor with a passion for their job cannot be understated. A successful mentor can establish a connection with their mentee built on the foundations of trust, mutual respect, clear communication, established boundaries, and shared interests and values.<sup>16</sup> Mentorship during the undergraduate years is also a way to increase diversity in medicine, specifically in the field of surgery—especially if the mentor and mentee are of the same gender or ethnic/racial background, since that has been shown to improve motivation among mentees.<sup>6,17-19</sup>

## CONCLUSIONS

Medical knowledge is not a necessity before starting microsurgery training. Early, hands-on exposure is motivating as it makes the career less intimidating and more achievable. This training introduced and exposed the primary author to the field of microsurgery and encouraged them to pursue a career in this field or another surgical subspecialty. Given the measurable success in microsurgical skill acquisition and positive feedback from the primary author on this course, we intend to provide microsurgery workshops for future Doris Duke Scholarship undergraduate students attending our institution. We hope that moving forward, this course becomes highly valued by our students and is implementable at other institutions as a means of enhancing the visibility, accessi-

bility, and the reality of careers in surgery and microsurgery for undergraduates, particularly those historically underrepresented in medicine.

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**Appendix:** Available at [www.wmjonline.org](http://www.wmjonline.org).

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# Classification of Obstructive Pulmonary Diseases Through Clinical Characteristics in a Prospective Cohort Study

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## ABSTRACT

**Introduction:** The use of clinical characteristics to differentiate obstructive lung diseases remains unclear, with limited supporting studies. This study aims to assess the effectiveness of signs and symptoms from clinical questionnaires in diagnosing obstructive lung diseases.

**Methods:** This prospective cohort study included patients diagnosed with chronic obstructive pulmonary disease (COPD), asthma, or asthma-COPD overlap (ACOS) based on spirometry. Clinical symptoms were gathered using questionnaires and incorporated into a multinomial logistic prediction model to evaluate their role in diagnosing obstructive lung diseases.

**Results:** A total of 1443 patients were analyzed: 177 (12.3%) with COPD, 135 (9.4%) with asthma, 163 (11.3%) with ACOS, and 968 (67.1%) without obstruction. The average age was 64 years (SD 13.23), with COPD patients being older than those with asthma or ACOS. Forced expiratory volume in the first second of expiration/forced vital capacity ratios after bronchodilator use were 61.1 (SD 8.48) for COPD, 78.9 (SD 6.99) for asthma, 57.3 (SD 9.48) for ACOS, and 81.7 (SD 7.15) for non-obstructed patients. The area under the curve for diagnosing COPD was 0.75, for asthma 0.68, and for ACOS 0.78 (all  $P < 0.001$ ).

**Conclusions:** Clinical variables can identify patients with obstructive lung diseases effectively, offering strong diagnostic performance and precision.

## INTRODUCTION

Obstructive lung diseases are marked by airflow limitation caused by airway narrowing, which increases resistance to air movement and makes breathing more difficult.<sup>1-3</sup> Chronic obstructive pulmonary disease (COPD) affects between 12.1% and 55.2% of the population, and asthma affects between 13.3% and 61%, while asthma-COPD overlap syndrome (ACOS) is less common, affecting 1.6% to 4.5% of individuals.<sup>4</sup>

Obstructive lung diseases share common symptoms, including dyspnea, cough, expectoration, and wheezing, which can be identified through structured clinical questions.<sup>4,5</sup> Using clinical questionnaires along with pulmonary function tests improves diagnostic accuracy, with a sensitivity of 72% and specificity of 97% for COPD.<sup>6-8</sup>

However, the ability to use clinical information alone to distinguish between different obstructive lung diseases remains debated.<sup>9</sup>

Using structured clinical questions can improve the quality of information for the differential diagnosis of obstructive lung diseases.<sup>7-9</sup> This study aims to evaluate how well symptoms gathered from these questions help in diagnosing COPD, asthma, and ACOS.

## METHODS

We conducted a prospective cohort study at a hospital in Chía, Colombia, from 2017 to 2020. It aimed to assess the role of clinical symptoms in diagnosing obstructive lung diseases. Patients were enrolled sequentially during the study period and diagnosed with COPD, asthma, or ACOS based on pulmonary function test results.

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## Selection Criteria

The study included individuals over 18, with or without respiratory symptoms, regardless of severity. All participants underwent spirometry and answered standardized questions from validated questionnaires to assess for obstructive lung diseases.<sup>6-9</sup> Those who did not complete the questions, had poor-quality spirometry, or for whom there was no atopy information were excluded.

## Variables

Study variables included age, sex, presence of respiratory symptoms, age at symptom onset, wheezing, cough, expectoration, dyspnea, smoking history (packs per year), and exposure to wood smoke. Data on symptoms were collected using clinical questionnaires, and accuracy was ensured by verification from at least 2 reviewers. Spirometry was performed according to American Thoracic Society/European Respiratory Society guidelines, and results were interpreted by specialists. Key measures included forced expiratory volume in the first second of expiration (FEV<sub>1</sub>), forced vital capacity (FVC), and the FEV<sub>1</sub>/FVC ratio pre- and post-bronchodilator. COPD was diagnosed with an FEV<sub>1</sub>/FVC ratio <0.7, while asthma and ACOS were diagnosed with an FEV<sub>1</sub> increase of 200 ml and 12% post-bronchodilator. To reduce bias, the spirometer was calibrated before each session.

The population was divided into 4 groups based on spirometry results: (1) COPD (obstructive, non-reversible), (2) asthma non-obstructive (reversible), (3) ACOS (obstructive, reversible), and (4) normal (non-obstructive, non-reversible). Respiratory symptoms were assessed using the Lung Function Questionnaire (LFQ), COPD Diagnostic Questionnaire (CDQ), COPD Population Screener (COPD-PS), and the PUMA COPD questionnaire.<sup>6-9</sup>

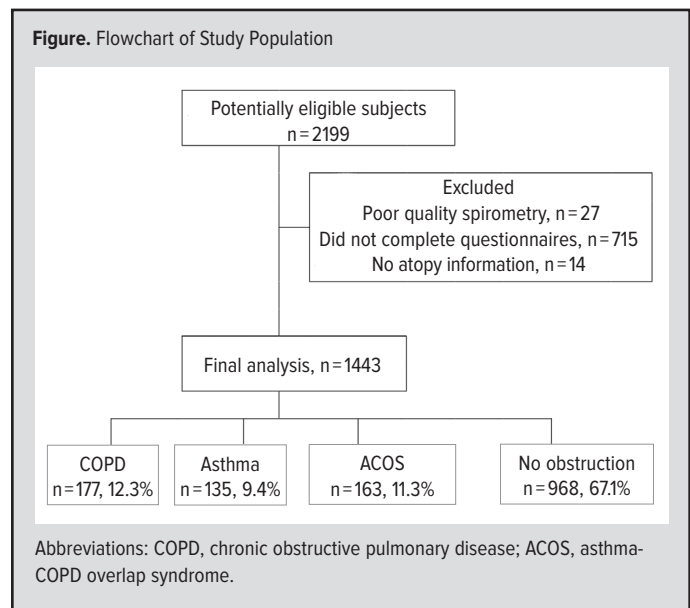
The LFQ consists of 5 questions about coughing, expectoration, wheezing, dyspnea, and years of smoking, with scores ranging from 5 to 25 points. The CDQ has 8 questions covering age, years of smoking, body mass index (BMI), weather-related cough, and symptoms such as wheezing and allergies, with a score range of 0 to 38. The COPD-PS questionnaire asks 5 questions about shortness of breath, coughing, reduced daily activities, smoking history, and age, with scores from 0 to 10. The PUMA questionnaire includes 7 questions on sex, age, smoking history, dyspnea, expectoration, chronic cough, and previous spirometry, with scores from 0 to 9.<sup>6-9</sup>

## Sample Size

To determine the sample size, data were used from Pascoe et al's study, which reported a 70% sensitivity and specificity for diagnosing COPD, asthma, and ACOS.<sup>3</sup> Using a formula for diagnostic test confidence intervals—with a disease prevalence of 30%, 5% accuracy, and a 95% confidence level—the required minimum sample size was 1076 patients.

## Data Analysis

Data were collected in Excel and analyzed using SPSS version 20



(IBM Corp). Descriptive analysis summarized quantitative variables as mean and standard deviation for normal distributions, or median and interquartile range for non-normal data. Qualitative variables were presented as absolute and relative frequencies. Bivariate analysis compared qualitative variables using chi-square, and quantitative variables using *t* test or Mann-Whitney U test, based on distribution. Variables related to obstructive lung diseases that were biologically plausible and statistically significant were included in a multinomial logistic regression model. Significant variables were used to calculate the area under the curve (AUC) for each disease, with *P* < 0.05 considered significant.

## Ethical Considerations

This study followed the ethical guidelines of the Declaration of Helsinki and national regulations (Resolution 8430 of 1993). It was considered risk-free, complying with Law 1266 of 2008 (Habeas Data) and Decree 1377 of 2013, ensuring confidentiality of all data.

## RESULTS

A total of 1443 patients were included in the final analysis: 177 (12.3%) had COPD, 135 (9.4%) had asthma, 163 (11.3%) had ACOS, and 968 (67.1%) had no obstruction (Figure). The average age of the population was 64 years, with the COPD group being older than those with asthma or ACOS. Men made up 45% of the population, with 46% having a smoking history and 55% exposed to wood smoke. Baseline characteristics and group differences are shown in Table 1.

## Pulmonary Function

The post-bronchodilator FEV<sub>1</sub>/FVC ratio was 61.1 (SD 8.48) in COPD, 78.9 (SD 6.99) in asthma, 57.3 (SD 9.48) in ACOS, and 81.7 (SD 7.15) in non-obstructed subjects. Significant FEV<sub>1</sub> increases (200 ml and 12%) were observed in asthma (2.1, SD



**Table 1.** Baseline Characteristics of the Study Population

|   | Total<br>n=1443 | COPD<br>n=177 | Asthma<br>n=135 | ACOS<br>n=163 | No Obstruction<br>n=968 | P value |
|---|-----------------|---------------|-----------------|---------------|-------------------------|---------|
| Age, mean (SD)                          | 64.2 (13.23)    | 71.69 (11.36) | 64.59 (12.76)   | 67.41 (11.20) | 62.17 (13.34)           | <0.01   |
| Male sex, n (%)                         | 643 (44.6)      | 97 (54.8)     | 48 (35.6)       | 97 (59.5)     | 401 (41.4)              | <0.01   |
| Full years of study, mean (SD)          | 9.03 (5.60)     | 6.61 (5.34)   | 8.93 (5.48)     | 8.31 (5.50)   | 9.60 (5.60)             | <0.01   |
| Clinical symptoms n (%)                 | 1240 (85.9)     | 156 (88.1)    | 126 (93.3)      | 151 (92.6)    | 807 (83.4)              | <0.01   |
| Age onset of symptoms, mean (SD)        | 56.4 (17.94)    | 60.98 (18.46) | 56.26 (18.72)   | 54.81 (20.55) | 55.75 (17.07)           |         |
| Wheezing, n (%)                         | 440 (30.5)      | 60 (33.9)     | 52 (38.5)       | 78 (47.9)     | 250 (25.8)              | <0.01   |
| Personal History                        |                 |               |                 |               |                         |         |
| Smoking n (%)                           | 664 (46)        | 93 (52.5)     | 50 (37)         | 82 (50.3)     | 439 (45.4)              | <0.01   |
| Age of initiation of smoking, mean (SD) | 18.7 (6.17)     | 17.61 (5.89)  | 19.52 (6.15)    | 17.35 (4.26)  | 250 (0.26)              |         |
| End of smoking age, mean (SD)           | 41.7 (16.36)    | 44.94 (15.54) | 40.98 (16.41)   | 45.48 (17.50) | 40.42 (16.15)           |         |
| Package/year index, mean (SD)           | 15.6 (24.49)    | 17.87 (26.51) | 11.95 (13.89)   | 25 (24.38)    | 13.9 (24.64)            |         |
| Passive smoker, n (%)                   | 267 (18.5)      | 30 (16.9)     | 23 (17)         | 33 (18.7)     | 181 (21.6)              | 0.64    |
| Years of exposure, mean (SD)            | 24.2 (16.26)    | 26.28 (13.31) | 18.86 (16.46)   | 24.06 (15.81) | 24.62 (16.66)           |         |
| Wood smoke exposure, n (%)              | 793 (55)        | 124 (70.1)    | 76 (56.3)       | 105 (64.4)    | 488 (50.4)              | <0.01   |
| Years of exposure, mean (SD)            | 22.3 (4.70)     | 25.22 (4.36)  | 19.87 (5.59)    | 23.92 (4.80)  | 21.56 (4.59)            |         |
| History of atopy, n (%)                 | 363 (25.2)      | 34 (19.2)     | 43 (31.9)       | 49 (30.1)     | 237 (24.5)              | <0.01   |
| Previous diagnosis of COPD, n (%)       | 401 (27.8)      | 79 (44.6)     | 35 (25.9)       | 85 (52.1)     | 202 (20.9)              | <0.01   |
| Previous asthma diagnosis, n (%)        | 213 (14.8)      | 19 (10.7)     | 30 (22.2)       | 44 (27)       | 120 (12.4)              | <0.01   |

Abbreviations: COPD, chronic obstructive pulmonary disease; ACOS, asthma-COPD overlap syndrome.

Statistical significance  $P < 0.05$ .

0.72) and ACOS (1.7, SD 0.61). Table 2 summarizes lung function data.

### Discriminative Power of Questionnaires

The CDQ had 4 out of 8 significant questions for differentiating diseases, COPD-PS had 4 of 5, PUMA had 6 of 7, and all LFQ questions showed discriminatory power. Significant questions are in Table 3, and selected variables formed a unified questionnaire (Table 4).

### Diagnostic Performance

The AUC for diagnosing COPD was 0.75 (95% CI, 0.71-0.79;  $P < 0.001$ , Supplemental Figure 1), for asthma 0.68 (95% CI, 0.63-0.72;  $P < 0.001$ , Supplemental Figure 2), and for ACOS 0.78 (95% CI, 0.75-0.82;  $P < 0.001$ , Supplemental Figure 3).

## DISCUSSION

The study aimed to evaluate how well symptoms reported through questionnaires help identify obstructive lung diseases. Factors such as age, sex, smoking history, and symptoms of bronchial obstruction were useful for non-expert examiners in diagnosing COPD, asthma, or ACOS. While creating new questionnaires was not the goal, the findings suggest that asking the right questions about symptoms can help differentiate patients with these conditions.

**Table 2.** Pulmonary Function

|                               | Total<br>n=443 | COPD<br>n=177 | Asthma<br>n=35 | ACOS<br>n=163 | No Obstruction<br>n=968 |
|-------------------------------|----------------|---------------|----------------|---------------|-------------------------|
| Weight kg, mean (SD)          | 70.8 (13.79)   | 69.0 (14.04)  | 70.7 (13.51)   | 67.2 (12.26)  | 71.8 (13.91)            |
| Height cm, mean (SD)          | 160.0 (9.14)   | 159.6 (8.94)  | 158.1 (8.49)   | 160.8 (9.38)  | 160.2 (9.20)            |
| Pulmonary function, mean (SD) |                |               |                |               |                         |
| FVC (L) pre-B2                | 3.0 (1.00)     | 2.9 (0.95)    | 2.5 (0.91)     | 2.6 (0.88)    | 3.1 (1.01)              |
| FVC (L) post-B2               | 3.0 (0.98)     | 2.9 (0.98)    | 2.7 (0.94)     | 3.0 (0.93)    | 3.1 (0.99)              |
| FEV1 (L) pre-B2               | 2.2 (0.82)     | 1.7 (0.63)    | 1.8 (0.63)     | 1.4 (0.58)    | 2.5 (0.77)              |
| FEV1 (L) post-B2              | 2.3 (0.83)     | 1.8 (0.67)    | 2.1 (0.72)     | 1.7 (0.61)    | 2.5 (0.80)              |
| FEV1 (%) change               | 8.0 (10.40)    | 5.2 (4.47)    | 19.9 (9.12)    | 26.1 (14.60)  | 4.0 (4.52)              |
| FEV1/FVC pre-B2               | 73.4 (13.15)   | 60.2 (9.07)   | 73.9 (10.15)   | 53.5 (10.83)  | 79.1 (8.86)             |
| FEV1/FVC post-B2              | 76.2 (12.15)   | 61.1 (8.48)   | 78.9 (6.99)    | 57.3 (9.84)   | 81.7 (7.15)             |

Abbreviations: FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; COPD, chronic obstructive pulmonary disease; ACOS, Asthma-COPD overlap syndrome.

Age is a useful factor in distinguishing between asthma and COPD. Holm et al noted a sharp rise in COPD prevalence after age 60, while asthma is more common under age 40 and remains stable throughout life.<sup>10-13</sup> In our study, COPD patients were older than those with asthma or ACOS.<sup>3,14</sup> While COPD is typically associated with men and asthma with women, a Canadian study found no gender differences for asthma or ACOS.<sup>3,15,16</sup> In our cohort, men were more likely to have COPD or ACOS, though a 2018 study showed ACOS was more frequent in women.<sup>17</sup>

COPD patients—especially in advanced stages—tend to have

**Table 3.** Variables Selected From the Validated Questionnaires

|  | Total<br>n = 1443 | COPD<br>n = 177 | Asthma<br>n = 135 | ACOS<br>n = 163 | No Obstruction<br>n = 968 | P value |
|--|-------------------|-----------------|-------------------|-----------------|---------------------------|---------|
| COPD Diagnostic Questionnaire, mean (%)  |                   |                 |                   |                 |                           |         |
| 1. BMI < 25  | 452 (31)          | 63 (36)         | 38 (28)           | 65 (40)         | 286 (30)                  | < 0.01  |
| BMI 25.4 – 29.7  | 629 (44)          | 80 (45)         | 56 (41)           | 74 (45)         | 419 (43)                  |         |
| BMI > 29.7   | 362 (25)          | 34 (19)         | 41 (30)           | 24 (15)         | 263 (27)                  |         |
| 2. Does the weather affect the cough?  |                   |                 |                   |                 |                           |         |
| Yes  | 860 (60)          | 107 (60)        | 86 (64)           | 124 (76)        | 543 (56)                  | < 0.01  |
| 3. In the cold do you have a cough and expectoration?  |                   |                 |                   |                 |                           |         |
| Yes  | 658 (46)          | 89 (50)         | 58 (43)           | 95 (58)         | 416 (43)                  | < 0.01  |
| 4. Do you usually have a cough and phlegm in the morning?  |                   |                 |                   |                 |                           |         |
| Yes  | 441 (31)          | 67 (38)         | 40 (30)           | 63 (39)         | 271 (28)                  | < 0.01  |
| 5. Do you wheeze?  |                   |                 |                   |                 |                           |         |
| Very frequent  | 451 (31)          | 62 (35)         | 53 (39)           | 79 (48)         | 257 (27)                  | < 0.01  |
| Never  | 992 (69)          | 115 (65)        | 82 (61)           | 84 (52)         | 711 (73)                  |         |
| Lung Function Questionnaire, mean (%)  |                   |                 |                   |                 |                           |         |
| 1. How often do you cough up mucus?  |                   |                 |                   |                 |                           |         |
| Very often   | 101 (7)           | 16 (9)          | 7 (5)             | 22 (13)         | 56 (6)                    | < 0.01  |
| Frequently   | 183 (13)          | 28 (16)         | 14 (10)           | 30 (18)         | 111 (11)                  |         |
| Sometimes  | 311 (22)          | 29 (16)         | 37 (27)           | 43 (26)         | 202 (21)                  |         |
| Rarely   | 494 (34)          | 64 (36)         | 48 (36)           | 47 (29)         | 335 (35)                  |         |
| Never  | 354 (25)          | 40 (23)         | 29 (21)           | 21 (13)         | 264 (27)                  |         |
| 2. How often do you feel noises in your chest (gasping, hissing, vibrating) when you breathe?                                      |                   |                 |                   |                 |                           |         |
| Very often   | 99 (7)            | 18 (10)         | 8 (6)             | 21 (13)         | 52 (5)                    | < 0.01  |
| Frequently   | 175 (12)          | 22 (12)         | 22 (16)           | 34 (21)         | 97 (10)                   |         |
| Sometimes  | 352 (24)          | 44 (25)         | 35 (26)           | 57 (35)         | 216 (22)                  |         |
| Rarely   | 234 (16)          | 27 (15)         | 27 (20)           | 25 (15)         | 155 (16)                  |         |
| Never  | 583 (40)          | 66 (37)         | 43 (32)           | 26 (16)         | 448 (46)                  |         |
| 3. How often do you feel short of breath during physical activity (walking up stairs or climbing a hill without stopping to rest)? |                   |                 |                   |                 |                           |         |
| Very often   | 321 (22)          | 46 (26)         | 34 (25)           | 57 (35)         | 184 (19)                  | 0.026   |
| Frequently   | 338 (23)          | 47 (27)         | 39 (29)           | 31 (19)         | 221 (23)                  |         |
| Sometimes  | 306 (21)          | 33 (19)         | 33 (24)           | 25 (15)         | 215 (22)                  |         |
| Rarely   | 191 (13)          | 19 (11)         | 17 (13)           | 24 (15)         | 131 (14)                  |         |
| Never  | 287 (20)          | 32 (18)         | 12 (9)            | 26 (16)         | 217 (22)                  |         |
| COPD Population Screener, mean (%)   |                   |                 |                   |                 |                           |         |
| 1. During the past 4 weeks, how many times did you feel short of breath?   |                   |                 |                   |                 |                           |         |
| Never / rarely   | 683 (47)          | 69 (39)         | 60 (44)           | 56 (34)         | 498 (51)                  | < 0.01  |
| Sometimes  | 403 (28)          | 53 (30)         | 47 (35)           | 41 (25)         | 262 (27)                  |         |
| Most of the time / all of the time   | 357 (25)          | 55 (31)         | 28 (21)           | 66 (40)         | 208 (21)                  |         |
| 2. Do you ever cough up something, mucus or phlegm?  |                   |                 |                   |                 |                           |         |
| Yes, every day   | 160 (11)          | 25 (14)         | 13 (10)           | 34 (21)         | 88 (9)                    | < 0.01  |
| Some days of the month/ Almost every day of the week   | 394 (27)          | 52 (29)         | 43 (32)           | 55 (34)         | 244 (25)                  |         |
| No / never / nly with occasional colds or chest infections   | 889 (62)          | 100 (56)        | 79 (59)           | 74 (45)         | 636 (66)                  |         |
| 3. During the past year, have you reduced your daily activities due to breathing problems?   |                   |                 |                   |                 |                           |         |
| Yes, a lot   | 165 (11)          | 26 (15)         | 19 (14)           | 31 (19)         | 89 (9)                    | < 0.01  |
| Yes  | 409 (28)          | 43 (24)         | 44 (33)           | 52 (32)         | 270 (28)                  |         |
| No, not at all / almost nothing / I'm not sure   | 869 (60)          | 108 (61)        | 72 (53)           | 80 (49)         | 609 (63)                  |         |
| 4. Have you smoked at least 100 cigarettes in your life?   |                   |                 |                   |                 |                           |         |
| Yes  | 594 (41)          | 89 (50)         | 50 (37)           | 75 (46)         | 380 (39)                  | < 0.01  |
| PUMA COPD Questionnaire, mean (%)  |                   |                 |                   |                 |                           |         |
| 1. Dyspnea: Yes  | 895 (62)          | 121 (68)        | 95 (70)           | 116 (71)        | 563 (58)                  | < 0.01  |
| 2. Chronic expectoration: Yes  | 393 (27)          | 57 (32)         | 40 (30)           | 66 (40)         | 230 (24)                  | < 0.01  |
| 3. Chronic cough: Yes  | 683 (47)          | 95 (54)         | 68 (50)           | 91 (56)         | 429 (44)                  | < 0.01  |
| 4. Spirometry has been performed previously: Yes   | 679 (47)          | 112 (63)        | 67 (50)           | 96 (59)         | 404 (42)                  | < 0.01  |

Abbreviations: COPD, chronic obstructive pulmonary disease; ACOS, asthma-COPD overlap syndrome; COPD-PS, chronic obstructive pulmonary disease population screener.

Statistical significance  $P < 0.05$ .

**Table 4.** Likelihood Ratio Tests

| Variable   | P value |
|--|---------|
| Age  | < 0.01  |
| Sex  | < 0.01  |
| Weight   | < 0.01  |
| Have you smoked at least 100 cigarettes in your entire life?   | < 0.01  |
| How many years have you smoked?  | < 0.01  |
| Have you ever been exposed to wood smoke in your life?   | < 0.01  |
| During the past 4 weeks, how many times did you feel short of breath?  | < 0.01  |
| How often do you feel short of breath during physical activity (walking upstairs or climbing a hill without stopping to rest)? | 0.026   |
| How often do you feel noises in your chest (gasping, hissing, vibrating) when you breathe?                                     | < 0.01  |
| Spirometry has been performed previously   | < 0.01  |

Statistical significance  $P < 0.05$ .

lower BMI and muscle mass, unlike asthma patients, whose nutritional status remains stable.<sup>18,19</sup> Smoking history is a key differentiator in questionnaires between COPD and healthy individuals, as it is a clear risk factor for COPD but less so for asthma.<sup>20</sup> Smoking also plays a major role in ACOS diagnosis, according to Spanish guidelines.<sup>4,20</sup> In our study, the smoking history difference between COPD and asthma was over 15.5% and 13% between ACOS and asthma.

Current diagnostic criteria for obstructive lung diseases share common features, making it challenging to differentiate between them. Pascoe et al used a model of 41 patient factors—including demographics and symptoms—compared to pulmonary function tests, achieving 89% specificity and 62% sensitivity.<sup>3</sup> Key variables for distinguishing these diseases were smoking, age, allergies, and sputum expectoration. In our study, asking about severe dyspnea improved discriminatory power for COPD from 13% to 20%.<sup>3,21</sup>

Factors including age, nutrition, and sex can help identify clinical phenotypes, but they may be less clear in early stages or when multiple phenotypes develop.<sup>22</sup> Additionally, the absence of a “gold standard” test complicates efforts to differentiate obstructive lung diseases using only targeted questions.

### Limitations

One limitation of our study is that it was conducted at a single center, which may limit the generalizability of the results. However, the large sample size still provides meaningful data. The higher male participation may have influenced the discriminatory power of this variable. Using spirometry as the final evaluation method could have caused some overlap in diagnoses, but it remains a valuable tool for distinguishing respiratory conditions. While a useful questionnaire was developed, further studies are needed to assess long-term outcomes, prognosis differences, and criteria for improving diagnostic accuracy in clinical practice.

## CONCLUSIONS

Patients with obstructive lung diseases can be identified accurately using clinical variables, such as age, sex, weight, smoking history, and bronchial obstruction symptoms. These variables can be useful for non-experts in recognizing COPD, asthma, or ACOS.

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**Appendices:** Supplemental Figures available at [www.wmjonline.org](http://www.wmjonline.org).

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# Emergency Department Door to Discharge Times

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## ABSTRACT

**Introduction:** Efficient emergency medical care is becoming more important with continually increasing emergency department volumes. Decreasing door to discharge (D2D) times has been shown to improve patient satisfaction and decrease wait times and health care costs. We hypothesize that standardized onboarding for new faculty physicians in microhospital emergency departments will reduce D2D times.

**Methods:** In this retrospective observational study, D2D times were tracked for newly hired physicians at 2 microhospital emergency departments within an academic health system during 2021-2022. Physicians hired after July 2022 received an onboarding process that emphasized reducing D2D times. D2D times for these physicians were compared with those of physicians hired earlier who did not receive any onboarding. D2D means and standard deviations (SD) of each group were compared with 2-sample *t* tests.

**Results:** There were 25 newly hired emergency department physicians across both study locations over 2 years; 15 received no onboarding, while 10 received onboarding. At one of the emergency departments, physicians who received onboarding had a significantly reduced mean D2D time compared with those who received no onboarding (119 minutes [SD = 29] vs 146 minutes [SD = 34],  $P = 0.049$ ). At the other emergency department, there was no significant difference in D2D times between physicians who did or did not receive onboarding (97 minutes [SD = 35] vs 102 minutes [SD = 30],  $P = 0.760$ ). Across both locations, physicians who received onboarding had a nonsignificant reduction in D2D times compared with those who received no onboarding (110 minutes [SD = 32] vs 126 minutes [SD = 39],  $P = 0.160$ ).

**Conclusions:** After implementing an onboarding process for new physician hires, there was a statistically significant decrease in D2D times at one of the microhospital emergency departments. Thus, an onboarding process may represent a simple, cost-effective technique that emergency departments can use to reduce D2D times and prevent overcrowding. Future work may evaluate the efficacy of such processes in non-microhospital emergency department settings.

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## INTRODUCTION

In 2019, 1 in 5 US adults were evaluated in the emergency department (ED), a rate that has increased progressively over the past 20 years.<sup>1</sup> Despite increasing patient volumes, the number of available hospital-based EDs has shrunk significantly over the same period.<sup>2</sup> These temporal trends have heightened the importance of efficient and timely care in the ED to avoid overcrowding. In emergency medicine, excellent patient care comes first, but a close second is the efficiency in which this care is provided. Thus, quality improvement initiatives to enhance ED efficiency have become increasingly necessary.

Door-to-Discharge (D2D) times are a commonly used metric for evaluating the efficiency, speed, and preparedness of EDs and physicians. This value measures the time from patient arrival to the ED to their discharge from the ED. Studies show that ED overcrowding, prolonged ED waiting times, and longer D2Ds have been associated consistently with poorer quality of care, reduced patient satisfaction, increased costs, and higher mortality rates.<sup>3-11</sup> In fact,

longer patient waiting times were found to be the second most cited cause of decreased patient satisfaction in the ED, behind only poor staff-patient communication.<sup>12</sup> Prior quality research has suggested a number of techniques to decrease D2D and waiting times, including nurse staffing adjustments, development of standard order sets, medical scribe use, and variation in patient flow models.<sup>13-16</sup>

In this study, we took a novel approach to evaluate whether D2D times decreased after the implementation of a standardized onboarding process for newly hired emergency faculty physicians at 2 microhospital EDs within an academic health care system. This rigorous orientation focused primarily on increasing ED efficiency and patient throughput. Use of standardized onboarding processes in other medical domains has been shown to improve a variety of outcomes, including reducing hospital staff turnover, improving protocol adherence, and increasing staff familiarity with new demands.<sup>17-20</sup> To our knowledge, no prior study has evaluated the effectiveness of a standardized onboarding process for newly hired emergency physicians and, specifically, its impact on D2D times. Given the prior research described above, we hypothesized that the implementation of a standardized onboarding process would lead to decreased mean D2D times in our microhospital ED setting. This would represent a simple and cost-effective technique EDs could introduce to reduce overcrowding and costs, while also improving patient outcomes and satisfaction.

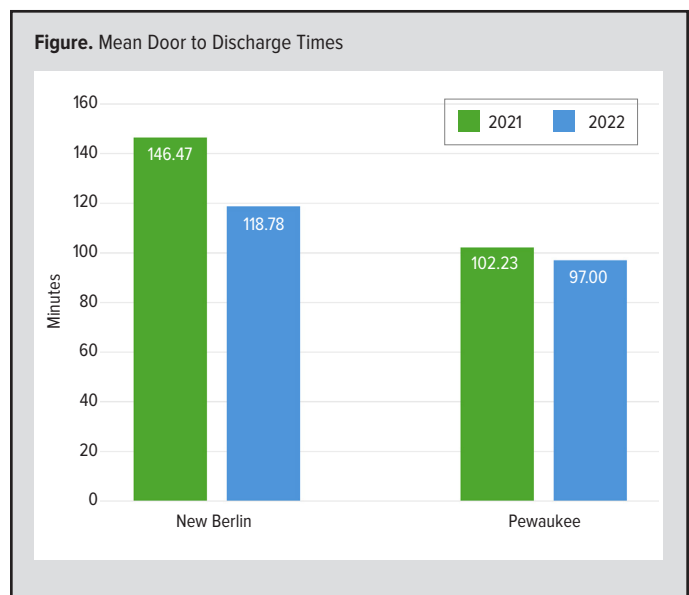
## METHODS

At the start of the 2022 academic year, an onboarding process was enacted at 2 microhospital EDs within the Froedtert & Medical College of Wisconsin (MCW) academic health care system: the Froedtert Community Hospital–New Berlin ED and the Froedtert Community Hospital–Pewaukee ED. These sites were chosen because they are in a pay-per-performance agreement between the Department of Emergency Medicine and the health system. The metrics related to the pay goals are D2D times and patient satisfaction.

New faculty starting at these sites prior to July 2022 did not receive any onboarding related to ED metrics. Starting in July 2022, each newly hired ED physician worked their first shift at one of these sites alongside either a medical director or the vice chair of community medicine. During this shift, the newly hired physicians were given a presentation on metric strategies while providing care at these microhospital ED sites. The presentation specifically emphasized the D2D time metric, with a goal average D2D time of less than 120 minutes. These presentations discussed evidence-based practices that could be implemented to increase patient satisfaction and decrease D2D times, as well as tips from successful faculty within the department. At 3 months and 6 months after receiving their onboarding orientation, these physicians met with the medical directors to discuss their metrics—including average D2D times—and strategies to improve if needed. A retrospective observational review on D2D time metrics was then performed for newly hired physicians from July 2021 through January 2022 who did not participate in a standardized onboarding orientation shift. These data were compared to the D2D time metrics for the physicians hired in July 2022 through January 2023 who did receive the multifaceted standardized onboarding process. The department statistician performed

|                         | New Hires | Males | Females | Former MCW Residents |
|-------------------------|-----------|-------|---------|----------------------|
| <b>2021</b>             |           |       |         |                      |
| New Berlin only         | 2         | 1     | 1       | 0                    |
| New Berlin and Pewaukee | 13        | 9     | 4       | 3                    |
| Total hires             | 15        | 10    | 5       | 3                    |
| <b>2022</b>             |           |       |         |                      |
| New Berlin only         | 3         | 2     | 1       | 0                    |
| New Berlin and Pewaukee | 7         | 4     | 3       | 1                    |
| Total hires             | 10        | 6     | 4       | 1                    |

Abbreviations: MCW, Medical College of Wisconsin



a 2 sample *t* test to determine statistical difference between the 2 groups, calculating means, standard deviations, *t*, *df*, and *P* values.

## RESULTS

Between July 1, 2021, and January 1, 2022, there were 15 new faculty physicians hired to work at the New Berlin and Pewaukee microhospital EDs. Between July 1, 2022, and January 1, 2023, there were 10 new faculty physicians hired to work at these microhospital EDs. Key demographics are presented in Table 1.

The D2D time decreased significantly for physicians who started at the New Berlin ED in 2022 compared to 2021 (*P*=0.049). The implementation of an onboarding process resulted in patients being in the ED for 28 minutes less than patients were previously (Table 2). There was not a statistically significant difference in the D2D times of the physicians who started at the Pewaukee ED in 2021 versus those who started at the same ED in 2022 after implementation of the onboarding process (Table 2, Figure). This lack of significant improvement in D2D times at the Pewaukee ED may stem from the baseline differences between these 2 EDs, such as annual patient volume, average Emergency Severity Index (ESI) score, and average number of patients seen per day (Tables 3 and 4). When comparing

**Table 2.** Door to Discharge Statistical Analysis

|            | 2021 Mean D2D | 2022 Mean D2D | P value | SD    | t value | df    |
|------------|---------------|---------------|---------|-------|---------|-------|
| New Berlin | 146.47 min    | 118.78 min    | 0.049   | 34.62 | 2.10    | 19.05 |
| Pewaukee   | 102.23 min    | 97.0 min      | 0.76    | 30.67 | 0.32    | 8.50  |
| Both sites | 125.93 min    | 110.07 min    | 0.16    | 37.12 | 1.43    | 33.44 |

Abbreviations: D2D, door to discharge; df, degrees of freedom; min, minutes.

**Table 3.** Site Demographics

|            | Volume 2021 | Avg PPD 2021 | Volume 2022 | Avg PPD 2022 | Avg ESI 2021 | Avg ESI 2022 | Avg ESI Overall |
|------------|-------------|--------------|-------------|--------------|--------------|--------------|-----------------|
| New Berlin | 6332        | 34.41        | 6119        | 33.26        | 3.09         | 3.27         | 3.18            |
| Pewaukee   | 2951        | 16.04        | 3396        | 18.46        | 3.30         | 3.30         | 3.30            |
| P value    | N/A         | <0.01        | N/A         | <0.01        | <0.01        | 0.05         | <0.01           |
| t value    | N/A         | 28.98        | N/A         | 34.52        | -13.22       | 1.94         | -11.19          |
| df         | N/A         | 366          | N/A         | 366          | 5723.8       | 7085.6       | 12922           |

Abbreviations: Avg, average; PPD, patients per day; ESI, Emergency Service Index; df, degrees of freedom.

**Table 4.** Emergency Service Index Proportions Per Site

|                | New Berlin (%) 2021        | Pewaukee (%) 2021         |
|----------------|----------------------------|---------------------------|
| ESI 1          | 23 (0.36)                  | 2 (0.07)                  |
| ESI 2          | 1138 (17.97) <sup>a</sup>  | 354 (12.00)               |
| ESI 3          | 3501 (55.29) <sup>a</sup>  | 1420 (48.14)              |
| ESI 4          | 1576 (24.89)               | 1106 (37.49) <sup>a</sup> |
| ESI 5          | 95 (1.48)                  | 68 (2.31) <sup>a</sup>    |
| Total          | 6332 (100)                 | 2950 (100)                |
| P value        |                            | P < 0.01                  |
| χ <sup>2</sup> |                            | χ <sup>2</sup> = 188.98   |
| df             |                            | df = 4                    |
|                | New Berlin (%) 2022        | Pewaukee (%) 2022         |
| ESI 1          | 8 (0.13)                   | 0 (0.00)                  |
| ESI 2          | 624 (10.20)                | 364 (10.72)               |
| ESI 3          | 3349 (54.73) <sup>a</sup>  | 1695 (49.93)              |
| ESI 4          | 1959 (32.02)               | 1282 (37.76) <sup>a</sup> |
| ESI 5          | 179 (2.93) <sup>a</sup>    | 54 (1.59)                 |
| Total          | 6119 (100)                 | 3395 (100)                |
| P value        |                            | P < 0.01                  |
| χ <sup>2</sup> |                            | χ <sup>2</sup> = 51.57    |
| df             |                            | df = 4                    |
|                | New Berlin (%) 2021 & 2022 | Pewaukee (%) 2021 & 2022  |
| ESI 1          | 31 (0.25) <sup>a</sup>     | 2 (0.03)                  |
| ESI 2          | 1762 (14.15) <sup>a</sup>  | 718 (11.32)               |
| ESI 3          | 6850 (55.02) <sup>a</sup>  | 3115 (49.09)              |
| ESI 4          | 3535 (28.39)               | 2388 (37.64) <sup>a</sup> |
| ESI 5          | 273 (2.19)                 | 122 (1.92)                |
| Total          | 12450 (100)                | 6345 (100)                |
| P value        |                            | P < 0.01                  |
| χ <sup>2</sup> |                            | χ <sup>2</sup> = 180.98   |
| df             |                            | df = 4                    |

Abbreviations: ESI, Emergency Service Index; df, degrees of freedom.  
<sup>a</sup>Signifies a statistically significant higher proportion.

total D2D data from 2021 to 2022 across both sites, there was a nonsignificant reduction in D2D times after implementation of the onboarding process (Table 3).

**DISCUSSION**

In this retrospective observational study, we analyzed the impact on D2D times after initiating a formal onboarding process for new faculty physician hires at 2 separate micro-hospital EDs within the Froedtert & MCW academic health care system. After performing a data analysis using 2-sample *t* test, the results revealed a statistically significant improvement of D2D times from 2021 to 2022 at the New Berlin site, while the D2D times at the Pewaukee site did not show statistically significant improvement from 2021 to 2022. Since 20 out of 25 (80%) of

the newly hired physicians in 2021 and 2022 worked at both EDs within their first 6 months, we also gathered data from both sites to compare the overall D2D time between 2021 and 2022. In doing so, it was evident that after implementation of a new onboarding process at both locations in 2022, there was a decrease in D2D times, but it was not a significant improvement of the D2D times when compared to 2021 data.

Interestingly, though D2D times at New Berlin improved significantly between 2021 and 2022, the D2D times at Pewaukee improved during the same period but not at a statistically significant rate. It is possible that given the small sample size of this group of physicians (n = 10), there was not enough data to reveal significance. Additionally, baseline differences between these 2 sites, such as annual patient volume, average ESI, and average patients seen per day, may have affected the D2D times for each site uniquely. For example, the New Berlin ED sees a slightly higher acuity of patients and nearly double the annual volume and average number of patients per day versus the Pewaukee ED. This is likely a reason why the average D2D times from Pewaukee are significantly less than those of New Berlin in both 2021 and 2022. Furthermore, with already low D2D times in the setting of a smaller patient volume and higher ESI, there is likely less room for statistically significant improvement—even after an intervention such as implementing an onboarding process. The lack of significant change at the Pewaukee site likely had a diluting impact on the insignificance calculated when evaluating the total data from 2021 versus 2022.

Additional variables that may have affected D2D times include specific physician factors, such as age, sex, years of experience, fellowship training, location of training, time or day of shift worked, and average shift load. For example, increased years of experience may be associated with shorter average D2D times, whereas D2D times may be slightly higher for a physician who received train-

ing outside of the Froedtert & MCW academic health system. Additionally, a comparison of the types of shifts worked by specific physicians may reveal that D2D times differ between weekends and weekdays or overnight shifts versus day shifts. Unfortunately, this type of demographic data was not obtained for this study and could not be analyzed.

There are confounding variables that may have affected these data over the 2 years studied. The age, previous Froedtert and MCW health system experience, or the number of years post-residency of the physician may have affected each individual physician's D2D times. There also could have been differences in nursing efficiency, specialty availability, transfer capabilities and speed, and overall system capacity constraints. This study also was limited due to the small sample size (2021: n = 15, 2022: n = 10) and lack of demographics obtained from these samples. Future iterations of this study would benefit from a larger sample size, which could be obtained by continuing to study new physician hires at these sites and by expanding the study to other microhospital sites within the system. Furthermore, it may be informative to gather additional demographic data about the physicians being studied to assess the impact of any confounding variables, such as age and experience.

In addition to the small sample size and lacking demographics, it is possible that the data may have been skewed by variations in ESI levels year-to-year between the 2 sites. For example, though the overall average ESI level for the New Berlin site is higher than that of the Pewaukee site, when these data were extrapolated and compared year-to-year, the New Berlin ED had a slight decrease in acuity from 2021 to 2022, whereas Pewaukee's ESI and, therefore, acuity remained consistent (Table 4). It is possible that this difference in ESI from 2021 to 2022 at New Berlin was a confounding variable affecting the statistically significant decrease in D2D time seen. Once again, obtaining data over multiple years to evaluate the fluctuations in ESI or volume between the 2 sites and the impact of these variables on ED efficiency would provide further insight into this study.

## CONCLUSIONS

After the implementation of a standardized orientation and onboarding process for new emergency medicine faculty physician hires, there was a statistically significant decrease in D2D times at 1 of the 2 microhospital EDs within the academic health care system involved in this study. While other studies have shown success in implementing orientation protocols for resident and nursing roles, this is the first study of its kind to our knowledge to provide a framework for developing an onboarding process for newly hired emergency physicians. Future studies would benefit from an evaluation of the impact of an onboarding process in different ED settings, including EDs with varying volumes and acuity levels, as well as a comparison between the impact of these protocols in different types of EDs, such as academic, community, county, and veterans affairs.

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# Symptomatic Improvement in Irritable Bowel Syndrome With Oral Ketamine

Omar Dyara, MD; Natasha Topoluk, MD, PhD; Harvey J. Woehlck, MD

## ABSTRACT

**Introduction:** Irritable bowel syndrome (IBS) often is treated as a partially diet-responsive functional bowel disorder. Few interventions have been found to be effective in diet-refractory IBS, leading to lifestyle disruptions due to persistent symptoms. The efficacy of low-dose home ketamine therapy suggests others may benefit.

**Case Presentation:** A female patient in her 60s with progressive presumed IBS with diarrhea found diet-based treatments ineffective, resulting in severe lifestyle disruptions. After a hysterectomy, intolerance to opioids for postoperative pain prompted the use of intravenous ketamine. An unexpected and prolonged improvement in IBS symptoms resulted. The patient sought continued treatment with ketamine for IBS symptoms and experienced continued symptomatic relief with 20 mg oral ketamine every 2 weeks at home.

**Discussion:** No other published cases of ketamine for IBS were found.

**Conclusions:** While dietary changes remain the gold standard for IBS, this patient experience highlights ketamine as a potential adjunct therapy.

## INTRODUCTION

Irritable bowel syndrome (IBS) is a common subtype of functional gastrointestinal disorder (FGID). In some patients, symptoms unresponsive to diet currently lack effective therapy. N-methyl-D-aspartate (NMDA) receptor antagonism with ketamine is a common analgesic practice in the treatment of acute and perioperative pain. Ketamine has been shown to successfully alleviate pain in multiple gastrointestinal (GI) syndromes and

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pathologies.<sup>1-4</sup> However, the successful use of ketamine therapy for functional abdominal pain syndrome has not been described previously. Here we describe a case of FGID with relief of both GI symptoms of diarrhea and abdominal pain with low-dose oral ketamine therapy.

## CASE PRESENTATION

A female patient in her 60s with past medical history significant for IBS and possible celiac disease presented to the pain clinic for evaluation and treatment of chronic diarrhea. She described almost 12 years of fatigue with progressive GI symptoms despite thorough diagnostic testing and multiple intervention modalities, as outlined below. The benefit of ketamine

was discovered serendipitously, as the initial prescription was for an unrelated medical issue, namely postoperative surgical pain therapy.

Briefly, 11 years prior, the patient developed lesions consistent with dermatitis herpetiformis, which resolved after initiation of a gluten-free diet. Because of prior episodes of this rash, she was considered to have celiac disease without biopsy confirmation, and she has remained on a gluten-free diet since that time without recurrence of skin lesions. Nine years prior, she began to experience severe fatigue, which she noted started after discontinuing venlafaxine therapy. Eight years prior, she developed 10 palpable nodules concerning for nodular fasciitis that sequentially appeared and resolved but were not all present at the same time. Although literature suggested an association of nodules with Lyme disease, to which the patient may have been exposed, Lyme serologies were negative. The lesions spontaneously resolved prior to biopsy and no definitive diagnosis could be made.

For relief of menopausal symptoms—primarily nighttime hot flashes that disturbed sleep and caused additional fatigue—the patient was started on estrogen and progesterone therapy with resolution of the hot flashes but without improvement of the fatigue. She underwent sleep polysomnography to rule out sleep apnea-related causes of fatigue but had a normal sleep study.

Seven years prior, the patient underwent upper and lower GI endoscopy for increasing diarrhea, flatulence, and bloating associated with worsening fatigue. The endoscopy showed colonic diverticulosis but normal gastric and small bowel mucosa without villous atrophy or inflammatory pathology. Over the next year, she continued to experience increased frequency and worsening severity of diarrhea, despite multiple antibiotic courses for presumed intestinal dysbiosis. Eosinophils were noted to be elevated as part of an investigation into fatigue, but no eosinophilic inflammation had been detected in intestinal biopsies.

The patient experienced her first episode of severe abdominal pain requiring urgent evaluation 5 years prior. No indications for surgical exploration were identified via abdominal imaging or white blood cell counts, and she was given ketorolac with resolution of abdominal pain. For the next 6 months, her bloating remained constant with 3 to 4 days per week of diarrhea. Transition to a low FODMAP (fermentable oligosaccharides, disaccharides, monosaccharides, and polyols) diet provided partial relief of diarrhea, although this intervention increased the severity of abdominal pain. At this time, eosinophils were noted to have increased to 16% (absolute count 1000). Out of concern for possible human intestinal spirochetosis, she completed a course of metronidazole therapy without improvement in symptoms. Two months later, she was in constant severe abdominal pain and experienced a period of rapid weight loss (8 lbs in 3 weeks to 107 pounds, body mass index [BMI] 16.8) resulting in further evaluation at urgent care centers and emergency departments. Abdominal computed tomography and magnetic resonance imaging scans showed no identifiable pathology. She was started on dexamethasone therapy with improvement of pain to allow participation in activities of daily living.

Four days after initiation of steroid therapy, the patient had return of normal appetite and was without diarrhea. Within 1 month of starting steroid therapy, she was referred to an endocrinologist and underwent corticotrophin stimulation testing significant for low-normal morning cortisol and adrenocorticotropic hormone levels. She was instructed to stop steroid therapy. Two days after stopping steroid therapy, she experienced another episode of severe abdominal pain. She underwent repeat endoscopy showing no significant pathology. At this time, eosinophil count and tryptase were within normal range. Genetic testing was significant for neither DQ-2 nor DQ-8 markers of celiac disease. A functional bowel disorder consistent with IBS with nonceliac gluten intolerance was considered given historically elevated eosinophils and IgE levels. However, a subsequent

trial of oral cromolyn therapy did not result in improvement of symptoms.

Two years prior, the patient started a 6-month course of tetracycline and folic acid therapy for treatment of possible tropical sprue, without improvement in symptoms. Symptoms persisted despite another trial of dexamethasone therapy 2 years prior.

Two years later, or about 1 year before present, the patient underwent hysterectomy. She described nausea and vomiting with perioperative opioids and was given ketamine to avoid further opioid administration. She subsequently experienced significant alleviation of her IBS symptoms for the first 5 to 6 postoperative weeks. Diarrhea began to recur thereafter, and a trial of very low-dose oral ketamine, 5 mg to 10 mg weekly, was initiated, with improvement in diarrhea and abdominal pain. Further adjustment of the dose revealed that 20 mg of oral ketamine once every 2 weeks was adequate to control symptoms of abdominal pain and diarrhea.

The patient kept a detailed symptom and diet diary for 60 days prior to hysterectomy, leading up to oral ketamine prescription and for 156 days after initiation of oral ketamine therapy. The diary indicated 9 out of 60 days with >6 bowel movements per day prior to initiation of oral ketamine therapy and only 5 out of 156 days after ketamine initiation ( $P < 0.05$  by chi-square analysis). Similarly, the diary indicated 7 out of 60 days with symptoms preventing activities of daily living prior to initiation of oral ketamine therapy and only 4 out of 156 days after ketamine initiation ( $P < 0.05$  by chi-square analysis). As long as she adhered to the low-FODMAP diet, she had the same low incidence of diarrhea and abdominal symptoms. She has been able to reintroduce many foods that previously caused symptoms and has gained back 11 pounds (118 pounds, BMI 18.5).

In follow-up for a year after initiation of ketamine, the dose requirement had not increased and efficacy remained constant. The patient described how after a 20 mg of oral ketamine administered in a sublingual lozenge, she will typically have to lie down for about 2 hours but remains conscious and does not experience side effects like hallucinations. She can read or get up to go to the bathroom but avoids any tasks requiring coordination, like cooking, driving, or outdoor activities.

## DISCUSSION

The patient was diagnosed with IBS with diarrhea due to the constellation of GI symptoms and abdominal pain without confirmed underlying pathology despite extensive diagnostic testing, which was consistent with FGID. While debate continues in published medical opinions, dysbiosis, dysmotility, and visceral hypersensitivity all have been implicated as contributors to FGID symptomatology. Disruption of the innate microbiota—dysbiosis—can cause and worsen GI symptoms. Studies also have shown dysmotility promotes dysbiosis, sometimes manifested as small intestinal bacterial overgrowth syndrome (SIBO).<sup>5</sup> Therapies com-

monly employed to treat the symptoms of functional abdominal pain syndrome, including loperamide, may reduce gut motility, potentially worsening SIBO and furthering a cycle of seemingly intractable GI symptoms. While not completely elucidated, both peripheral and central sensitization have been implicated in visceral pain perception.<sup>6</sup>

We present 2 possible mechanisms for symptom alleviation: NMDA mediation of central sensitization and toll-like receptor (TLR) pathway mediation of dysbiosis. Ketamine is an NMDA antagonist commonly administered for its analgesic properties, including chronic pain involving the GI tract. Central sensitization results from increased responsiveness of dorsal horn neurons and heterosynaptic potentiation of these neurons, creating the perception of an increased and more widespread pain than the original area of neuronal excitation.<sup>6-7</sup> This phenomenon of central sensitization has been linked to the NMDA receptor via multiple mechanisms, for which ketamine as an NMDA antagonist is beneficial.<sup>6-8</sup>

Ketamine has been used in both acute and acute on chronic pancreatitis with reported successful analgesia in both intravenous (IV) and oral formulations.<sup>1-2</sup> Though the exact mechanism has not been elucidated, ketamine has successfully alleviated symptoms in other GI pathologies, including cyclic vomiting syndrome and Crohn's disease.<sup>3-4</sup> A small, randomized, double-blinded, crossover study evaluated IV ketamine's ability to mitigate induced visceral hypersensitivity caused by esophageal acid infusion.<sup>7</sup> The study reported both reduction and prevention of esophageal pain thresholds with IV ketamine bolus. However, ketamine therapy alleviating pain and GI distress in this type of functional bowel disorder, as seen in this case, has not been reported previously in the literature.

A second possible mechanism accounting for both improvements in GI function as well as perceived abdominal pain involves ketamine action on TLR pathways. In vivo studies in mice have linked dysbiosis with up-regulation of TLR pathways, including TLR 4.<sup>9</sup> Ketamine has been shown to suppress TLR 4 signaling pathways in the lungs and intestines of rats.<sup>10,11</sup> Thus, ketamine could improve symptoms of GI distress and abdominal pain through TLR-mediated regulation of dysbiosis. Additionally, while anatomic factors and antidiarrheal drugs that slow small bowel and colonic transit are associated with dysbiosis,<sup>5</sup> ketamine does not appear to have adverse effects on gut motility,<sup>12</sup> potentially limiting the cyclic contribution of dysmotility and dysbiosis to overall symptomatology.

Non-IV ketamine therapy is a novel concept, with older literature indicating administration in a health care setting<sup>13</sup> and more contemporary reports indicating a transition to home ketamine therapy for intractable pain and treatment-resistant depression.<sup>14,15</sup> The low dose required by this patient has resulted in successful home therapy, avoiding the cost and inconvenience of in-clinic administration. The lack of tolerance or escalation

in dose requirement suggests that the treatment may have long-term benefit in some patients.

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# Elsberg Syndrome: An Overlooked But Treatable Cause of Back Pain

Anji Li, MD; John Ning, MD; Pinky Jha, MD

## ABSTRACT

**Introduction:** Elsberg syndrome is an uncommon cause of lumbosacral radiculitis that presents as a constellation of symptoms, including urinary retention, bowel incontinence, severe constipation, impotence, and saddle anesthesia.

**Case Presentation:** A 32-year-old female presented to the emergency department with complaints of bilateral leg pain and urinary retention. Two weeks prior, she noticed new genital lesions and had a positive nucleic acid amplification test for herpes simplex virus (HSV) type 2. Magnetic resonance imaging of the lumbar spine showed extraforaminal enhancement and edema-like signal within all the lumbosacral nerve roots. Cerebrospinal fluid (CSF) studies, CSF culture, and meningitis panel were unremarkable.

**Discussion:** Elsberg syndrome likely accounts for 5% to 15% of patients with cauda equina syndrome. However, physicians often leave out Elsberg syndrome in the differential diagnosis of acute cauda equina syndrome and do not perform HSV testing to facilitate definitive diagnosis. As a result, Elsberg syndrome is underreported.

**Conclusions:** A high degree of clinical suspicion should be deployed when diagnosing patients with bilateral lumbosacral radiculitis, as early detection and treatment of Elsberg syndrome prevents long-term morbidity.

## INTRODUCTION

Elsberg syndrome was first described by American neurosurgeon Charles Elsberg in 1931 as a self-limiting syndrome of acute urinary retention combined with spinal cord dysfunction and cerebrospinal fluid pleocytosis.<sup>1</sup> Elsberg syndrome encompasses a constellation of symptoms, including urinary retention, bowel incontinence, severe constipation, impotence, and saddle anes-

thesia due to acute lumbosacral meningo-radiculitis.<sup>2</sup>

## CASE PRESENTATION

A 32-year-old female with a past medical history of migraines, anxiety, and depression presented to the emergency department (ED) with complaints of bilateral leg pain and urinary retention. Two weeks prior, she started experiencing urinary frequency and was started on nitrofurantoin at an urgent care center after urine dipstick was concerning for a urinary tract infection. Three days later, she returned to urgent care because she noticed new genital lesions. Nucleic acid amplification test (NAAT) of the lesions returned positive for herpes simplex virus type 2 (HSV-2). She tested negative for other sexually transmitted diseases, including HIV. She

was sexually active with 1 partner who takes daily valacyclovir, and she was prescribed a 7-day course of valacyclovir after being diagnosed with HSV-2. Prior to initiating treatment, she started experiencing new onset sacral pain that progressed to a burning sensation along the back of both thighs, extending into her heels. She denied any numbness or weakness in her lower extremities.

Despite completing treatment with nitrofurantoin, the patient continued experiencing dysuria, urinary hesitancy, and incomplete voiding. Her leg pain also was progressing, so she returned to urgent care 1 week later. Urinalysis at that time showed trace blood, 30 protein, and moderate leukocytes. Culture was positive for >100 000 colony forming units of *Gardnerella vaginalis*. Urology also evaluated her at urgent care and suspected her symptoms were due to continued HSV-2 infection, even though she did not have evidence of active lesions at that time. She was sent

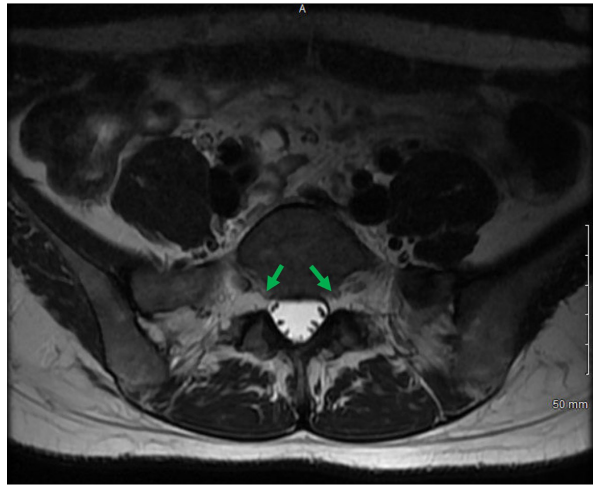
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**Figure.** Magnetic Resonance Imaging Spine With and Without Contrast Demonstrating Extraforaminal Enhancement in the Lumbosacral Nerve Roots



home with a 5-day course of ciprofloxacin and a 10-day course of valacyclovir and prednisone and told to follow up with Neurology outpatient. One day later, she felt increased burning and itching in her vaginal area, along with new onset neck stiffness and headache. She presented to the ED for further workup of her symptoms.

In the ED, admission vitals and labs were within normal limits. Kernig and Brudzinski signs were negative on physical exam. Her basic metabolic panel, comprehensive metabolic panel, and urinalysis were unremarkable. Bladder scan showed 252 mL of urine. Given the clinical symptoms of headache and neck stiffness, lumbar puncture, head computed tomography (CT) and magnetic resonance imaging (MRI) of the brain were obtained to rule out an infectious etiology or an acute intracranial process. The patient's cerebrospinal fluid (CSF) protein, glucose, red blood cell count, and white blood cell count were within normal limits. CSF culture showed 3+ mononuclear cells with no organisms or evidence of polymorphonuclear neutrophils. The meningitis/encephalitis NAAT panel was negative for all pathogens, including HSV-2. Head CT and MRI brain showed no acute intracranial findings, but MRI of the lumbar spine showed extraforaminal enhancement and edema-like signal within all the lumbosacral nerve roots.

Based on the clinical presentation, recent HSV-2 infection, and abnormal MRI findings, the patient was diagnosed with Elsberg syndrome. Per Neurology's recommendations, she was started on intravenous (IV) acyclovir and methylprednisolone. Her leg pain improved significantly after 2 days of treatment. While she still experienced some urinary hesitancy, she no longer felt that she was voiding incompletely. She completed 5 days of IV acyclovir and methylprednisolone and was discharged on an oral prednisone taper and home IV acyclovir infusions to complete 14 days of treatment. She reported complete resolution of urinary symptoms and sacral pain following completion of the acyclovir course.

**Table.** Diagnostic Criteria for Elsberg Syndrome

| Categories   | Criteria  |
|--|---|
| 1. Laboratory-supported definite   | (A1 OR A2) AND B5   |
| 2. Clinically definite   | A1 OR A2; B1 AND two of B2–B4; B1 and B2 (if concomitant) |
| 3. Clinically probable   | A1 OR A2; B1 AND one of B2–B4                             |
| 4. Clinically possible   | A1 OR A2; one of B1–B4                                    |
| 5. Excluded  | Neither of A1 nor of A2; any of D1–D3                     |
| <b>A. Required</b>   |   |
| A1. Clinical symptoms and signs of cauda equina involvement: urinary hesitancy or retention; bowel incontinence, or severe constipation (erectile dysfunction insufficient on its own) |   |
| A2. MRI or electrophysiologic evidence of cauda equina involvement: enhancement of cauda equina; EMG evidence of radiculopathy   |   |
| <b>B. Supportive but not required</b>  |   |
| B1. Time course: acute/subacute onset; no relapse; progression over <3 months  |   |
| B2. Coexisting or recently preceding symptoms of genital herpes infection OR other clinical symptoms of herpes virus infection   |   |
| B3. Clinical (eg, exaggerated reflexes and Babinski signs) or MRI evidence of myelitis in conus  |   |
| B4. CSF pleocytosis  |   |
| B5. Documented herpes virus infection from CSF by PCR, culture, or detection of IgM serology   |   |
| <b>C. Red flags</b>  |   |
| C1. Relapses beyond 1 year from onset  |   |
| <b>D. Exclusionary</b>   |   |
| D1. Myelitis extending rostral to T9   |   |
| D2. Other neurologic symptoms suggestive of alternative etiology: optic neuritis, brain/brainstem syndrome   |   |
| D3. Other etiology proven/more likely for syndrome: NMOSD, dural arteriovenous fistula, viral transverse myelitis, other causes of myelopathy  |   |

Abbreviations: CSF, cerebrospinal fluid; EMG, electromyography; IgM, immunoglobulin M; MRI, magnetic resonance imaging; N/A, not applicable; NMOSD, neuromyelitis optical spectrum disorder; PCR, polymerase chain reaction.

## DISCUSSION

Elsberg syndrome is a rare neuroinflammatory disease that typically presents with lower extremity sensory impairment, weakness, saddle anesthesia, and urinary and/or bowel incontinence following HSV-2 infection.<sup>3</sup> Here we present a case of Elsberg syndrome secondary to HSV-2 infection in a young, immunocompetent, sexually active female. While the exact pathophysiology of Elsberg syndrome is unknown, it is thought to be related to latent viral infection resurfacing in the spinal nerve roots.

In cases of an identifiable trigger, Elsberg syndrome is most commonly preceded by HSV-2 or related viruses, including severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), West Nile virus, and varicella-zoster virus (VZV).<sup>3</sup> Reactivation of latent viral infection in spinal nerve roots and their sensory neurons is the posited mechanism of lumbosacral myeloradiculitis. While many patients with HSV-2-related Elsberg syndrome are immunocompetent, immunocompromised patients are at greater risk for VZV-related Elsberg syndrome.<sup>4</sup>

Elsberg syndrome is fairly uncommon, accounting for up to

10% of cases with combined myelitis and lumbosacral radiculitis.<sup>3</sup> Retrospective review of lumbosacral myeloradiculitis evaluated at the Mayo Clinic from 2000 to 2016 identified 1035 patients with both myelitis and radiculitis, which are most suggestive of Elsberg syndrome.<sup>5</sup> Thirty of those patients were suspected to have Elsberg syndrome, but only 2 had been diagnosed at the time of clinical evaluation, indicating that Elsberg syndrome often goes unrecognized.

Diagnosis of Elsberg syndrome is based primarily on patient history, clinical symptoms, and diagnostic imaging. Salvodi et al published a tool to characterize Elsberg syndrome based on diagnostic certainty. Required symptoms include either clinical or MRI/electromyographic evidence of cauda equina involvement. Supporting symptoms include an acute onset (progression over less than 3 months), recent genital herpes infection, clinical or MRI evidence of myelitis in the conus medullaris, or CSF pleocytosis.<sup>5</sup>

According to the diagnostic criteria above, our patient had laboratory-supported definite Elsberg syndrome. She presented with dysuria and lower extremity pain around the time she developed primary HSV-2 lesions. She also presented with MRI evidence of cauda equina involvement within 1 month of HSV-2 infection confirmed via NAAT testing. Although CSF pleocytosis is a supporting symptom of Elsberg syndrome, it may be normal as it was in this case.

When treating Elsberg syndrome, confirmation of the causative virus is not always required, as medications are effective in mild cases without a definitive viral cause. However, in severe cases where meningitis is suspected, the causative virus is more necessary as higher doses of antiviral drugs are required to treat VZV infection than HSV infection.<sup>6</sup> Moreover, VZV-related Elsberg syndrome is associated with a more severe presentation.<sup>7</sup> Direct immunofluorescence assay, viral culture, and polymerase chain reaction (PCR) all can be used to distinguish HSV from VZV infections.<sup>8</sup> If antigen or PCR testing is unavailable, the patient's age and sexual history can provide clues for diagnosis because older age is a risk factor for VZV, whereas HSV is more common in younger, sexually active patients like our patient.<sup>9</sup>

Treatment of Elsberg syndrome consists of 10 to 21 days of acyclovir, which has been shown to decrease pain and improve symptoms.<sup>5</sup> While oral steroid tapers or high-dose IV steroids can help shorten the duration of symptoms, the use of steroids to treat Elsberg syndrome remains a topic of debate.<sup>10</sup> Our patient received 14 days of IV acyclovir and 5 days of IV methylprednisolone with an oral prednisone taper. She reported full resolution of her symptoms upon completion of treatment.

## CONCLUSIONS

Because Elsberg syndrome is rarely reported and has a highly variable clinical presentation, it often goes unrecognized. There is a wide spectrum of neurological disorders associated with

Herpesviridae, and clinicians should evaluate for preceding or ongoing symptoms of herpes infections when treating patients with unexplained multifocal neurological symptoms. We encourage clinicians to consider Elsberg syndrome as a differential diagnosis for patients with bilateral lumbosacral radiculitis, as treatment with acyclovir may shorten symptom duration and decrease pain severity. The diagnosis of Elsberg syndrome relies on clinical judgement, taking into account the patient's history, symptoms, and imaging findings. This case of Elsberg syndrome highlights the importance of early detection and treatment to prevent long-term morbidity.

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# Endocrine Abnormalities in Mosaic Trisomy 16 Adolescent: A Case Report

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## ABSTRACT

Chromosomal trisomy presents with a range of clinical manifestations, from subtle to life-threatening conditions that include trisomy 16, the most common aneuploidy in first trimester abortions. Most cases are linked to maternal complications and spontaneous abortions, typically detected prenatally. Infants who survive with trisomy 16 often have mosaic variants and may exhibit various anatomical and metabolic abnormalities, though a trisomy 16 diagnosis does not guarantee the presence of such abnormalities. We share the case of a 15-year-old boy who has mosaic trisomy 16. He was diagnosed after birth and showed mild symptoms without any major anatomical issues. However, he did experience several metabolic problems, such as insulin resistance, obesity, hormonal imbalances, and vitamin D deficiency. This report highlights the diverse clinical characteristics of trisomy 16, comparing them to previously reported cases.

## INTRODUCTION

Trisomy 16 happens when the chromosome 16 bivalents separate too early during the first stage of maternal meiosis.<sup>1</sup> Trisomy 16 mosaicism occurs when there is a post-zygotic loss of chromosome 16, which helps some parts of the trisomic embryo. One of the most frequent reasons for trisomy 16 is uniparental disomy.<sup>2</sup> Mosaicism found during amniocentesis has been closely linked to fetal death, birth defects, and fetal anomalies, as well as intrauterine growth restriction.<sup>3,4</sup> We report the case of a 15-year-old boy who came to our outpatient department with signs that pointed towards Klinefelter syndrome. After conducting a chromosomal study, we discovered that he has trisomy 16 mosaicism.

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## CASE PRESENTATION

A 10-year-old boy of South Asian descent came to our outpatient department 5 years ago with several health concerns. He had been experiencing bilateral gynecomastia, which was first noticed 2.5 years prior, as well as small genitalia and delayed developmental milestones. The boy was also obese and displayed aggressive behavior. At the time of the visit, he measured 160 cm in height and had a body mass index (BMI) of 16, with a z-score of 2.46. His mother was 29 years

old when she gave birth to him.

The clinician suspected Prader-Willi syndrome and referred him to pediatric endocrinology for further evaluation. Laboratory tests revealed the following: levorotatory thyroxine 0.88 ng/dl, thyrotropin 2.36 uIU/ml, serum cholesterol at 174 mg/dl, serum triglycerides at 100 mg/dl, serum high-density lipoprotein (HDL) cholesterol 41 mg/dl, serum low-density lipoprotein (LDL) cholesterol 120 mg/dl, very low-density lipoprotein cholesterol 20 mg/dl, fasting plasma glucose 77 mg/dl, serum cortisol 5.70 µg/dl, testosterone 7.1, and serum insulin levels ranging from 66 to 90 µU/mg (see Table). The screening for Prader-Willi syndrome was negative. In response to the elevated insulin, HDL, and LDL levels, the pediatric endocrinologist prescribed metformin 500 mg, to be taken half a tablet in the morning and half a tablet in the evening.

The patient returned to the outpatient department 1 month later. At this visit, his BMI was 33.6. Noticing the worsening of his clinical symptoms and complaints, the clinician suspected Klinefelter syndrome. He ordered a variety of tests, including complete blood cell count, follicle-stimulating hormone, luteinizing hormone, testosterone levels, and karyotyping. See results

**Table.** Patient's Laboratory Findings 2017–2022

| Variables                          | Ref Range                                 | 2017         | 2018 | 2018+ 2 months | 2019  | 2020  | 2021  | 2021+ 5 months | 2022 |
|------------------------------------|---|--------------|------|----------------|-------|-------|-------|----------------|------|
| Fasting blood glucose              | 3.3–5.6 mmol/L<br>65–100 mg/dL            | 4.30<br>77.0 | 4.80 | 4.50           | 4.80  | 4.70  |       | 4.40<br>(79.0) | 4.10 |
| HBA1c                              | 4.0%–6.5%                                 | –            | –    | 5.0            | –     | –     |       |                | 5.7  |
| Serum insulin                      | 2–25 µU/mL                                | 66.90        | –    | –              | 58.70 | 15.16 | 51.01 | 13.60          | 36   |
| Serum cholesterol                  | <200 mg/dL                                | 174          | –    | –              | –     | –     |       |                |      |
| Serum triglycerides                | <150 mg/dL                                | 100          | –    | –              | –     | –     |       |                |      |
| Serum LDL                          | <100 mg/dL                                | 120          | –    | –              | –     | –     |       |                |      |
| Serum VLDL                         | <30 mg/dL                                 | 20           | –    | –              | –     | –     |       |                |      |
| Serum HDL                          | ≥40 mg/dL                                 | 41           | –    | –              | –     | –     |       |                |      |
| Serum T <sub>4</sub>               | 0.89–1.76 ng/dL                           | 0.88         | –    | –              | 1.02  | –     | 1.78  |                |      |
| Serum thyrotropin                  | 0.34–5.6 µIU/mL                           | 2.36         | –    | –              | 2.47  | –     | 3.28  |                |      |
| Serum cortisol                     | AM: 4.3–22.4 µg/dL<br>PM: 3.1–16.66 µg/dL | 5.7          | –    | –              | –     | –     |       |                |      |
| Serum testosterone                 | 6–27 nmol/L                               | 7.1          | –    | –              | –     | –     | 9.71  |                | 14.2 |
| Serum FSH                          | 0.0–6.0 mIU/mL                            | 0.22         | –    | –              | –     | –     |       |                |      |
| Serum luteinizing hormone          | 1.0–3.5 mIU/mL                            | 0.10         | –    | –              | –     | –     |       |                |      |
| Total lung capacity                | 4.0–11.0 x 10 <sup>9</sup> /L             | –            | 10.9 | –              | –     | 7.9   |       |                | 11.6 |
| Red blood cells                    | 4.50–5.50 x 10 <sup>12</sup> /L           | –            | 5.4  | –              | –     | 6.1   |       |                | 5.86 |
| Hemoglobin                         | 13.0–17.0 g/dL                            | –            | 11.2 | –              | –     | 12.0  |       |                | 12.4 |
| Hematocrit                         | 40%–50%                                   | –            | 36.6 | –              | –     | 40.6  |       |                | 40   |
| Mean corpuscular volume            | 83.0–101.0 fL                             | –            | 67.0 | –              | –     | 66.6  |       |                | 68.8 |
| Mean corpuscular hemoglobin        | 27.0–32.0 pg                              | –            | 20.5 | –              | –     | 19.7  |       |                | 21.2 |
| MCHC                               | 31.5–35.0 g/dL                            | –            | 30.2 | –              | –     | 29.6  |       |                | 30.8 |
| Platelets                          | 150–400 x 10 <sup>9</sup> /L              | –            | 432  | –              | –     | 342   |       |                | 178  |
| Neutrophils                        | 40%–80 %                                  | –            | 65   | –              | –     | 60    |       |                | 70   |
| Lymphocytes                        | 20%–40 %                                  | –            | 25   | –              | –     | 32    |       |                | 25   |
| Eosinophils                        | 1%–6 %                                    | –            | 04   | –              | –     | 04    |       |                | 02   |
| Monocytes                          | 2%–10 %                                   | –            | 06   | –              | –     | 04    |       |                | 03   |
| Serum calcium                      | 8.6–10.2 mg/dL                            | –            | 9.3  | –              | –     | –     |       |                |      |
| Serum 25-hydroxy vitamin D         | >30 ng/mL                                 | –            | 6.62 | –              | –     | –     | 36.09 |                |      |
| Total bilirubin                    | 3–18 µmol/L                               | –            | 12.0 | –              | –     | –     |       |                |      |
| Serum alkaline phosphatase         | <645 U/L                                  | –            | 260  | –              | –     | –     |       |                |      |
| Serum alanine aminotransferase     | <42 U/L                                   | –            | 29.0 | –              | –     | –     |       |                |      |
| Serum uric acid                    | 200–420 µmol/L                            | –            | 370  | –              | –     | –     |       |                | 567  |
| Serum urea                         | 3.3–7.5 mmol/L                            |              |      |                |       |       | 3.3   |                |      |
| Serum creatinine                   | 62–120 µmol/L                             |              |      |                |       |       | 54    |                |      |
| Serum sodium                       | 3.5–5.1 mmol/L                            |              |      |                |       |       | 4.5   |                |      |
| Serum potassium                    | 135–145 mmol/L                            |              |      |                |       |       | 139   |                |      |
| Growth hormone (basal)             | 6–15 mIU/L                                |              |      |                |       |       |       |                | 0.18 |
| Growth hormone (after exercise)    | >20 mIU/L                                 |              |      |                |       |       |       |                | 1.30 |
| Serum follicle-stimulating hormone | 1.3–19.3 IU/L                             |              |      |                |       |       |       |                | 3.6  |
| Serum luteinizing hormone          | 1.2–7.8 IU/L                              |              |      |                |       |       |       |                | 10.4 |

Abbreviations: ref, reference; HBA1c, hemoglobin A1c; LDL, low-density lipoprotein; VLDL, very low-density lipoprotein; HDL, high-density lipoprotein; T<sub>4</sub>, free levorotatory thyroxine; FSH, follicle-stimulating hormone; MCHC, mean corpuscular hemoglobin concentration.

in Table. The karyotyping report revealed that he had mosaic trisomy 16, specifically 47,XY + 16 [12]/46,XY [08] (see Figure 2).

The finding of mosaicism in this patient was unexpected, as it did not align with his symptoms. Two months after his initial visit, he was prescribed metformin (500 mg, twice daily), dietary modifications for anemia, exercise, psychiatric

**Figure 1.** Timeline of Patient's Age During Follow-ups

Abbreviation: yo, years old.

All lab results are presented in the Table.



counseling for autism and behavioral issues, and further lab tests (fasting blood sugar, hemoglobin A1c, uric acid, alanine aminotransferase, vitamin D, and cortisol). Based on his lab results, he was given vitamin D injections and continued on metformin. A month later, his thyroid and fasting glucose levels were normal but insulin remained elevated, leading to an increase in his metformin dosage to 750 mg and continued vitamin D supplementation.

Over time, the patient's weight increased, and he returned with similar complaints. Lab results showed elevated insulin, and metformin was maintained at 750 mg. Later, due to persistent behavioral concerns, a psychiatrist prescribed Adblizer. A year ago, after presenting with aggression, obesity, and hand pain, he underwent tests for bone age, thyroid function, testosterone, and was referred to a neurologist. Despite some improvement in labs, elevated glucose and insulin levels led to adjustments in his treatment, including metformin and vitamin D.

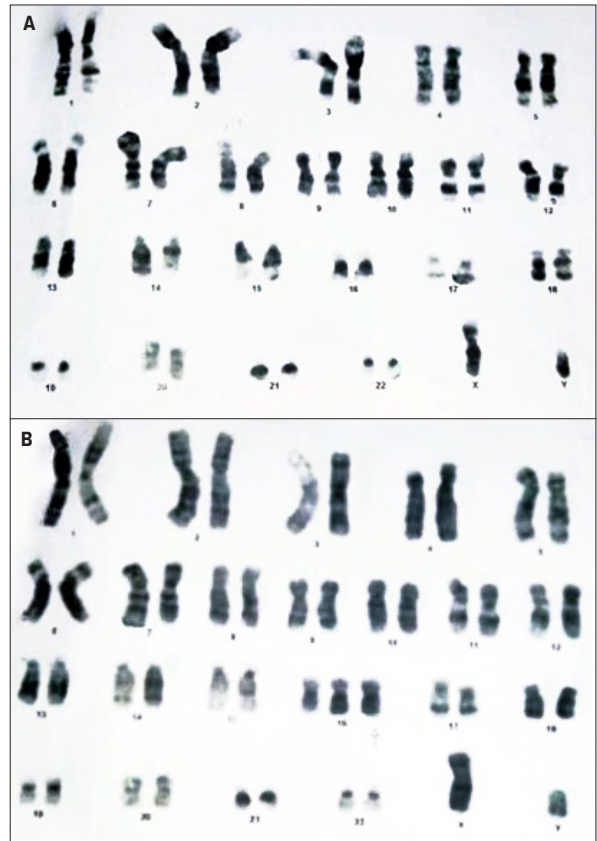
## DISCUSSION

In this case report, the patient received a diagnosis of trisomy 16 mosaicism after birth at the age of 10, confirmed through blood karyotyping. Excluding earlier cases identified before chromosome banding techniques were available, there are just five documented cases of trisomy 16 mosaicism diagnosed postnatally. The limited number of cases makes it challenging to predict a specific phenotype, and establishing a clear connection between genotype-phenotype, the degree of mosaicism, and the severity of symptoms remains difficult.<sup>5</sup> The effects of trisomy 16 mosaicism can range widely, from neonatal loss to a relatively mild phenotype with normal development. In between these extremes, individuals may experience issues such as intrauterine growth restriction, preterm birth, aortic coarctation, craniofacial differences, orofacial clefts, heart defects, kidney dysplasia, imperforate anus, and various other anomalies.<sup>3,5-10</sup> Patients with trisomy 16 mosaicism experience a wide range of outcomes, highlighting the diverse nature of mosaic chromosome abnormalities.<sup>5</sup>

Our patient, a school-aged child, presented with mild to moderate clinical features not typical of mosaic trisomy 16. He showed rapid growth (height and BMI above the 99th percentile), small genitalia, bilateral gynecomastia, and aggressive behavior later diagnosed as autism spectrum disorder. Lab results indicated insulin resistance and signs of metabolic syndrome. There was no significant prenatal history, though he had delayed developmental milestones. Initially suspected of having Klinefelter syndrome, a cytogenetic study confirmed mosaic trisomy 16. These clinical features had not been associated with mosaic trisomy 16 before and may result from an undiagnosed recessive condition linked to a parental mutation on another chromosome.

As mentioned in previous studies, there are numerous instances of children with mosaic trisomy 16 who have been diagnosed with

**Figure 2.** Patient's Karyotype Showing Trisomy 16 Mosaicism



A. Normal karyotype with 46 chromosomes.

B. Trisomy 16 with 47 chromosomes.

a normal phenotype and have shown positive long-term outcomes, with many of them attending school.<sup>5,9-11</sup> In fact, in about 20% of cases, pregnancy outcome is absolutely normal,<sup>7</sup> which points to the existence of bias in publications, with more severe and complicated cases of mosaic trisomy receiving disproportionately higher interest in published literature.<sup>5,9</sup> This also suggests that mosaic trisomy 16 is underdiagnosed. Many cases, such as the one reported in Ousager et al,<sup>10</sup> Rieubland et al,<sup>5</sup> and our case were missed prenatally and, even at birth, and were diagnosed later.

## CONCLUSIONS

In summary, we shared a case of mosaic trisomy 16 that presents clinical features distinct from those previously documented. Confirming this diagnosis can be beneficial for parents considering future pregnancies. Additionally, further research on the long-term outcomes and clinical characteristics of mosaic trisomy cases is needed to enhance our understanding of mosaic trisomy 16 syndrome.

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# Greater Auricular Trophic Syndrome Following Parotidectomy

Collin Evenson, BS; Daniel Hertel, MD; Robert Sonnenburg, MD

## ABSTRACT

**Introduction:** Trigeminal trophic syndrome causes self-injurious lesions secondary to cutaneous dysesthesia following damage of the trigeminal nerve. A similar syndrome, greater auricular trophic syndrome, can result following sacrifice of the greater auricular nerve during a parotidectomy.

**Case Presentation:** A 59-year-old woman presented with ulceration and crusting of her right ear 5 months after parotidectomy. She was determined to have greater auricular trophic syndrome with prurigo nodularis-like histopathologic changes and was successfully treated with topical clobetasol, occlusive dressing, and behavioral modification.

**Discussion:** Six similar cases have been reported. Mental health disorders were noted in 4 of these cases, and treatment focused on managing psychiatric comorbidities. This case considers treatment of a patient without a prior mental health disorder.

**Conclusions:** Greater auricular trophic syndrome is a rare complication following a parotidectomy. Occlusive dressing and behavioral modification led to subsequent improvement of the ulceration for this patient.

## INTRODUCTION

Trigeminal trophic syndrome is a well-documented complication resulting from damage of the trigeminal nerve, often secondary to nerve ablation to treat trigeminal neuralgia.<sup>1</sup> This nerve damage results in cutaneous dysesthesia—or discomfort and unpleasant sensation—that can lead to subsequent self-inflicted damage and ulceration of de-innervated tissue, most commonly the nasal ala.<sup>1</sup>

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In this case, we describe a similar syndrome that occurred following damage to the greater auricular nerve rather than the trigeminal nerve. The greater auricular nerve (GAN) provides cutaneous innervation of the lobule, antitragus, and inferior helix of the ear. Identification and preservation of the facial nerve and its branches is a critical part of parotid surgery. Surgical landmarks for identifying the main trunk of the facial nerve as it leaves the stylomastoid foramen include the tragal pointer, origin of the posterior belly of the digastric muscle, and tympanomastoid suture line. In order to optimize exposure of these structures, the greater auricular nerve (see Figure 1) or some of its individual branches are often sacrificed. This sacrifice can lead to residual numbness, dysesthesia, and paresthesia of the de-innervated area that is well known to surgeons who perform parotidectomies.<sup>2,3</sup> A syndrome similar to trigeminal trophic syndrome can occur following sacrifice of the GAN, of which there are 6 known reports.<sup>4-7</sup> The term greater auricular trophic syndrome (GATS) has been established and is used in this report.<sup>4</sup> We report a case of GATS affecting the cutaneous innervation of the GAN.

of the de-innervated area that is well known to surgeons who perform parotidectomies.<sup>2,3</sup> A syndrome similar to trigeminal trophic syndrome can occur following sacrifice of the GAN, of which there are 6 known reports.<sup>4-7</sup> The term greater auricular trophic syndrome (GATS) has been established and is used in this report.<sup>4</sup> We report a case of GATS affecting the cutaneous innervation of the GAN.

## CASE PRESENTATION

A 59-year-old woman underwent a right-sided parotidectomy for a mass that was revealed to be low-grade mucoepidermoid carcinoma with negative surgical margins and negative surrounding lymph nodes. Her initial postoperative recovery was uneventful with mild incisional pain. At 5-month follow-up, she reported sporadic bleeding and drainage from her ear and

**Figure 1.** Intraoperative Photo of Greater Auricular Nerve Emerging From Erb's Point, Crossing the Sternocleidomastoid Muscle and Crossing Parotid Fascia Close to Tragal Cartilage



**Figure 2.** Cutaneous Findings Upon Presentation 5 months Post-Parotidectomy



Erosions and erythema along with intermittent areas of crusting, bleeding, and serous drainage distributed in a geometrical pattern affecting the helix and lobule of the right ear.

admitted to manipulating/picking at her right ear due to numbness and tingling. On physical examination, there was ulceration and erythema along with areas of crusting, bleeding, and serous drainage in a geometric pattern affecting the helix and lobule of the right ear and inferior preauricular area as seen in Figure 2. There was concern for secondary infection due to excoriations, and she was placed on a 10-day course of oral clindamycin and topical mupirocin.

Due to the lack of improvement and uncertain etiology, a punch biopsy of the inferior helix was obtained after 10 days. The result demonstrated histologic changes consistent with prurigo nodularis, which was thought to be secondary to chronic excoriation of the skin. Dermatology was consulted and recommended topical clobetasol for 10 days for the prurigo nodularis-like component and occlusive dressing to aid with healing and behavioral modification. The patient's numbness and tingling were most consistent with paresthesia. She was advised to avoid picking, scratching, and rubbing the affected area. After this course of treatment, the appearance and symptoms were improved, with minimal residual erythema and hemorrhagic crusting affecting a smaller area of the right helix as well as some scarring with posttraumatic milia in the inferior preauricular area (see Figure 3).

## DISCUSSION

Trigeminal trophic syndrome and GATS can be challenging to treat, relying on behavioral modification to reduce self-manipulation of focal areas of skin dysesthesia or paresthesia. It can be difficult for patients to avoid manipulating the affected skin, as doing so often will provide relief despite damaging the skin

**Figure 2.** Cutaneous Findings 2 Months After Development of Trigeminal Trophic-like syndrome.



This is after therapy of occlusive dressing, clobetasol, and education about manipulation through picking/itching will worsen the skin.

further. One patient resorted to applying a hot water bottle to relieve his discomfort and developed full thickness burns of his ear lobe.<sup>7</sup> Of patients who have their GAN sacrificed, approximately 46% will have permanent symptomatic nerve dysfunction, while the remaining patients eventually achieve spontaneous resolution of nerve dysfunction.<sup>8</sup> The exact mechanism of why a very small subset of these patients develop GATS is unclear. Mental health disorders (anxiety, depression, obsessive-compulsive disorder) were noted in 4 of the 6 previously reported cases.<sup>4-7</sup>



Our patient did not have a history of a mental health disorder, and the small sample size makes it difficult to infer a reliable correlation between mental health disorders and GATS. Previous cases focused on treating psychiatric comorbidities with benzodiazepines, selective serotonin receptor inhibitors, and antipsychotics.<sup>5</sup> In this case, clobetasol was used to reduce surrounding inflammation, skin discomfort, and to reverse secondary skin changes. Maintaining a physical barrier with an occlusive dressing was used to help prevent self-injurious behavior.

## CONCLUSIONS

Greater auricular trophic syndrome is a rare complication following parotidectomy. Occlusive dressings and behavioral modification led to improvement of cutaneous ulceration for this patient. Clobetasol likely helped to reduce the skin thickening associated with chronic rubbing/picking.

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# Inferior Vena Cava Agenesis as Cause of Pulmonary Embolism: Case Report and Literature Review

Juan Felipe Coronado-Sarmiento, MD; Christian Eduardo Rey-Ramos, MD

## ABSTRACT

**Introduction:** Inferior vena cava agenesis (IVCA) is a very uncommon vascular condition, occurring in about 0.0005% to 1% of the population. It is often overlooked as a potential cause of deep venous thrombosis and pulmonary embolism, particularly in younger patients.

**Clinical Case:** A 25-year-old Hispanic woman presented to the emergency department with leg swelling and pain. She later developed shortness of breath and chest pain, prompting her transfer to the intensive care unit. Chest and abdominal computed tomographic angiography confirmed a left pulmonary embolism, absence of the infrarenal vena cava, and a thrombus in the left superficial iliac and femoral veins. She was treated with thrombolytic therapy followed by a successful thrombectomy.

**Discussion:** IVCA is a rare vascular condition caused by either a developmental failure of the inferior vena cava or thrombosis with secondary resorption. This leads to a complex collateral venous system with slower blood flow, increasing the risk of stasis and thrombus formation. IVCA should be considered in young patients with recurrent thromboembolism who lack typical risk factors. Diagnosis is best achieved through computed tomography or magnetic resonance angiography. Management usually involves long-term anticoagulation, with surgery reserved for select cases.

**Conclusions:** IVCA is an uncommon cause of thromboembolism events. It is important to consider this diagnosis in young patients after immune, genetic, or traumatic issues have been ruled out, as prompt treatment can help prevent serious health risks.

## INTRODUCTION

Inferior vena cava (IVC) abnormalities are rare conditions that affect up to 4% of the total population.<sup>1</sup> One of the unique characteristics noted for this vessel is agenesis, a vascular condition that affects about 0.0005% to 1% of the population. Interestingly, it accounts for up to 5% of deep venous thrombosis (DVT) cases in younger patients.<sup>2</sup> Two hypotheses explain this abnormality. The first involves an embryological issue between the 4th and 8th weeks of gestation, affecting the development of the IVC. The second suggests it results from intrauterine or perinatal thrombosis, causing the vessel's obstruction and resorption. This condition may occur alone or alongside other abnormalities, such as dextrocardia, heart defects, or spleen malformations.<sup>1,3</sup> The best way to diagnose this condition is through vascular evaluation using tomography or magnetic resonance studies,

though these methods are not commonly applied for patients with DVT.<sup>4</sup>

We report the case of a female patient who experienced DVT and pulmonary embolism, ultimately leading to a diagnosis of infrarenal vena cava agenesis (IVCA).

## CASE PRESENTATION

A 25-year-old Hispanic woman presented to the emergency department with severe, sharp pain in her left thigh, along with swelling that gradually affected her entire leg. Her medical history included schizophrenia, managed with 50 mg of clozapine daily. She had no history of surgery, fractures, immobilization, or previ-

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**Table 1.** Patient's Lab Results

| Test                       | Result   | Control  |
|----------------------------|--|--|
| Chloride                   | 102.5 mEq/L  | 98 – 106 mEq/L                                 |
| Potassium                  | 3.98 mEq/L   | 3.3 – 5.1 mEq/L                                |
| Sodium                     | 139 mEq/L  | 136 – 145 mEq/L                                |
| Creatinine                 | 0.77 mg/dL   | 0.51 – 0.95 mg/dL                              |
| Ureic nitrogen             | 23.6 mg/dL   | 6 – 20 mg/dL                                   |
| <b>Hemogram</b>            |  |  |
| Leucocytes                 | 10.77 x 10 <sup>3</sup> /uL  | 4.5 – 11.3 x 10 <sup>3</sup> /uL               |
| Neutrophils                | 8220 x 10 <sup>3</sup> /uL   | 2.25 – 8.48 x 10 <sup>3</sup> /uL              |
| Lymphocytes                | 1340 x 10 <sup>3</sup> /uL   | 0.9 – 4.52 x 10 <sup>3</sup> /uL               |
| Monocytes                  | 990 x 10 <sup>3</sup> /uL  | 0 – 1.24 x 10 <sup>3</sup> /uL                 |
| Hemoglobin                 | 12 g/dL  | 12.3 – 15.3 g/dL                               |
| Hematocrit                 | 36.9%  | 35% – 47%                                      |
| Platelets                  | 319,000 x mm <sup>3</sup>  | 150,000 – 450,000 x mm <sup>3</sup>            |
| Reticulocytes              | 6.93%  | 0.5% x 2.0%                                    |
| Blood smear test           | Mormocytic and normochromic erythrocytes, platelets with normal shape and number, leukocytes with normal features, shape, and number | –  |
| Fibrinogen                 | 245 mg/dL  | 200 – 397 mg/dL                                |
| PTT                        | 31.5 seconds   | 25.1 – 36.5 mg/dL                              |
| INR                        | 1.08   | –  |
| Prothrombin time           | 12.4 seconds   | 9.1 – 12.5 seconds                             |
| D-dimer                    | 47046 ng/mL  | 0 – 499 mg/dL                                  |
| Haptoglobin                | 287.62 mg/dL   | 30 – 200 mg/dL                                 |
| Total bilirubin            | 0.32 mg/dL   | 0 – 1.0 mg/dL                                  |
| Direct bilirubin           | 0.18 mg/dL   | 0 – 1.3 mg/dL                                  |
| Lupus anticoagulant        | Negative   | –  |
| β-2 glycoprotein IgG       | 0.7 UA/mL  | Negative <10 UA/L<br>Positive >20UA/L          |
| β-2 Glycoprotein IgM       | 0.00 UA/mL   | Negative <10 UA/L<br>Positive ≥10UA/L          |
| Cardiolipin antibodies IgM | 0.0 MPL U/mL   | Negative <10 MPL U/mL<br>Positive >10 MPL U/mL |
| Cardiolipin antibodies IgG | 1.3 GLP U/mL   | Negative <10 GPL U/mL<br>Positive >20 GPL U/mL |
| Anti-La/SSB antibodies     | 0.00 UA/mL   | Negative <10 UA/L<br>Positive ≥10UA/L          |
| Anti RNP antibodies        | 0.00 UA/mL   | Negative <10 UA/L<br>Positive ≥10UA/L          |
| Anti-Ro/SSA antibodies     | 0.00 UA/mL   | Negative <10 UA/L<br>Positive ≥10UA/L          |
| Anti-Sm antibodies         | 0.00 UA/mL   | Negative <10 UA/L<br>Positive ≥10UA/L          |
| Anti-DNA antibodies        | Negative   | Negative <1/10                                 |

Abbreviations: PTT, partial thromboplastin time; INR, international normalized ratio; RNP, ribonucleoprotein.

ous symptoms, including lower limb edema, chest pain, palpitations, or dyspnea.

On examination, she had tachycardia, but other vital signs were normal. Her heart and lungs sounded normal, and her abdomen showed no signs of vascular issues. The left leg was swollen from the groin down, with visible veins on the upper back of the thigh. Both Homans and Pratt's signs were positive.

With a clinical suspicion of DVT, the patient was admitted for further testing. (See blood test results in Table 1.) An arterial and venous duplex ultrasound revealed a thrombus in the femoropopliteal region, leading to the initiation of treatment with low molecular weight heparin. During her hospital stay, she experienced chest pain and shortness of breath, prompting transfer to the intensive care unit, where she was stabilized. A transthoracic echocardiogram showed a normal left ventricular ejection fraction (58%) and normal systolic and diastolic function, with a low probability of pulmonary hypertension. No intracavitary thrombus was detected.

A chest and abdominal angiogram revealed the absence of the infrarenal portion of the inferior vena cava with multiple collateral vessels; acute thrombosis in the superficial femoral, common iliac, and superficial iliac veins; and a flow defect in the proximal left renal vein (Figure 1 and 2A). It also showed a left pulmonary embolism without heart involvement (Figure 2B).

With that diagnosis, we performed thrombolysis using intravenous alteplase through a Fountain catheter (Squirt Fluid Dispensing System). After the procedure, we started a continuous dose of heparin for anticoagulant therapy. However, evaluation indicated minimal reperfusion following the thrombolysis, so we proceeded with thromboaspiration using an 8F catheter (Penumbra CAT8TORQ85 Indigo Catheter 8.0Fr. Torq Tip, 85 cm). Following that, we infused heparin and plasminogen intravenously, which resulted in complete reperfusion of the affected vessels. Postoperative recovery went smoothly, chest pain resolved, and, after checking for any autoimmune or coagulation issues, the patient was discharged with a plan for long-term rivaroxaban therapy and compression socks. Six months later, during a follow-up at the outpatient clinic, she showed no signs of new embolism episodes.

## DISCUSSION

DVT occurs when a clot forms in a deep vein. VTE affects up to 1 million people annually in the United States, with higher rates in older adults and women. The mortality rate is 10.6% in the first 30 days and up to 23% annually.<sup>5</sup> Most patients under 30 typically are evaluated for acquired risk factors, such as cancer, surgery, immobility, estrogen use, pregnancy, and certain medical conditions—ie, obesity, venous insufficiency, rheumatologic diseases, macrovascular arterial disease, and antiphospholipid antibody syndrome—which explain 95% of cases.<sup>6</sup>

IVCA accounts for 6% of IVC malformations. Though most

**Table 2.** Publications Presenting IVCA as Cause of Pulmonary Embolism or Renal Vein Thrombosis

| Authors                          | Sex/Age | Main features and outcome   |
|----------------------------------|---------|---|
| Van Laethem et al <sup>2</sup>   | F/30 yo | Patient with history of bariatric surgery presented to ED with edema of right lower extremity and NYHA Class II dyspnea. D-dimer was within normal values and chest CT scan showed bilateral pulmonary embolism and unusual dilation of azygos vein and para-aortic varicose networks. Abdominal angiography CT showed IVCA with paralumbar varicose networks draining into azygos vein. This CT also showed thromboses in primitive iliac veins bilaterally and in right superficial and common femoral veins. Patient was managed with rivaroxaban considering risk of impaired absorption of vitamin K antagonists, along with elastic compression. Patient had no recurrence during 2 years follow up.            |
| Ramos-Aranda et al <sup>10</sup> | M/30 yo | Patient had history of DVT in left leg 5 weeks prior to hospital admission due to severe dyspnea. Chest CT scan showed bilateral pulmonary embolism. VDU showed DVT in left leg at the femoropopliteal segment. LMWH was started as treatment. Abdominal CT scan showed extensive thrombosis of the femoropopliteal segment, suprarenal IVCA and duplicated IVC, with azygos continuation of a left retro-aortic renal vein. After venogram confirming the thrombosis, UET was performed along with alteplase infusion. Balloon angioplasty was required due to residual thrombosis of the left iliac vein with full resolution. Patient was managed with rivaroxaban and had no recurrence within 6-month follow-up. |
| Skeik et al <sup>13</sup>        | M/23 yo | Patient presented to ED with 6 days of right lower quadrant pain, initially mild ache that progressed to severe pain. History was unremarkable. Physical examination revealed tenderness to palpation in right flank and lower quadrant. Blood tests were significant only for slight leukocytosis (12.400 x/mL). Abdominal CT revealed IVCA below the infrahepatic segment with large retroperitoneal collateral veins draining into azygos and hemiazygos systems and a thrombus in right renal vein. Management included LMWH and warfarin started later. Patient was discharged when proper INR. No follow-up information was available.  |

Abbreviations: ED, emergency department; NYHA, New York Heart Association Functional Classification; CT, computed tomography; IVC, inferior vena cava; IVCA, inferior vena cava agenesis; DVT, deep vein thrombosis; VDU, venous doppler ultrasound; LMWH, low molecular weight heparin; UET, ultrasound enhanced thrombolysis; INR, international normalized ratio.

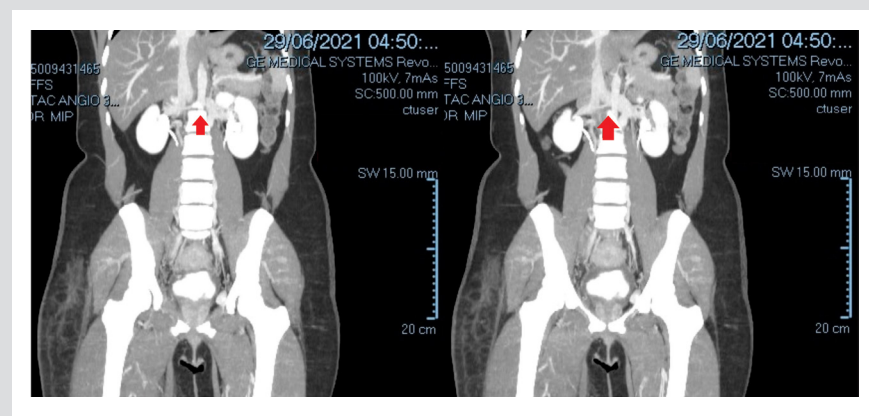
patients are asymptomatic due to collateral vein development, VTE is common due to inadequate venous drainage, leading to stasis and clot formation.<sup>7</sup>

IVCA often is discovered incidentally,<sup>8</sup> and typically, it is diagnosed due to complications such as embolism. Symptoms may include abdominal or back pain, caused by the collateral venous system compensating for the absent IVC. If the lower extremity drainage is compromised, DVT signs such as leg edema, discomfort, and skin discoloration may occur. Though rare, pulmonary embolism is the most concerning complication.<sup>2,9,10</sup>

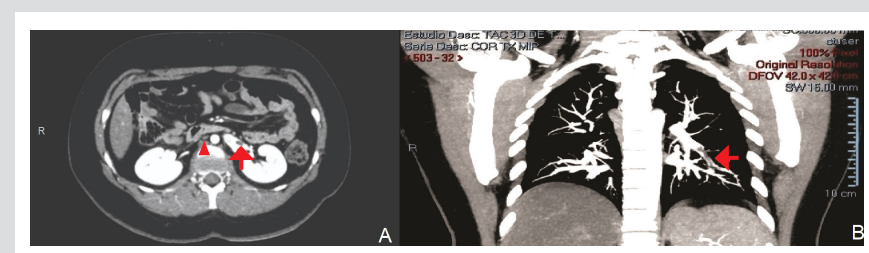
IVCA should be suspected in young patients without typical DVT risk factors or with recurrent thrombosis.<sup>6,11</sup> Diagnosis is best made using abdominal contrast magnetic resonance imaging, though CT and venography are also effective.<sup>4,9,12</sup>

Due to the low incidence of this condition, there is no standard treatment. Thrombolytic therapy via catheter is effective, while thrombectomy is used for large clots or failed thrombolysis. Outpatient management often includes anticoagulation and compression therapy, with Xa inhibitors favored for their lower bleed-

**Figure 1.** Coronal Computed Tomographic Angiography Showing in Both Frames the Absence of the Infrahepatic Inferior Vena Cava (red arrow)



**Figure 2.** Computed Tomographic (CT) Angiography



A. Transversal CT angiography, showing absence of the infrarenal inferior vena cava (red arrowhead), and filling defect on the arrival of the gonadal vein to the left renal vein, suggesting thrombosis (red arrow).  
B. Chest CT angiography, showing filling defects in segmental and lobar sections in the basal region of the left lung due to a pulmonary embolism (red arrow).



ing risk.<sup>14</sup> However, thrombosis recurrence is common within 2 years.<sup>9,10,12,15</sup> Surgical treatment is reserved for those who cannot take anticoagulants or experience a high rate of recurrence. Procedures may include IVC replacement or bypass, with minimal complications reported. Endovascular management with a WALLSTENT endoprosthesis (Boston Scientific) has shown success, with no recurrence after 15 months.<sup>9,12,16</sup>

## CONCLUSIONS

IVCA is an uncommon condition that usually presents with DVT. In younger patients who have typical DVT risk factors or lack significant immune or genetic findings, this condition should be considered. It is important to tailor the management approach based on the patient's specific medical situation and comfort.

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# Proceedings From the 2024 Annual Meeting of the American College of Physicians, Wisconsin Chapter

The following abstracts were presented during the 68th Annual Scientific Meeting of the Wisconsin Chapter of the American College of Physicians on September 6-7, 2024 in Wisconsin Dells. Internal medicine residents and medical students from Wisconsin programs presented their research and/or unusual clinical experience via clinical- and research-based vignettes and posters. Winning vignettes and posters are published here. Additional presentations are available online at [https://www.acponline.org/sites/default/files/documents/about\\_acp/chapters/wi/24\\_ACP\\_Abstract\\_Book\\_AWARDS\\_v2.pdf](https://www.acponline.org/sites/default/files/documents/about_acp/chapters/wi/24_ACP_Abstract_Book_AWARDS_v2.pdf)

## CLINICAL ORAL VIGNETTES

### **Winner: (Mental Status) Goes Down, Down, Down in a Burning Ring of Fire**

*Jake Thomas, DO; Kelsey Lamb, MD; Amit Taneja, MD*

**Introduction:** Toxoplasmosis represents the clinical disease of infection with the intracellular protozoan *Toxoplasma gondii*. Infection primarily occurs via 2 methods: the first through ingestion of oocysts typically in food contaminated with cat feces and the second through consumption of undercooked meat contaminated within cysts. Infection primarily remains asymptomatic in immunocompetent hosts; however, immunocompromised populations may experience reactivation of latent cysts. This has been described classically in the HIV/AIDS population; however, allogeneic hematologic stem cell transplantation (HSCT) represents another group susceptible to infection. Here we describe a case of central nervous system (CNS) toxoplasmosis in a patient who underwent allogeneic HSCT.

**Clinical Course:** A 64-year-old male with acute myeloid leukemia status post allogeneic HSCT presented with fever and elevated creatinine 30 days posttransplant. He was started

on cefepime and metronidazole while a large infectious workup was started. Four days after admission, he became acutely altered. Head CT was negative for acute intracranial abnormalities. CNS studies revealed elevated protein and nucleated cells. Brain magnetic resonance imaging (MRI) later revealed multiple ring-enhancing lesions. Serologic testing of blood and CNS revealed positive IgG and IgM toxoplasma antibodies. He was started on high-dose trimethoprim-sulfamethoxazole and later was transitioned to pyrimethamine, clindamycin, and leucovorin due to hyperkalemia. His altered mental status gradually improved with antibiotics. polymerase chain reaction (PCR) toxoplasma via blood sample was negative prior to discharge, and he was discharged on the pyrimethamine, clindamycin, and leucovorin with a transition to trimethoprim-sulfamethoxazole in the outpatient setting.

**Discussion:** This case highlights a unique case of CNS toxoplasmosis in an HSCT recipient. Roughly 11% of immunocompetent individuals have serologic evidence of toxoplasmosis infection. Many toxoplasmosis cases are the result of reactivation of latent infection. The incidence of toxoplasmosis in allogeneic HSCT recipients

ranges from 0.1% to 6%, with incidence varying by region. However, the mortality rate attributed to these infections is between 60% and 90% with the majority of cases being diagnosed postmortem. Due to its high mortality and the possibility of being underrecognized, clinicians need to keep toxoplasmosis encephalitis as part of their differential diagnosis when considering altered mental status for patients who underwent allogeneic HSCT.



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### **Runner-up: Adult-Onset Still's Disease Complicated by Macrophage Activation Syndrome**

*Zabraa Qambieh, MBBS, PMSc; Dalia Sriwi, MBBS; Sean O'Neill, MD*

**Introduction:** Adult-onset Still's disease (AOSD) is a rare inflammatory disorder typically seen in young adults and characterized by recurrent fever, rash, arthralgias, and other systemic manifestations. Its etiology involves genetic susceptibility, infectious triggers, and cytokine storm. Diagnosis is by exclusion, aided with the Yamaguchi criteria. One potential complication is macrophage activation syndrome (MAS), which occurs in 1.7% of patients and often is triggered by infection or treatment changes. This case presents AOSD with MAS/hemophagocytic lymphohistiocytosis (HLH) likely triggered by infection.

**Case Presentation:** A 20-year-old healthy female presented with a week-long history of fevers, sore throat, migratory polyarthralgia, and ankle swelling after exposure to a sick roommate. She was tachycardic (120

beats per minute) with otherwise stable vitals. Labs revealed white blood cell count (WBC) 23.8, predominantly neutrophils; alanine aminotransferase (ALT) 69 U/L; aspartate aminotransferase (AST) 83 U/L; and C-reactive protein (CRP) 32.9 mg/dL. Computed tomography (CT) neck reported pharyngitis, but throat culture was negative. Transthoracic echocardiogram (TTE) was negative for valvular disease or carditis. Symptoms improved with intravenous (IV) antibiotics and nonsteroidal anti-inflammatory drugs (NSAID) for presumed postinfectious immune activation; however, she re-presented with diffuse skin papules and worsening peripheral swelling. Lab tests showed persistent leukocytosis with new anemia (hemoglobin 8.8 g/dL) and high ferritin (5000 ng/mL). Consultations with Rheumatology, Infectious Disease, and Dermatology led to extensive workup notable for positive DNase B. She was started on penicillin for rheumatic fever; however, symptoms persisted with rising ferritin levels (62 000 ng/mL) and a positive interleukin 2 receptor. Bone marrow biopsy was normal. Eventually, Rheumatology favored a diagnosis of AOSD—based on the 1992 Yamaguchi criteria—complicated by MAS. She was started on dexamethasone and anakinra with near resolution in symptoms.

**Discussion:** Timely diagnosis of AOSD is challenging owing to its diverse manifestations and the absence of serologic markers, increasing risk of complications like permanent joint damage, disseminated intravascular coagulation, and pulmonary hemorrhage. Early collaboration among specialties is crucial. While there are no universal guidelines for treatment, steroids, disease-modifying antirheumatic drugs, and interleukin 1 inhibitors have emerged as common approaches.

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## RESEARCH ORAL VIGNETTES

### **Winner: Comparative Evaluation of Various Artificially Intelligent Chatbots for Management of Common Internal Medicine Conditions**

*Daniel Willcockson MD, MPH*

**Introduction:** The integration of artificial intelligence (AI) in health care—particu-

larly within internal medicine—holds the potential to significantly enhance diagnostic accuracy, patient management, and clinical workflows. Advanced AI tools, such as ChatGPT-4o, Gemini Pro, and Perplexity Pro, are capable of interpreting clinical data, generating differential diagnoses, and automating various administrative tasks. These advancements can streamline medical procedures and personalize treatment plans.

**Methods:** This study aimed to compare the accuracy and reliability of ChatGPT-4o, Gemini Pro, and Perplexity Pro in responding to internal medicine-related medical management questions, including those related to acute coronary syndrome, type 2 diabetes, acute kidney injury, and others. Each chatbot's response was reviewed independently by itself and against the others using an answer key derived from current literature on UpToDate. Responses were rated on a 10-point Likert scale, with 10 indicating the highest accuracy. The overall statistical significance was assessed using the Friedman test, while pairwise comparisons between chatbots were conducted using the Mann-Whitney U test.

**Results:** The analysis showed no significant difference in the chatbots' abilities to answer medical management questions accurately and reliably when using the Friedman test ( $P=0.06-0.72$ ). Despite the lack of statistical significance, ChatGPT-4o and Perplexity Pro repeatedly achieved higher Likert scores compared to Gemini Pro. However, pairwise comparisons revealed significant differences between ChatGPT-4o and Gemini Pro ( $P<0.01$ ) and between Gemini Pro and Perplexity Pro ( $P<0.01$ ) but no difference between ChatGPT-4o and Perplexity Pro ( $P=0.48$ ).

**Discussion:** AI chatbots like ChatGPT-4o, Gemini Pro, and Perplexity Pro demonstrate substantial potential for enhancing internal medicine practices. While the Friedman test showed no significant difference, pairwise comparisons revealed that ChatGPT-4o and Perplexity Pro were superior in answering internal medicine-related medical questions compared to Gemini Pro ( $P<0.01$ ). The comparable performance among these chatbots underscores the necessity for continued development and evaluation to ensure their effectiveness in clinical settings. Future studies should focus on refining these AI tools and exploring their integration into clinical

practice, such as answering patient portal messages. Of note, AI was used in the development of this abstract.

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### **Runner-up: Utilization of Point-of-Care Ultrasound in the Emergency Department: A Systematic Review and Meta-Analysis**

*Apurva Popat, MD; Sweta Yadav, MD; Ateeq Rehman, MD*

**Introduction:** Point-of-care ultrasound (POCUS) is an imaging modality that has become a fundamental part of clinical care provided in the emergency department (ED). The applications of this tool in the ED have ranged from resuscitation, diagnosis, and therapeutic to procedure guidance. This review aims to summarize the evidence on the use of POCUS for diagnosis and procedure guidance.

**Methods:** CrossRef, PubMed, Cochrane Library, Web of Science, and Google Scholar databases were searched extensively for studies published between January 2000 and November 2023. Additionally, the risk of bias assessment was performed using the Quality Assessment of Diagnostic Accuracy Studies 2 (for studies on the diagnostic role of POCUS) and Cochrane Risk of Bias tool (for studies on the use of POCUS for procedure guidance). Furthermore, diagnostic accuracy outcomes were pooled using STATA 16 software (StatCorp, College Station, Texas), while outcomes related to procedure guidance were pooled using the Cochrane Review Manager software.

**Results:** The study included 81 articles (74 evaluating the diagnostic application of POCUS and 7 evaluating the use of POCUS in guiding clinical procedures). In our findings, sensitivities and specificities for various conditions were as follows: appendicitis, 65% and 89%; hydronephrosis, 82% and 74%; small bowel obstruction, 93% and 82%; cholecystitis, 75% and 96%; retinal detachment, 94% and 91%; abscess, 95% and 85%; foreign bodies, 67% and 97%; clavicle fractures, 93% and 94%; distal forearm fractures, 97% and 94%; metacarpal fractures, 94% and 92%; skull fractures, 91% and 97%; and pleural effusion, 91% and 97%. A subgroup analysis of data from 11 studies also showed that

the two-point POCUS has a sensitivity and specificity of 89% and 96%, while the three-point POCUS is 87% sensitive and 92% specific in the diagnosis of deep vein thrombosis. In addition, the analyses showed that ultrasound guidance significantly increases the overall success rate of peripheral venous access ( $P=0.02$ ) and significantly reduces the number of skin punctures ( $P=0.01$ ) compared to conventional methods.

**Conclusions:** POCUS can be used in the ED to diagnose a wide range of clinical conditions accurately. Furthermore, it can be used to guide peripheral venous access and central venous catheter insertion.



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## RESEARCH POSTERS

### 1st Place: Perception of Academic Hospitalists About Rounding Methods

*Chidinma Ikonte; Mohamed T. Abdelrahim, MA; Pinky Jha, MD, MPH*

**Background:** Bedside rounding traditionally has been viewed as a crucial tool for training learners and providing quality patient care. However, in the last several years, medical professionals in the academic setting have shifted away from rounding at the bedside and adopted alternative methods and settings to complete daily rounds on their patients. This study explores the mixed responses to these changes and aims at identifying strategies for incorporating key educational components for the trainees while ensuring efficient and effective patient care.

**Methods:** A Qualtrics survey was conducted among academic hospitalists from the Division of General Internal Medicine at the Medical College of Wisconsin. This Institutional Review Board-approved study aimed to understand the perception of hospitalists about rounding methods, including their benefits and barriers. Quantitative data were analyzed using descriptive statistics and Fischer exact tests to examine differences based on gender and years of experience as a hospitalist. All analyses were done using R version 4.1.2.  $P$  value  $<0.05$  was considered statistically significant. Additionally, the survey included an open-ended section for free-text commentary, which was reviewed to identify common themes.

**Results:** Of the 86 hospitalists surveyed, 36 responded to the survey, resulting in a 41% response rate. The respondents were 53% male and 47% female. Most of the respondents (49%) had less than 5 years of work experience as a hospitalist. “Table rounds followed by bedside rounds” was the most preferred method of rounding (33%), followed by “bedside rounds” (24%), and “table rounds” (21%).

Key perceived benefits of bedside rounds included learning communication skills (94%), empathy (92%), and involving patients in shared decision-making (91%). Major barriers to bedside rounding included residents’ duty hour restrictions (89%) and scheduled educational activities/didactics for the residents (86%).

The free-text comments from the survey respondents produced several suggestions for changes to be made to bedside rounding to accommodate evolved hospital workflows while ensuring this form of teaching is retained. Key suggestions included standardizing the format and duration of bedside rounds, aligning patient geographical location with portable computers, and reinforcing the importance of bedside rounds.

**Significance:** The evaluation of the findings indicates that gender—with the exception of perceptions regarding nonclinical responsibilities as a barrier to bedside rounds—and the number of years as a hospitalist do not significantly influence the overall perception of bedside rounds. Nonetheless, hospitalists advocated for changes to be made to the structure of bedside rounding to ensure its position in the educational process of training physicians. Further research is needed to better analyze and optimize how this process should be addressed and employed.

**Conclusions:** Hospitalists perceive benefits to bedside rounds but report several barriers. This study highlights the need for innovation in rounding methods that are efficient and effective.



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### 2nd Place: Breaking the Stigma: Integrating Debriefing Sessions Into Medical Education

*Heather Burton, MD; Chana Bushee, MD; Jared Squires, MD*

**Introduction:** Distressing/adverse events are experienced by most medical students and residents. Previous studies show that despite the high prevalence, utilization of support services remains limited, primarily due to time constraints and the stigma associated with seeking help. Debriefing following adverse events offers health care professionals a platform to share healthy coping strategies, manage grief, and maintain professional integrity while improving resilience, increasing career satisfaction, and reducing the risk of burnout. Despite these benefits, less than half of the adverse events experienced by medical students are followed by a debrief.

**Methods:** We designed a debriefing curriculum for third-year medical students (MS3) and collaborated with the Internal Medicine (IM) clerkship administrative team to integrate it into the MS3 IM core clerkship. During the 2023-2024 academic year, we led six 1-hour debriefing workshops for each group of students at the halfway point of their IM clerkship. The workshops included a large group teaching session followed by small group discussions and practice. We constructed preworkshop and postworkshop surveys to assess MS3 experiences with debriefing throughout their third-year clerkships and general debrief knowledge prior to and following the workshop.

**Results:** Over the course of the academic year, as well as during their IM clerkships, 80% of MS3s experienced 1 or more adverse events, yet the majority of these were not followed by a debrief (70%). Prior to the workshops, most students agreed that debriefs are important (89%); however, few felt comfortable leading or even requesting a debrief (14% and 27%, respectively). After the workshops, there was a significant increase in students’ ability to identify when a debrief was needed (54% to 87%), and students felt more comfortable requesting debriefs (27% to 67%) and leading debriefs (14% to 52%). Students also found the workshops helpful for teaching the components of a debrief (63%) and empowering their participation (63%). Most MS3s recommended the session (75%).

**Conclusions:** The implementation of debriefing workshops successfully increased MS3 comfort and competence in debriefing following distressing events and empowered student participation and leading of debrief



sessions. Most students reported positive experiences and recommended the continuation of the program with further integration into the IM core clerkships.

**Acknowledgements:** The authors would like to acknowledge the additional resident volunteers who assisted with leading the workshops; this includes but is not limited to Sarah Barrett, Luke Clawson, Adriana Jelen, Ilakkiya Thanigaivelan, and Alice Zhang. They also would like to recognize the Internal Medicine Clerkship administrative team for their help in the implementation and coordination of the workshops.

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### **3rd Place: Determining the Effectiveness of Machine Learning Models for Predicting Hospital Length of Stay: A Systematic Review**

*Mukul Sharda; Nathaniel Verhagen; Pinky Jha, MD, MPH*

**Background:** The application of machine learning (ML) to predict hospital length of stay (LoS) displays promise for advancements in health care management and patient care. LoS is frequently seen as a metric that can help determine the severity of sickness, cost of care, and resource use. Furthermore, individualized discharge planning has been linked to quantifiable outcomes, including lower rebound admission rates and increased patient satisfaction. However, these results depend on best practice standards being in place for working health professionals. The goal of this study is to determine ML's viability to assist the health care process in predicting LoS. If ML can help predict the LoS, it would help improve patient care and reduce hospital penalizations from the Hospital Readmissions Reduction Program.

**Methods:** In this publication, a systematic review was conducted using mainly PubMed articles (with 2 exceptions, 1 article from the Association for Computing Machinery and 1 from the Multidisciplinary Digital Publishing Institute) using the keywords "machine learning" and "length of stay." We found 24 studies from January 2020 to January 2024 that highlight the efficacy of different ML models/algorithms in various LoS medical contexts, looking specifically at

their potential to improve operational decisions, resource allocations, and clinical outcomes. The scope of this systematic review is to evaluate recent developments related to the use of ML in LoS prediction.

**Results:** We found in our systematic review that a majority of studies highlight the accuracy of ML models being very high when predicting LoS. The accuracy rating cited by multiple sources was often greater than or equal to 89%; however, many did mention the limitations of needing a larger data scope and potential biases in the program. The algorithm's predictions can be classified as short-term or long-term LoS predictions for patients, with the former usually being a prediction of fewer than 7 days and the latter being anything past short-term. However, the prediction quality often decreases near the beginning of the long-term marker. This (short and long) marker varies between studies due to factors such as data quality and the ML algorithm/model used. Many studies reference the Random Forest model as having the highest or near highest accuracy when predicting LoS. Furthermore, this accuracy was consistent across different sectors of medicine, with missing or uncategorized data.

**Conclusions:** ML models hold substantial promise in predicting hospital LoS, potentially transforming health care operations by enabling more informed decision-making, early intervention, efficient scheduling, decreased workload on physicians, a more informed patient, and optimized resource allocation. This would ultimately help create better-personalized discharge plans that would benefit the patient, clinician, and hospital administrators. Programming advancements and further validation are crucial to fully realize the possible benefits.

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### **CLINICAL POSTERS**

#### **1st Place (tie): A Case of Pernicious Anemia Presenting as Severe Pancytopenia and Hemolysis**

*Tarek Jaber, DO*

**Case Presentation:** A healthy 18-year-old male who recently immigrated from Mexico and works as a landscaper presented to the

ED with concern for ongoing epistaxis. He reported a varied diet daily but endorsed poor oral intake for the past 1 to 2 months with associated 10-pound weight loss, as well as intermittent epistaxis and bleeding gums after brushing his teeth, which would take 20 minutes to resolve.

On presentation, his initial vitals were stable. Physical exam revealed evidence of mild scleral icterus, abdominal tenderness to the epigastric region, and mild generalized jaundice with no ecchymosis or petechia appreciated.

Lab results included the following: pancytopenia with WBC 2.8, macrocytic anemia with hemoglobin 2.4, mean corpuscular volume 105, and thrombocytopenia (platelets 36). Comprehensive metabolic panel results showed ALT elevation of 43 U/L, AST 64 U/L, and total bilirubin of 2.6 mg/dL. Ferritin was elevated to 221 ng/mL with normal iron levels and total iron-binding capacity at 175 mcg/dL. Infectious workup was noncontributory, with HIV, Epstein-Barr virus, and cytomegalovirus negative. Hepatitis C was also negative. Folate was within normal limits, fibrinogen level and coagulation labs also were normal. Direct coombs was negative. CT chest, abdomen, and pelvis showed evidence of cardiomegaly and hepatosplenomegaly. Lactate dehydrogenase (LDH) was elevated to 4000 IU/L, haptoglobin was <10 mg/dL, and reticulocyte count at .047, which was concerning for hemolysis.

The patient was given 2 units of packed red blood cells and admitted to the medical intensive care unit for further management. His vitamin B12 level returned at <150 pg/mL. Hemepath review of the peripheral smear showed no evidence of blasts or schistocytes, lowering the concern for acute hematologic malignancies, though there was evidence of ring sideroblasts. Due to previous CT findings of cardiomegaly with additional concern for possible anemia-induced cardiomyopathy, TTE was obtained, demonstrating severe left ventricle (LV) enlargement and a preserved ejection fraction. Parvovirus antibodies were negative. The rest of the patient's vitamin B levels were normal. Intrinsic factor inhibitor was negative. erythrocyte sedimentation rate was normal. His parietal IgG levels returned positive, confirming the suspicion of pernicious anemia. Upper endoscopic evaluation demonstrated diffuse gastric erythema with loss of gastric folds.

Through his hospital stay, the patient was given 1000 mcg of B12 supplementation intramuscularly daily for 7 days. His B12 levels were 892 on day of discharge. His pancytopenia improved, with WBC at 9.8, hemoglobin 10.5 g/dL, mcv 96 fL, and platelet count of 458 on day of discharge. His original symptoms greatly improved, and he was discharged with improved appetite, jaundice, and resolved epistaxis episodes.

*Discussion:* This case demonstrated the effects of longstanding B12 deficiency. As seen in this case, through its role in DNA synthesis, we observe both the classic macrocytic anemia and B12 deficiency's role in causing pancytopenia – affecting all hematopoietic cell lines. Also demonstrated here is severe anemia-induced cardiomyopathy. Lastly, B12 deficiency can lead to intravascular hemolysis due to red blood cell membrane deformity, as our patient had elevated LDH levels and low haptoglobin, with the absence of schistocytes seen on peripheral smear. Therefore, it is important to remember the long-term effects of pernicious anemia, its presentation, and its role in causing pancytopenia.

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### **1st Place (Tie): Iron Deficiency Presenting as Refractory Migraines**

*Jenna Wettstein; Whitney Lynch, MD*

*Introduction:* Iron deficiency has been recognized by the World Health Organization as the most common nutritional deficiency worldwide and is the predominant form of anemia. Common causes of iron deficiency include heavy menstruation in women, gastrointestinal bleeding, and deficient dietary iron intake or absorption. Reduced blood oxygen levels that result from iron deficiency can cause symptoms of shortness of breath, tachycardia, heart palpitations, fatigue, headaches, and dizziness.

*Case Presentation:* A 36-year-old female with a past medical history of hypertension, postpartum preeclampsia, gestational diabetes, anxiety, attention-deficit/hyperactivity disorder, hyperhidrosis, heavy menstrual cycles, and migraine headaches consulted her primary care clinician due to increased frequency of migraines that were significantly affecting activities of daily living.

She requested a refill of sumatriptan, which previously aborted her headaches. However, due to ongoing, refractory symptoms, she was changed to rizatriptan, ultimately titrated to 10 mg, with minimal response. Recent menstrual cycles were not noted to be heavy, but the patient had a history of menorrhagia.

Bloodwork was obtained and revealed results consistent with significant iron deficiency (ferritin 3 ug/mL, iron 16ug/dL, total iron binding capacity 472ug/dL, transferrin saturation 3%, and unsaturated iron binding capacity 456ug/dL). Iron infusions were initiated once weekly for 3 weeks with resolution of symptoms. Bloodwork was repeated postinfusion and showed a normalization of iron deficiency markers (hemoglobin 10.6 g/dL, ferritin 162ug/dL, iron 85ug/dL, total iron binding capacity 313ug/dL, transferrin saturation 27%, and unsaturated iron binding capacity 228ug/dL). At that time, the patient was instructed to begin oral iron supplementation with ferrous sulfate 325 mg twice daily with plan for additional workup to rule out possible sources of bleeding given absence of recent abnormal uterine bleeding. Upper and lower endoscopies were obtained to evaluate for evidence of an *Helicobacter pylori* infection, celiac disease, or structural lesions, which were normal. Hematology was consulted to discuss any other potential sources and noted many cases to be idiopathic. They agreed with plan for endoscopy and advised screening for volume of tea use. Additionally, they remarked on the absence of proton pump inhibitor (PPI) therapy on the patient's medication list, as this was another potential source of iron deficiency. The patient did not drink tea regularly and had not previously been on PPI therapy. Hematology recommended continuing oral iron supplementation and advised monitoring iron levels 2 to 3 times per year with replacement as indicated with goal ferritin >50 ng/mL along with a normal hemoglobin level. Labs were repeated 2 months after initiation of oral replacement and showed continued normal levels of iron stores and hemoglobin.

*Discussion:* This case presents the importance of considering the diagnosis of iron deficiency when faced with intractable and/or worsening migraines. Patients may not always have a historical feature that would

suggest this diagnosis (ie, this patient's more remote history of menorrhagia), and many cases are without a clear source making ongoing follow-up and lab monitoring pertinent to avoiding recurrence of symptoms.

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### **2nd Place (Tie): Nonbacterial Thrombotic Endocarditis in the Setting of Renal Cell Carcinoma**

*James Dickman, MD; Michael Witcik, MD*

*Introduction:* Most endocarditis cases are bacterial in etiology; however, rarely, cardiac valve vegetations can be primarily thrombotic in nature. Sterile vegetations in nonbacterial thrombotic endocarditis (NBTE) patients likely form from a combination of endothelial damage and thrombogenic conditions. The biggest risk factor for developing NBTE is active malignancy, especially adenocarcinomas of the lung, colon, pancreas, ovary, and biliary tree. Clinically, NBTE generally presents with thromboembolic manifestations (stroke, splenic infarct, etc) rather than with valvular dysfunction manifestation (heart failure, murmur, etc). The suspected reason for this is that thrombotic valve lesions are more fragile and susceptible to dislodging in comparison to lesions of ineffective endocarditis.

*Case Presentation:* We present the case of a 76-year-old man with a past medical history of stage IV renal cell carcinoma diagnosed 6 months prior with resulting ischemic stroke in the interim who presented to the ED with progressive severe lower extremity edema and generalized fatigue/weakness for 8 days. The admitting team felt that the primary pathophysiology was likely diastolic heart failure given that a TTE from 2 months prior showed normal left ventricular ejection fraction with moderate diastolic dysfunction; the patient was correspondingly started on an IV furosemide regimen.

Two days into the hospitalization, because of a lack of clinical improvement, a TTE showed normal left ventricular ejection fraction and new mitral regurgitation, along with new small vegetations on the mitral valve. One day after that, a transesophageal echocardiogram confirmed the presence of mitral valve vegetations and demonstrated the presence of aortic valve vegetations as well. Given that the patient was entirely

afebrile throughout this hospitalization and that his blood cultures showed no evidence of growth, the vegetations were presumed to be nonbacterial thrombotic endocarditis. To treat, the patient was started on enoxaparin in addition to furosemide. One day after that, his fluid status was thought to be significantly improved and he was discharged; given the progression of disease, his regimen of nivolumab was discontinued on discharge. Unfortunately, he passed away a few weeks after this hospitalization due to progression of his malignancy.

**Discussion:** NBTE is generally a poor prognostic factor and can be used to help initiate and conduct goal-of-care discussions. The diagnosis is made when valvular vegetations are seen on imaging with wholly negative cultures (as in this patient). The most common malignancies that co-occur with NBTE are adenocarcinomas; however, NBTE should be suspected in any patient with widely metastatic cancer who presents with cardio-embolic manifestations or heart failure symptoms to expediate treatment (heparin or enoxaparin; generally avoid warfarin and direct oral anticoagulants) and goals-of-care discussion. This case illustrates a rare presentation of NBTE with heart failure manifestations rather than definitive cardio-embolism manifestations, as well as having a more rare etiology, as renal cell carcinoma generally does not cause NBTE.

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### **2nd Place (Tie): Double Trouble: Myocardial Infarction With Takotsubo Syndrome**

*Akinwale Iyeku, MD, MS; Matthew Tattersall, DO, MS*

**Background:** Takotsubo syndrome (TS) is a nonischemic cardiomyopathy characterized by transient acute regional left ventricular (LV) wall dysfunction in the absence of angiographically significant coronary artery disease or acute plaque rupture. The clinical presentation of TS mirrors that of acute coronary syndrome and often is associated with periods of intense emotional or physical stress.

**Case Presentation:** A 67-year-old female with tobacco use disorder and dyslipidemia presented with central chest pain, new anterolateral T wave inversions with pro-

longed QTc interval, and elevated troponin (peak 9.5 ng/ml) consistent with a non-ST-elevation acute myocardial infarction (NSTEMI). Chest CT was negative for pulmonary embolism or acute aortic pathology. She was placed on dual antiplatelet therapy (DAPT), low molecular weight heparin, and underwent a coronary angiography that revealed severe single-vessel obstructive coronary artery disease of the mid left anterior descending artery (LAD), with successful intravascular ultrasound-guided percutaneous coronary intervention (PCI) with a drug-eluting stent. Primary PCI was complicated by the “jailing” of a small diagonal branch. Post-PCI, the patient had chest pain, likely attributable to the jailed diagonal branch. Serial worsening of anterolateral T wave inversions and QTc prolongation (Bazett’s, peak 505 milliseconds) occurred on electrocardiograms over the subsequent 48 hours, in patterns commonly seen in TS. Echocardiography demonstrated apical circumferential wall motion abnormalities, raising the suspicion of an associated stress-induced cardiomyopathy as a complication of her NSTEMI. Cardiac MRI confirmed a normal LV ejection fraction of 59% with a transmural infarct in the mid to apical anterior segments without apical thrombus. She was discharged on a beta-blocker, statin, angiotensin-converting enzyme (ACE) inhibitor, and DAPT and outpatient cardiac rehabilitation.

**Discussion:** TS is usually triggered by unexpected emotional or physical stress. The stressful precursor is thought to lead to sympathetic overdrive and catecholamine release, which has been hypothesized to lead to microvascular dysfunction. Such sympathetic surges also occur with acute coronary syndromes. Traditionally, TS is diagnosed by the absence of coronary artery disease, and in classic mid-apical TS variants, exclusion of proximal LAD disease is vital. Although the clinical presentation and electrocardiographic and biomarker profiles are similar between both conditions, this case shows that myocardial infarction is a stressful event that may trigger TS. Post-PCI electrocardiographic data demonstrating a serial worsening of anterolateral changes with QTc prolongation and imaging demonstrating circumferential apical dysfunction discordant with the distribution of the culprit vessel are key to identifying this sequence. While TS is often an

acute and transient cardiomyopathy, its course is not always as benign as previously thought. TS can be associated with significant complications, such as LV thrombus, cardiogenic shock, and malignant ventricular arrhythmias.

**Conclusions:** Patients presenting with myocardial infarction may develop an additional TS as a complication. The presence of apical ballooning or dyskinesia that does not align with the distribution of the diseased coronary artery is key to diagnosing TS in such cases. This is clinically relevant as the development of TS is associated with increased morbidity and mortality.

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# Statistical Thinking Part 3: Interpreting Diagnostic Tests with Probabilistic Thinking

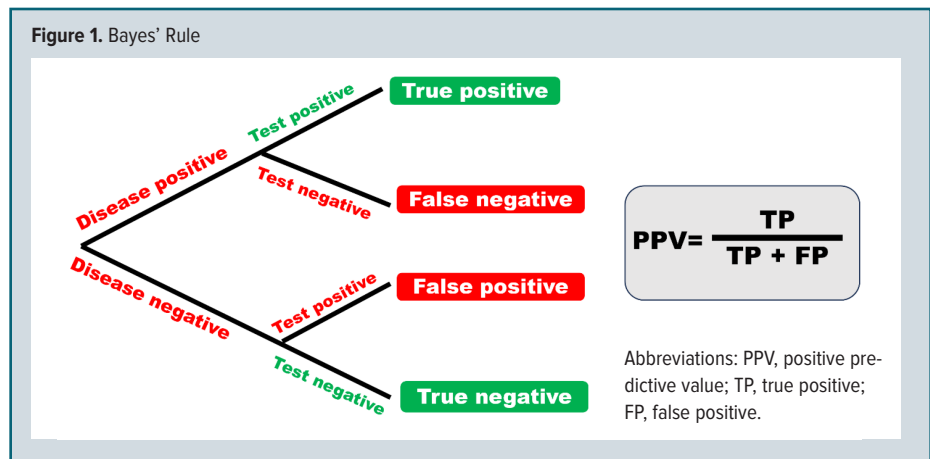
Robert A. Calder, MD, MS; Katherine Gavinski, MD, MPH, MEd; Jayshil J. Patel, MD

Epidemiology is the study of how disease is distributed, transmitted, and develops in populations. Screening and diagnostic tests help us differentiate between the people who have the disease and people who do not, but diagnostic tests may suffer from problems with validity and reliability. For example, it may be tempting to think that a positive diagnostic test means that the patient has the disease in question, but without incorporating clinical context or test characteristics, we may make an erroneous conclusion. Understanding context, such as pretest probability, and the validity and reliability of diagnostic tests are critical for clinical practice. In this column, we apply Bayes' rule using a story-like format. We describe operating characteristics of diagnostic tests, discuss diagnostic test sequencing, and depict the receiver operating characteristic curve. Finally, we apply likelihood ratios and describe how these ratios can enrich illness scripts.

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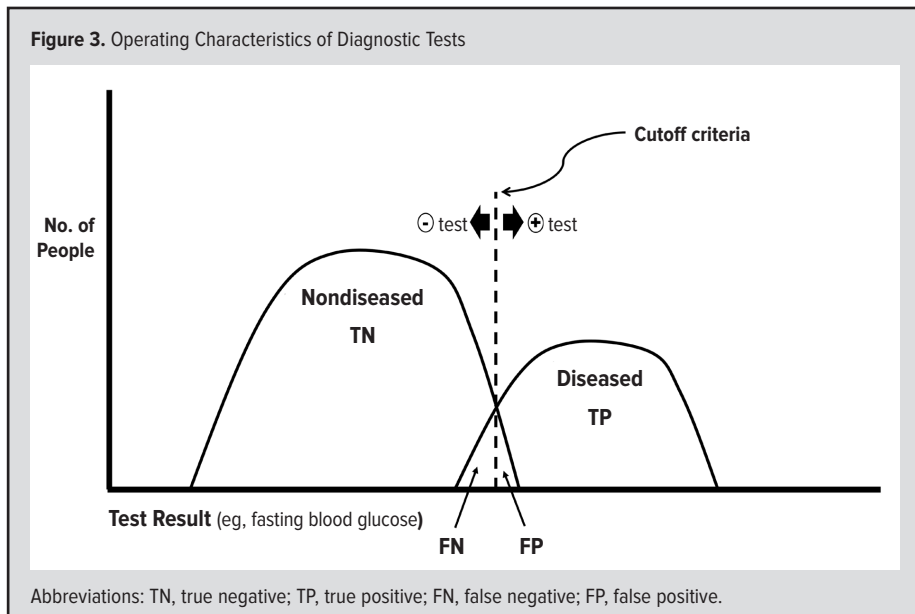
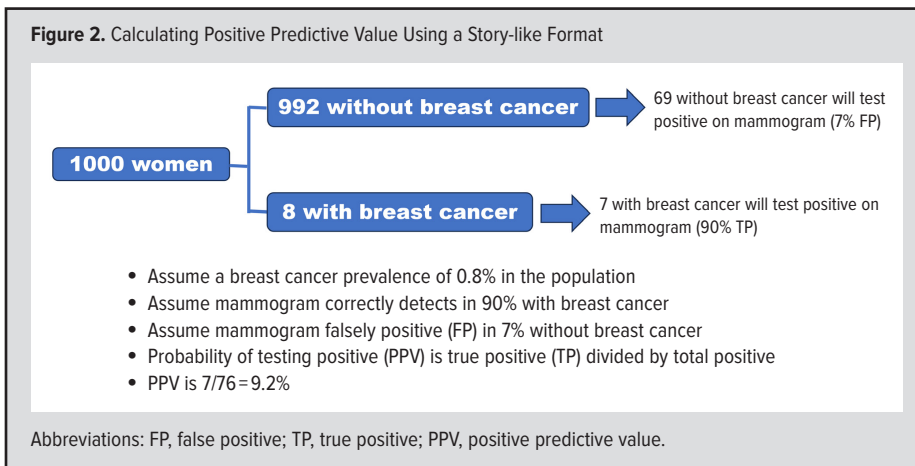
## Bayes' Rule and Application in a Story-Like Format

English clergyman Thomas Bayes derived his “rule” in the late 18th century.<sup>1</sup> Assuming that the prevalence of disease and efficiency of the test in those with and without disease are known, Bayes' rule allows us to predict the probability of disease by knowing only the test results. Here's how Bayes' rule works (Figure 1): imagine a population who are either “diseased” or “non-diseased.” Those with the disease have either a positive or a negative test for the disease, and those without disease also have a positive or negative test. Bayes' rule informs us that the probability of disease is simply the ratio of those with the disease who have a positive test (“true positive” or TP) divided by everyone with a positive test (those who have a positive test with the disease [TP] plus those who have a positive test without the disease [“false positive” or FP]).

Over 20 years ago, Gerd Gigerenzer presented physicians with a diagnostic riddle.<sup>2</sup> Suppose a woman has a positive mammogram. What is the probability that she has breast cancer? In this case, we assume that mammography is 90% sensitive for detecting breast cancer, the prevalence of breast cancer in the woman is 0.8%, and there is a 7% false positive percentage for mammography (93% specificity). The most common answer physicians provided was 90%.

Gigerenzer addressed these problems by popularizing a “story-like format” for Bayes' rule (Figure 2). He proposed that we begin by thinking of a population of 1000 women. If the prevalence of breast cancer in this group is 0.8%, then 8 will have breast cancer and 992 will not. Of the 8 with breast cancer, approximately 7 will have a positive mammogram, since mammography is posi-





tive in 90% of patients with breast cancer ( $8 \times 0.90 = 7.2$  or approximately 7). Of the 992 without breast cancer, approximately 69 will have a positive mammogram, since 7% have a FP test ( $992 \times 0.07 = 69.4$  or approximately 69). Of the 76 total positive tests (7 + 69), 7 are TPs. The probability of having breast cancer if the test is positive, which is the positive predictive value (PPV), is the ratio of TP (7) to total positives (76), or  $7/76$  (9.2%). The application of Bayes' rule using a story-like format may turn what seems like a complicated mathematical calculation into a sensical solution. Nevertheless, it is important to understand the prevalence of disease and the operating characteristics of diagnostic tests that underly the use of both Bayes' rule and Gigerenzer's story-like format.

**The Relationship Between Prevalence and Positive Predictive Value**

How does the prevalence of disease affect the positive predictive value of a test? Suppose that a woman who detects a breast lump on self-exam has a 20% risk of breast cancer. What is the probability she has breast cancer if she has a positive mammogram? The answer is far higher than 9%. Using the story-like format, imagine a population of 1000 women. If the prevalence of breast cancer in the population is 20%, 200 of these women will have breast cancer and 800 will not have breast cancer. Of the 200 women with breast cancer, 180 would have a positive mammogram if the sensitivity of mammogram for breast cancer is 90% ( $200 \times 0.90 = 180$ ). Of the

800 without breast cancer, and assuming the FP rate is 7% (if specificity of mammogram is 93%), then 56 ( $800 \times 0.07 = 56$ ) would have a FP test. The total number of positive tests is 236 (180 TP + 56 FP), which equates to a PPV of 76.3% ( $180/236$ ). When the prevalence of disease increases from 0.8% to 20%, the PPV increases from 9% to 76% (we assumed the mammogram test had the same operating characteristics: sensitivity of 90% and FP percentage of 7%). This is a striking difference. It is the difference between using a test for "screening" purposes and "diagnostic" purposes. Screening for disease involves testing individuals in a population with a very low prevalence of disease. Diagnosis typically involves testing individuals in a population with a much higher prevalence of disease. As a result, the probability that a positive test truly represents disease is much greater when there is a higher prevalence of disease.

**Operating Characteristics of Diagnostic Tests**

In an ideal world, individuals with disease would have a positive test and those without disease would have a negative test. Of course, such a world does not exist and, therefore, it is imperative to understand the operating characteristics of diagnostic tests.

Suppose we use the level of fasting blood glucose (FBG) to diagnose diabetes (Figure 3). To do this, we must define some "cutoff" level, above which the test is "positive" for diabetes. Currently, the cutoff level is 126 mg/dL. Individuals who have an FBG of 126 or greater have a positive test for diabetes. Most individuals with an FBG of  $\geq 126$  have diabetes and are considered TPs. The clinical signs of diabetes include polyuria (excessive urination), polydipsia (excessive thirst), and polyphagia (excessive appetite), and some individuals with an FBG of  $\geq 126$  mg/dL do not meet the clinical definition of diabetes, and their test results are considered FP.

Most individuals without diabetes have a negative test. Specifically, they have an FBG of 125 mg/dL or less, considered a "true negative" (TN) test result. Furthermore, these individuals do not have the clinical signs of diabetes (described above). However, some

**Table.** Definitions and Calculations of Operating Characteristics of Diagnostic Tests

| Operating Characteristic    | Definition  | Calculation                     |
|-----------------------------|---|---------------------------------|
| Sensitivity                 | Proportion of all diseased individuals who test positive for the disease  | $TP/(TP + FN)$                  |
| 1–Sensitivity               | Probability of a false negative   | $FN/(TP + FN)$                  |
| Specificity                 | Proportion of all nondiseased individuals who test negative for the disease   | $TN/(TN + FP)$                  |
| 1–Specificity               | Probability of a false positive   | $FP/(TN + FP)$                  |
| Positive Predictive Value   | Proportion of all positive tests that truly represent disease   | $TP/(TP + FP)$                  |
| 1–Positive Predictive Value | Probability an individual with a positive test does not have the disease  | $FP/(TP + FP)$                  |
| Negative Predictive Value   | Proportion of all negative tests that truly represent non-disease   | $TN/(TN + FN)$                  |
| 1–Negative Predictive Value | Probability an individual with a negative test has the disease  | $FN/(TN + FN)$                  |
| Positive Likelihood Ratio   | The ratio of the probability of having a positive test in the individual who has the disease in question divided by the probability of having a positive test in the individual who does not have the disease in question | $Sensitivity/(1 - Specificity)$ |
| Negative Likelihood Ratio   | The probability of having a negative test in the individual who has the disease in question divided by the probability of having a negative test in the individual who does not have the disease in question              | $1 - Sensitivity/Specificity$   |

Abbreviations: TP, true positive; FN, false negative; TN, true negative; FP, false positive.

individuals with an FBG  $\leq 125$  mg/dL may meet the clinical definition of diabetes, and the result of their test is considered a “false negative” (FN). Thus, the diseased population consists of both TPs and FNs, whereas the non-diseased population consists of both the TNs and FPs.

The “sensitivity” of a test is the proportion of diseased who have a positive test. This is the proportion of the diseased to the right of the cutoff criteria in Figure 3 and is calculated as  $TP/(TP + FN)$ . The “specificity” of a test is the proportion of nondiseased who have a negative test. This is the proportion of the nondiseased to the left of the cutoff criteria in Figure 3 and is calculated as  $TN/(TN + FP)$ . One minus the specificity (1-specificity) of a test is the probability of having a positive test even though you truly do not have the disease (the FP) and is the proportion of the nondiseased to the right of the cutoff criteria in Figure 3.

It is worth emphasizing that the number of positive tests in a population is critically dependent on the prevalence of the disease in the population (reflected by the size of the “diseased” population in Figure 3). A higher prevalence of disease will yield more positive tests than a lower prevalence of disease, which will yield fewer positive tests. Therefore, the prevalence of disease is an extremely important factor when deciding whether a positive test represents the true presence of disease.

How could the FBG test be more sensitive (or identify more individuals with diabetes)? We would have to move the cutoff criteria

lower, for example, to 100 mg/dL. The new cutoff value would ensure nearly everyone with diabetes has a positive test. However, many more people without diabetes also would have a positive test, reducing the specificity of the new cutoff value. Recall that specificity is the proportion of the nondiseased who have a negative test. If the cutoff were lower, more individuals without diabetes would have a (false) positive test. Thus, there is a tradeoff between sensitivity and specificity. Lowering diagnostic cutoff criteria would reduce specificity. Raising the cutoff criteria would reduce sensitivity (and would miss diabetes in those with the disease).

### Diagnostic Test Sequencing and “Ruling Out” Disease

A sensitive test will be performed to “rule out” disease if the test is negative, meaning there are very few false negatives. For example, if a child has a sore throat, a rapid Streptococcal test, which has approximately 90% sensitivity for *Streptococcus pyogenes*,<sup>3</sup> would likely “rule out” the probability of strep throat without the need to do a follow-up throat culture.

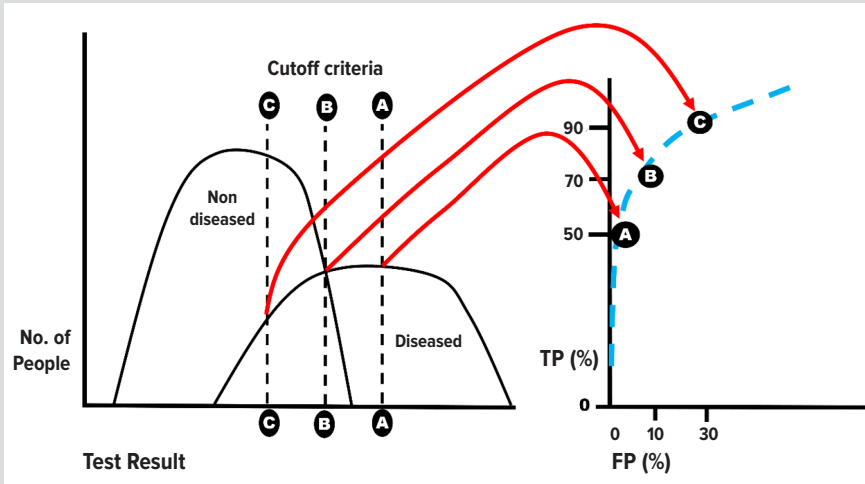
What happens when a highly sensitive test is positive? In these scenarios, diagnostic tests frequently are done in succession. Recall a highly sensitive test does not necessarily indicate the individual has the disease. Therefore, the positive screening test is confirmed with a more specific diagnostic test. For example, nascent testing for HIV included a rapid and highly sensitive test. If positive,

it did not confirm that the individual had HIV. Instead, the positive test was followed by a much more specific test, which was more difficult to perform. To appreciate why this sequence is necessary, imagine a highly sensitive test whereby almost everyone with the disease in question tests positive. If the test is negative, then it effectively rules out the disease in question since everyone with the disease should test positive. However, having a positive test does not indicate the individual has the disease in question, and a positive test would need to be followed up with a highly specific test, which is usually negative in those without the disease.

### Receiver Operating Characteristic Curves

The receiver operating characteristics (ROC) curves were first used during World War II to quantify predictions of radar operators differentiating enemy from allied aircraft.<sup>4</sup> In medicine today, ROC curves quantify the extent to which a test discriminates between the diseased and the nondiseased. The ROC curve is a graph of the probability of TP to the probability of FP for various cutoff criteria of a test. For a given cutoff criteria, a certain percentage of the diseased will have a positive test (TP) and—unless the cutoff criteria are extremely high—a certain percentage of the nondiseased will also have a positive test (FP). As the cutoff criteria change, the percentage of TP and FP will change. When the cutoff criteria are extremely high, only a small percentage of the diseased will be identi-

**Figure 4.** Receiver Operating Characteristic Curve



Abbreviations: TP, true positive; FP, false positive.

fied with a positive test. As the cutoff criteria is lowered, a greater percentage of the diseased will have a positive test, but so will some individuals without disease. When the cutoff criteria is very low, almost all of the diseased will have a positive test, but so will many of the nondiseased. The area under the ROC curve reflects the extent to which the test separates out the diseased from the nondiseased.

By plotting the TP percentage (sensitivity) against the FP percentage (1–specificity) for three different cutoff criteria, Figure 4 illustrates the construction of an ROC curve.

When the cutoff criteria is at point A of the test result curve (Figure 4, graph on left), approximately 50% of the diseased will have a positive test (sensitivity) and none of the nondiseased will have a positive test (zero FP). Therefore, point A on the ROC curve (Figure 4, graph on right) will be halfway up the Y-axis, which represents the percentage of TP.

When the cutoff criteria is at point B of the test result curve (Figure 4, graph on left), approximately 70% of the diseased will have a positive test (sensitivity), but so do approximately 10% of the nondiseased. Therefore, point B on the ROC (Figure 4, graph on right) curve will be at 70% up the Y-axis (TP) and 10% on the X-axis (FP).

Finally, when the cutoff criteria is at point C on the test result curve (Figure 4, graph on left), about 90% of the diseased will have a positive test (sensitivity) and so will about

30% of the nondiseased. Therefore, point C on the ROC curve (Figure 4, graph on right) will be at 90% on the Y-axis (TP) and 30% on the X-axis (FP).

A perfect test would identify all of the diseased and reach 100% on the Y-axis (TP axis) before any FPs occurred. In this case, the ROC curve would proceed straight up the Y-axis (TP axis) and to the right, forming a right angle. The area under this curve would be 1.00.

If the diseased population and the nondiseased populations were exactly the same, the ROC curve would proceed in a straight line at a 45-degree angle starting at the origin. At every cutoff point, the same percentage of diseased (TP) and nondiseased (FP) would be identified. The area under such a curve would be 0.5. Such a test would be no better than a coin flip. The 45-degree line is sometimes referred to as the “coin-flip” ROC curve.

Therefore, the greater the area under the ROC curve, the better the test is at discriminating between the diseased and the nondiseased. This area is also called the C (concordance) statistic.

If one were at point B on an ROC curve and the cutoff criteria were then made more sensitive, would the next likely point on the ROC curve be point A or C? To respond to this question, it is important to realize that if the cutoff criteria were made more sensitive, a greater proportion of the diseased would have a positive test. Therefore, the TP value would be

higher. Point C has a higher TP value, which makes it the correct answer.

### Likelihood Ratio and Application Using Story-like Format

The likelihood ratio (LR) offers a convenient way to make processes we do every day in medicine (eg, history taking, conducting a physical examination, laboratory testing) more mathematically precise. LR can be positive or negative. A positive LR is the ratio of the probability of having a positive test in the individual who has the disease in question divided by the probability of having a positive test in the individual who does not have the disease in question. The probability of having a positive test if disease is present is simply the sensitivity of the test. The probability of having a positive test if the disease is not present is 1–specificity of the test (the FP). On the contrary, a negative LR is the ratio of the probability of having a negative test in the individual who has the disease in question divided by the probability of having a negative test in the individual who does not have the disease in question. The probability of having a negative test if disease is present is 1–sensitivity, and the probability of having a negative test if the disease is absent is the specificity.

For example, suppose two people come to the emergency department complaining of chest pain. One person is in their mid-60s with hypertension, a lifelong smoker who does not exercise, and has pronounced visceral adiposity. The other is a healthy 30-year-old never smoker, without family history of premature coronary heart disease, and who exercises regularly. Let us further suppose that each performed and had a positive treadmill stress test. What is the likelihood that either (or both) of them has significant coronary heart disease?

The positive likelihood ratio for the treadmill stress test will give us extremely helpful information in this situation. When the likelihood ratio is multiplied by the “prior odds” of having disease, as determined before the test is done, that gives the “posterior odds” or the odds of having the disease given that the test is positive, represented by the formula: Prior Odds x Likelihood Ratio = Posterior Odds

Let us apply this approach to our two

patients with chest pain. First, we must estimate the prior odds of coronary disease for each patient. For the individual in their mid-60s, we may reasonably estimate that the probability of chest pain due to coronary disease may be approximately 75%, or a prior odds of 3:1. For the younger individual, we may estimate that the prior probability of coronary disease is approximately 0.1% (1 in a 1000), or a prior odds of 1:999, since otherwise healthy young individuals rarely have symptomatic coronary artery disease.<sup>5</sup>

Next, what is the positive likelihood ratio of a treadmill stress test? Suppose that both the sensitivity and specificity of this test—for both patients—is 75%. Based on the test characteristics, the positive likelihood ratio would be sensitivity/(1 – specificity) or 0.75/(1 – 0.75), which is 0.75/0.25, or 3.

For the older individual, prior odds multiplied by LR equals 9:1 (3:1x3:1=9:1). The posterior odds are 9:1. Odds of 9:1 represent a probability of 9/(9+1) = 9/10, or 90%. Therefore, the positive stress test increased our estimate of the probability of the older individual having coronary disease from 75% (pretest) to 90% (posttest). The pretest probability of 75% may make you wonder why the patient went for a stress test instead of a coronary angiogram, considered a definitive test.

What about the young individual? The prior odds were 1:999. When multiplied by the likelihood ratio for a positive stress test (3:1), we arrive at a posterior odds of 3:999, or a posterior probability of 0.3%. Since the prior probability of coronary disease in the young individual was low, having a positive stress test does not add additional information, and it is highly likely to be a FP test.

This example is similar in many other diagnostic situations. For example, if you hear an isolated crackle in the lung of an otherwise healthy patient, it probably does not mean much. However, if you hear the same crackle in the lung of a cachectic patient with a temperature of 104°F, a respiratory rate of 35 per minute, and a heart rate of 110 beats per minute, you should be thinking about pneumonia.<sup>6</sup>

The breast cancer question that Gigerenzer posed also can be solved using LRs. Since the

prevalence of breast cancer was 0.8%, the prior odds of breast cancer were 8:992. Since the sensitivity of mammography was 90% and the FP rate 7%, the LR positive (or sensitivity divided by 1 – specificity) was 0.90/0.07, or 12.9. The posterior odds are prior odds multiplied by the LR = 8/992 x 12.9 = 7.2/69.4. The posterior probability is 7.2/(7.2 + 69.4) = 9.4%. Notice, the 9.4% is same as was calculated with the story-like approach, neglecting rounding errors.

How are LRs interpreted? As rules of thumb, assuming complete equipoise (a prior odds of 1:1, ie, 50% probability) a positive LR of 2 increases the probability of the disease in question by about 15%, an LR of 5 by about 30%, and an LR of 10 by about 40%. An LR >10 is considered strong evidence for a disease. Similarly, a negative LR of 0.5 reduces the probability of disease by about 15%, an LR of 0.2 by about 30%, and an LR of 0.1 by about 40%. An LR of <0.1 is considered strong evidence against a disease.

In summary, the LR (positive or negative) helps us refine our estimate of some disease. It is algebraically identical to the story-like format for Bayes' rule discussed above. It is simply another way to apply Bayes' rule, and it is used when thinking about how much information a positive or negative test would add to our estimate of disease.

### Likelihood Ratios and Illness Script Enrichment

Understanding script theory is a key component of diagnostic reasoning. An illness script is an individual's organized mental model of a disease state. The information is organized in domains: epidemiology, pathophysiology, signs and symptoms, diagnostics, therapeutics, and prognosis. Novice learners begin building their script with biomedical knowledge, often gleaned from textbooks. By seeing more patients with varied presentations of diseases and deliberately practicing medicine, more experienced learners mature their illness scripts and build tolerance for ambiguity.

Over time, learners accumulate clinical experience that contributes to knowledge of diseases, and their corresponding illness scripts will be refined. In the case of physical examination findings or diagnostic testing for a disease,

understanding their operating characteristic (such as LR) proffers an opportunity to add precision to biomedical and clinical knowledge. For instance, a novice learner's illness script for acute bacterial meningitis may include the commonly taught Kernig's and Brudzinski's signs, which were described over a century ago in patients with late-stage bacterial and tuberculous meningitis.<sup>7</sup> A study evaluating the utility of these signs in acute bacterial meningitis found they lacked diagnostic value: both signs were found to have a sensitivity of 5% and a positive LR of 0.97, akin to flipping a coin.<sup>8</sup> Informed with new information, learners can refine their "signs and symptoms" domain of the acute bacterial meningitis illness script to include more precise (LR-based) estimates of diagnostic value for the Kernig and Brudzinski maneuvers.

In all cases, probabilistic thinking is needed to interpret diagnostic tests. For that reason, the next article in this series will discuss probability and its relationship to statistics.

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# Honoring the 20th Anniversary of Blue Cross and Blue Shield United's Gift to Improve Health in Wisconsin

Amy J. H. Kind, MD, PhD; Robert N. Golden, MD; Jesse Ehrenfeld, MD, MPH; Joseph E. Kerschner, MD

More than 20 years ago, the Medical College of Wisconsin (MCW) and University of Wisconsin Medical School [now the UW School of Medicine and Public Health (SMPH)] realized an opportunity to profoundly impact the landscape of health in our state, because of a remarkable gift provided to our two schools.

## History

In 1999, Blue Cross and Blue Shield United of Wisconsin (BCBS) petitioned the state's Office of the Commissioner of Insurance (OCI) to permit BCBS to convert from a non-profit service corporation to a stock insurance corporation. In 2000, the OCI approved the conversion, with proceeds to be distributed equally between the state's two medical schools: the UW Medical School and Medical College

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of Wisconsin. The funds were transferred to these schools, creating the Wisconsin Partnership Program (WPP) at the SMPH and the Advancing a Healthier Wisconsin Endowment (AHW) at MCW. AHW and WPP have missions to improve the health of the

have collectively invested more than \$650 million in 1388 projects and initiatives aimed at improving health and advancing health equity in our state.

Both AHW and WPP utilize the principles of science and inquiry; innovation in education;

Through our collective efforts and shared goals,  
we will continue to address complex health challenges,  
create positive health outcomes, and advance health  
equity for the people of Wisconsin and beyond.

people of our state now and for years to come, using their respective funds to support population health, medical education, and research initiatives aimed at improving health across Wisconsin.

BCBS's decision to give the funds to the medical schools was unique to Wisconsin. Similar BCBS conversion funds in other states were used to establish foundations or cover other state budgetary needs. The Badger State's gift resulted in a tremendous opportunity and responsibility. Our institutions continue to steward these endowed funds to benefit the health of people and populations across Wisconsin and beyond.

In 2004, when the conversion was complete, AHW and WPP funded their first research, education, and community health initiatives; at present, these organizations

community knowledge and expertise; and rigorous review to tackle Wisconsin's most pressing and complex health challenges. Through their distinct grant programs and diverse array of partners, the two programs support a wide range of nimble approaches and solutions for driving research innovation, tackling current health workforce needs, and helping communities address health disparities.

## Education

AHW and WPP are committed to supporting our schools' missions to train the next generation of clinicians and public health leaders and to equip them with the latest skills and knowledge. By introducing innovative curriculum models and establishing vital connections — such as MCW's regional campuses in Green Bay and Central Wisconsin, and the SMPH's

Wisconsin Academy for Rural Medicine (WARM) — we are building the health care workforce and addressing the state’s physician shortage, particularly in rural areas. To date, these programs boast a total of at least 500 graduates, many of whom have gone on to practice in Wisconsin.

The respective endowments have helped our schools shape the future of health care and public health leadership in the state through programs like the SMPH’s Master of Public Health Program and Population Health Service Fellowship. A WPP-funded partnership with the Native American Center for Health Professions, housed at the SMPH, and Wisconsin’s Tribal colleges is creating new pathways for Native American students to pursue education in health sciences-related fields. AHW has advanced the state’s health care workforce through foundational investments in more than 20 MCW schools and degree programs and through dozens of community partnerships that support health worker education and well-being. AHW also has funded two National Academy of Medicine fellowships aimed at tapping national best practices to advance state policies related to changes in health-focused systems.

### Research

The research investments made by AHW and WPP have led to significant advancements, including novel medical discoveries, diagnostic tools, and treatments. These investments have facilitated the translation of new knowledge into clinical innovations. Researchers supported by WPP and AHW are addressing complex health challenges including Alzheimer’s disease, blindness, cancer, diabetes, hypertension, heart disease, infectious diseases, obesity, maternal and infant health, and more.

Research grant recipients are leveraging their findings to sustain or expand their work. For example, an innovative telehealth eye-screening program funded by WPP and led by an SMPH faculty member/UW Health ophthalmologist in partnership with Mile Bluff Medical Center in Mauston, Wisconsin, has improved the number of diabetic eye screenings in rural communities. This vision-saving program is

being evaluated in a clinical trial at eight rural health systems across the country.

At the MCW Cancer Center, AHW has made investments in major scientific initiatives aimed at dismantling cancer through increasing the understanding of pancreatic cancer biology, advancing leading research in immuno-oncology, accelerating the impact of translational metabolomics, and uncovering molecular mechanisms of cancer that can lead to life-saving therapies for more people.

SMPH researchers are addressing the growing threat of antibiotic-resistant infections. An initial project funded by WPP provided crucial data that enabled researchers to establish a National Institutes of Health-funded center focused on drug discovery at the SMPH. The center has identified hundreds of antibiotic drug candidates, with some in active development.

AHW funding helped MCW establish Wisconsin’s first cancer precision medicine simulation unit to better diagnose rare diseases through 3-D genomic simulation.

In total, AHW and WPP grantees have leveraged at least \$1.8 billion from federal funding or other external sources to expand or sustain their work.

### Community

Both the AHW and WPP collaborate with rural, urban, and Tribal communities across Wisconsin to foster community-driven initiatives aimed at enhancing health and promoting health equity. Grant recipients spearhead efforts to address a broad spectrum of public health topics and concerns, including aging; behavioral and mental health; maternal and child health; opioid misuse and prevention; food security and nutrition; lead poisoning prevention; and numerous other critical issues. The endowments collectively support more than 100 community partnerships, including notable collaborations with the Foundation for Black Women’s Wellness, Marshfield Clinic, Oneida Nation, Southwest Wisconsin Community Action Program, United Community Center, the Children’s Health Alliance of Wisconsin, Heroes for Healthcare, Center for Suicide Awareness, Wisconsin Women’s Health Foundation, Hmong American

Center, and many others. These partnerships bridge the expertise of local communities with the academic resources of our institutions to generate positive health impacts across diverse populations and geographic regions.

### Future Outlook

The shared 20th anniversary for AHW and WPP represents a significant milestone that warrants celebration and reflection. We extend our profound gratitude to the many visionary, talented leaders whose foresight, collaboration, and commitment to Wisconsin made the AHW and WPP possible. We also express our sincere appreciation to the many grant recipients whose dedication, tireless work, innovative ideas, and significant achievements advance our missions. Through our collective efforts and shared goals, we will continue to address complex health challenges, create positive health outcomes, and advance health equity for the people of Wisconsin and beyond.

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THE PAIN,  
THEY'RE  
KILLERS.**

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It's a myth that prescription painkillers are completely safe because a doctor prescribes them. The Dose of Reality is that in Wisconsin, prescription painkillers are involved in more overdose deaths than heroin and cocaine combined. In fact, 63% of opioid-related deaths in 2015 involved prescription drugs. And everyone is at risk, especially young people ages 12-25.

Working together, we can prevent prescription painkiller abuse in Wisconsin. Since 4 out of 5 heroin addicts start with prescription painkillers, we can also help to curb the statewide heroin epidemic. Go to [DoseOfRealityWI.gov](http://DoseOfRealityWI.gov) to learn what you can do to help.



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A message from Wisconsin Department of Justice, and the Wisconsin Department of Health Services



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