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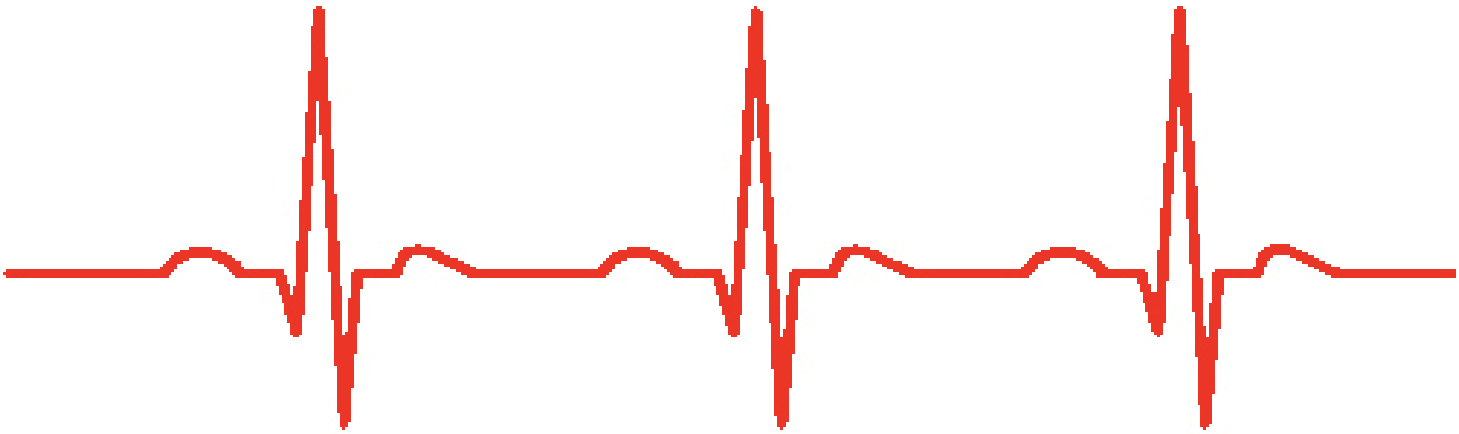

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CPCEM Clinical Practice & Cases

Addressing Emergency Department Care for Patients Experiencing Incarceration: A Narrative Review

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Patients experiencing incarceration face a multitude of healthcare disparities. These patients are disproportionately affected by a variety of chronic medical conditions. Patients who are incarcerated often remain shackled throughout their hospital course, experience bias from members of the healthcare team, and have many barriers to privacy given the omnipresence of corrections officers. Despite this, many physicians report little formal training on caring for this unique patient population. In this narrative review, we examine the current literature on patients who are incarcerated, especially as it pertains to their care in the emergency department (ED). We also propose solutions to address these barriers to care in the ED setting. [West J Emerg Med. 2023;24(4)654–661.]

INTRODUCTION

The United States has over 1.6 million incarcerated people.[1] This population has been historically medically underserved and faces a variety of healthcare disparities. Individuals who are incarcerated are more likely than the general population to have medical conditions such as diabetes, hypertension, HIV, hepatitis C, and tuberculosis.[2,3] The often substandard living conditions in jails and prisons also negatively impact incarcerated patients' health. For example, the morbidity and mortality from COVID-19 was significantly higher in prisons than in the general public.[4,5] While incarceration sometimes connects individuals who have not had previous access to care with continuity of care and medication for chronic conditions, many individuals are still unable to access adequate treatment while incarcerated.[6,7] For example, cancer patients report inadequate access to pain medications, patients face barriers to acute surgical care, and pregnant patients report inadequate prenatal care.[8,9,10] Even when patients are able to access care while incarcerated, they often face immense barriers to healthcare once released.[2,3]

In addition to the disparities noted above, incarceration is associated with mental illness and early mortality. When compared to non-incarcerated people, those who are incarcerated have higher rates of major depression, bipolar disorder, and schizophrenia.[11–16] Furthermore, incarceration itself may predispose individuals to mental illness, as experiencing incarceration is a risk factor for developing a first psychotic episode.[17] Substance use disorders (SUD) are more prevalent in the incarcerated population than the general population.[18] Many correctional facilities do not provide adequate treatment for SUD, which can lead to situations of life-threatening withdrawal in individuals with benzodiazepine and alcohol use disorder.[19,20] Individuals with opioid use disorder have a markedly increased risk of opioid overdose after release, especially if they are not started on medication-assisted treatment while incarcerated.[21–24] With regard to mortality, studies have shown that people who have been incarcerated have an increased risk of death at a younger age when compared to the general population.[25,26] This risk of premature death in incarcerated people disproportionately affects Black populations when compared to other demographic groups.[27,28]

It is impossible to discuss the disparities faced by incarcerated patients without recognizing that the criminal justice system is one based on racial oppression.[29] Black Americans are incarcerated, wrongfully convicted, and stopped and searched by police at disproportionately higher rates than White Americans.[30–33] The history of policing is

also rooted in systemic racism. In the 18th and 19th centuries, groups called "slave patrols" would search for and detain enslaved people who escaped; these groups are considered the basis of "modern-day policing."[34,35] When formal police departments were established in the early 20th century, these organizations served a large role in enforcing Jim Crow laws (laws in the South that institutionalized racial segregation, such as requiring separate water fountains for Black and White people).[34] In the late 20th century, the systemic criminalization of recreational drug use from President Ronald Reagan's "War on Drugs" and President Bill Clinton's Violent Crime Control and Law Enforcement Act disproportionately targeted Black and Latino Americans.[36,37] These are some examples, but by no means an exhaustive list, of how systemic racism is linked to the criminal justice system in the US.

While this review focuses on patients who are incarcerated, patients present to the emergency department (ED) in various types of custody. Often patients are brought to the ED after they are arrested but before they are convicted of a crime so that emergent medical concerns can be addressed prior to booking. Some patients are brought in while detained by US Immigration and Customs Enforcement officers. Patients may also present to the ED during the pre-trial period or post-conviction from jail or prison. Patients from both jails and prisons experience barriers to healthcare, but there are great discrepancies in the care provided at jails, based on the variation in a jail's size and resources and given that people typically spend less time in jails than in prisons.[6,38,39] Additionally, smaller jails may contract out most of their medical services, and jails are subject to less regulatory healthcare oversight than prisons.[39] While we will focus on the care of individuals who are incarcerated, many of the principles outlined in this article are applicable to patients in various types of custody.

Physicians employed by jails and prisons face an ethical dilemma termed "dual loyalty," meaning the conflict in interest between caring for their patient and catering to the demands of the prison administration.[40] Sometimes, physicians are asked to perform tasks that go against their role as healers, ie, to perform drug tests without a patient's consent, to withhold an expensive medical treatment despite it being the standard of care, and to perform medical exams for the purpose of "certify[ing] that prisoners are fit for imprisonment."[40] Similarly, emergency physicians must be aware of the conflicts of interest that arise when caring for patients who are incarcerated, such as cases when they are asked to "medically clear" a patient prior to booking or perform tests or exams that are not clinically indicated.

Penal harm refers to any "planned governmental act whereby a citizen is harmed" for punitive reasons; the harm is considered "justifiable precisely because it is an offender who is suffering."[41,42] Although the Eighth Amendment of the US Constitution broadly "prohibits cruel and unusual punishment," it was not until the 1976 Supreme Court ruling in the case of *Estelle v Gamble* that penal harm in the context of medical care was explicitly deemed unconstitutional.[43] The *Estelle v Gamble* ruling, which centered on "the deliberate indifference of the medical needs of prisoners," set a clear precedent for the rights of incarcerated patients to accessible medical care (including inpatient and specialist care).[43,44] Failure to provide incarcerated patients with the same "standard of care" as non-incarcerated patients has henceforth been considered a violation of the Eighth Amendment.[44] However, in practice, upholding the healthcare rights of incarcerated patients is more challenging to enforce.[45]

In this narrative review, we will identify several barriers to maintaining the standard of care for incarcerated patients in the ED. We hope to increase awareness of these disparities and propose solutions to better address them in clinical practice.[34,46]

BARRIERS TO CARE

Through our review of the existing literature, we identified multiple barriers to treating incarcerated patients in the ED: biased care from physicians; presence of law enforcement; and use of physical restraints.

Bias

Members of the healthcare team, including physicians and nurses, often have their own preconceived notions about incarcerated patients that ultimately affect patient care. A survey study of formerly incarcerated individuals found that many patients have experienced discrimination based on their criminal record.[47] Many patients also reported discrimination in the healthcare setting due to their race and ethnicity.[47] This survey study also found that formerly incarcerated individuals with increased ED utilization reported a higher rate of discrimination from healthcare professionals.[47]

However, many physicians already recognize the disparities in the care of patients who are incarcerated. One recent qualitative study by Douglas et al acknowledges the need to optimize quality of care for incarcerated patients.[48] In this paper, surgical residents were surveyed about their encounters with law enforcement while caring for patients experiencing incarceration. The surgical residents noted many challenges when caring for these patients, including barriers to adequate follow-up care and the designated holding areas for incarcerated patients that may contribute to "substandard care" or decreased monitoring of critically ill patients.[48]

Bias has been reported among many members of the healthcare team. The study "Caring for Hospitalized Incarcerated Patients: Physician and Nurse Experience" by Brooks et al examined physician and nurse experiences when caring for hospitalized incarcerated patients using open and

closed-ended survey questions.[49] A majority of physicians believed patients who were incarcerated received less frequent non-medical interventions (defined as "social work support, physical therapy visits, nutrition consults") during hospitalization than other patients.[49] Over 30% of physicians believed that these patients received "fewer diagnostic tests" and "fewer medical interventions" than other patients.[49]

Patient Privacy

There are also many limits to patient privacy when caring for patients who are incarcerated in the ED. The presence of corrections officers who accompany these patients to the ED often leads to protected health information (PHI) being shared if members of the healthcare team do not ask officers to step away during the history and physical.[43,50]

In the survey study by Brooks et al, a higher percentage of nurses when compared to physicians reported that they kept law enforcement in the exam rooms when performing their histories and physicals.[49] Still, 35% of physicians reported not asking corrections officers to leave during patient encounters, and over 50% of the physicians reported not asking for shackles to be removed during their histories and physicals.[49] In the survey, physicians also identified a lack of formal training in their medical education when caring for this group of patients.[49]

Many surgical residents in the Douglas et al study recognized incarcerated patients' barriers to privacy. The majority of residents in this study reported witnessing incidents when law enforcement officers would question patients during trauma assessments, at times disrupting the primary and secondary survey and impinging on patient privacy.[48] In addition, many residents reported instances when an "armed guard was present in the operating room" during a surgical procedure.[48] One resident reported an instance when an officer requested an ethanol level on a patient, even though this test was not pertinent to the patient's care at that time.[48]

The literature also describes instances when law enforcement, namely police officers, have requested invasive body searches and tests on patients, although these tests were not clinically indicated.[51,52] In a survey study, emergency physicians reported breaches of patient privacy in the presence of law enforcement, including instances when officers solicited PHI.[53] Physicians reported being uncertain of the exact role and limitations of law enforcement in their workplace.[53]

While physicians should always strive to maintain patient privacy, there are circumstances in which aspects of patient care may need to be disclosed to law enforcement. For example, PHI may need to be disclosed if a patient requires specific treatment or follow-up care in the outpatient setting. Given the delays that can occur in the care of incarcerated patients, instructions may need to be explicitly written or discussed with law enforcement to ensure appropriate care occurs after discharge from the ED.[54] However, physicians should always attempt to obtain approval from patients prior to sharing their PHI. There are also instances where incarcerated patients may exhibit violent behavior that poses a safety threat to themselves or to ED staff. In these instances, it is appropriate to interview patients in the presence of law enforcement.

Physical Restraints

Physicians are taught to use physical restraints with caution and only when absolutely necessary. Physical hospital restraints, which are often applied to protect patient safety, are associated with numerous complications. For example, there is a statistically significant increased incidence of pulmonary embolism and deep vein thrombosis in patients who are physically restrained.[55,56] Furthermore, restraints are associated with delirium, emotional distress, rhabdomyolysis, injury, and even death when improperly used.[57–59] Indeed, both the American College of Emergency Physicians (ACEP) and The Joint Commission have published standards on the criteria necessary to justify restraint use and minimize harm associated with restraints.[59–61]

Despite the caution advised when using physical restraints, patients who are incarcerated often arrive to the ED in shackles and remain in shackles throughout the course of their ED stay. Some surgery residents have even reported caring for patients who are shackled to the bed while intubated and sedated.[48] There are some policies in place to limit the use of shackles in clinical settings. Recognizing the risks of physical restraints in pregnancy, many states have mandated against physical restraints for patients who are incarcerated in the perinatal period.[62] Federal policies have also been enacted to restrict use of physical restraints in pregnancy, except when considered necessary for safety reasons.[62]

There is a dearth of protections for patients who are not pregnant. Non-pregnant, incarcerated patients often remain shackled throughout their hospital stay; this includes those who are terminally ill and those who are intubated and sedated.[63–65] There is little data to support the medical rationale for shackling and, indeed, its use is mainly determined by federal and local policy to be a requirement during transport.[63,64,66–68] A discussion on ways to address shackling in the ED is included below.

STRATEGIES TO IMPROVE CARE

In this section, we propose several strategies to improve the quality of ED care for patients who are incarcerated. These suggestions are not exhaustive; much more research is required to further investigate the many disparities these patients face.

Bias

Hofmeister and Soprych discuss the importance of including formal teaching on treating incarcerated patients in

medical curricula.[69] The authors discuss how the use of workshops on implicit biases can be incorporated into resident medical education. The workshop they performed allowed resident physicians to self-reflect on their biases and better recognize the disparities that specifically affect incarcerated patients.[69] There should be increased curriculum development in medical education that focuses on addressing the biases faced by patients who are incarcerated.

Privacy

The US Department of Health and Human Services outlines PHI protections for patients who are incarcerated. Sharing of PHI is only permitted in a few distinct circumstances, such as when healthcare clinicians are responding to a request for "PHI [that] is needed to provide health care" to the patient, or when the PHI is necessary to protect the health/safety of the individual or people around them.[70] As one can imagine, information may be inadvertently divulged to corrections officers if the emergency physician (EP), nurse practitioner (NP), or physician assistant (PA) conducts the history and physical with corrections officers in the room.[43] A toolkit for protecting patient privacy created by the Working Group on Policing and Patient Rights of the Georgetown University Health Justice Alliance recommends that EPs, NPs, and PAs ask officers to step out of "earshot" to protect PHI and "prevent accidental disclosures."[50] EPs, NPs, and PAs should also obtain patient consent prior to lab tests and procedures.[50] The "Medical Provider Toolkit" and ACEP also note that while law enforcement personnel may even provide warrants for specific tests and exams such as body cavity searches, EPs, NPs, and PAs can refuse if they are not clinically indicated or are not in the patient's best interest.[50,71]

Physical Restraints

Just as certain federal and state policies advocate for limiting shackle use in pregnant patients, so too should there be a greater emphasis placed on the removal of shackles on patients who are not pregnant. When interviewed, many physicians and nurses reported not requesting that shackles be removed.[49] As mentioned above, there is little data to support the use of shackles, and many of the rules and regulations regarding shackle use focus on transportation. Barriers to shackle removal are often due to knowledge deficits and unclear institutional guidelines surrounding shackling. EPs, NPs, and PAs should recognize the harms associated with shackles and request their removal whenever possible, as these are often not medically necessary.[50,64] Indeed, the International Association for Healthcare Security & Safety states that it is the responsibility of the physician and other members of the healthcare team to "assess the safety of continued use of restraint."[72] In addition, it is the duty of the corrections officers, and not the medical team, to ensure the patient's security.[64] Given that there are often unclear guidelines surrounding shackles and non-medical restraints, hospitals should also set forth their own guidelines to uphold the principle of medical non-maleficence in all treatment areas including the ED.[64]

To minimize harm, physicians should avoid and advocate against the shackling of patients in the prone position. This type of restraint confers an even greater risk of complications and has been linked to cardiopulmonary arrest, especially in agitated patients.[73] Controversy remains as to whether this is secondary to positional asphyxia; Steinberg provided a review of the current literature detailing how the cause of sudden death in prone restraint is "multifactorial," resulting from "reduced cardiac output," metabolic acidosis, and impaired ventilation.[73] While the Joint Commission does not explicitly prohibit prone restraint, hospitals are required to report any deaths that occur while a patient is restrained.[74,75] Since prone restraint has been identified as a contributor to death in subjects who are agitated, many institutions have created policies against its use.[76,77]

Advocacy

We encourage EPs to advocate for change in the carceral system and in their own institutions to improve the healthcare of patients who are incarcerated. Issues of inadequate living conditions in prisons, prison crowding, and discrimination outside the hospital have been well documented.[78–81] Given the health implications of these issues, physicians should recognize and advocate for better living situations for these vulnerable patients.[82] Conditions for patients who are incarcerated are sometimes inadequate in the hospital. Some hospital EDs have separate holding areas for patients who are incarcerated. The quality of care in these ED holding areas could be improved by increasing the staffing, resources, and attention to these sections.[48] Physicians should advocate for better conditions for incarcerated patients, both within the ED and without.

Continuity of Care

In addition to the reported substandard care that incarcerated patients receive while in the hospital setting, there are many barriers to appropriate medical care in correctional facilities. The article "Emergency Medical Care of Incarcerated Patients: Opportunities for Improvement and Cost Savings" by Martin et al is a chart review of incarcerated patients' ED visits at a single institution.[54] Patients reported barriers to care, such as difficulty accessing prescription medications for chronic conditions.[54] In light of this, EPs, NPs, and PAs should ask patients who are incarcerated about their access to medications for chronic conditions and refill appropriate prescriptions prior to discharge. In addition, there are many documented cases of patients eventually presenting to the medical system with late-stage illnesses that could have been treated earlier if they

had been previously identified.[79] We encourage EPs, NPs, and PAs to refer patients to specialists and recommend clinic visits when appropriate.[79]

Education

There is a lack of formal education surrounding care for incarcerated patients. In addition to bias workshops, the implementation of lectures, case-based discussions, and simulation cases can provide residents, attending physicians, NPs, and PAs with the tools necessary to care for this unique patient population. We developed and successfully implemented a simulation case for resident learners involving the presentation of a patient experiencing incarceration. This simulation aimed to expose learners to the issues unique to incarcerated patients as well as promote discussion on the removal of shackles during ED care, implicit biases, and protecting PHI. We are in the process of analyzing survey data from this simulation session, and results are forthcoming.

CONCLUSION

Incarcerated patients are part of a vulnerable population that currently receives substandard care in many healthcare settings, including EDs. The biases held by members of the healthcare team, the presence of corrections officers, and pervasive use of restraints contribute to the numerous healthcare inequities. We have proposed strategies to improve the quality of care for this group of patients, recognizing that changes must be made on the physician level, throughout medical education, and institutionally.

> *"Medicine should be viewed as social justice work in a world that is so sick and so riven by inequities."*[83] – Dr. Paul Farmer.

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A Virtual National Diversity Mentoring Initiative to Promote Inclusion in Emergency Medicine

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Introduction: Trainees underrepresented in medicine (URiM) face additional challenges seeking community in predominantly white academic spaces, as they juggle the effects of institutional, interpersonal, and internalized racism while undergoing medical training. To offer support and a space to share these unique experiences, mentorship for URiM trainees is essential. However, URiM trainees have limited access to mentorship from URiM faculty. To address this gap, we developed a national virtual mentoring program that paired URiM trainees interested in emergency medicine (EM) with experienced mentors.

Methods: We describe the implementation of a virtual Diversity Mentoring Initiative (DMI) geared toward supporting URiM trainees interested in EM. The program development involved 1) partnering of national EM organizations to obtain funding; (2) identifying a comprehensive platform to facilitate participant communication, artificial intelligence-enabled matching, and ongoing data collection; 3) focusing on targeted recruitment of URiM trainees; and (4) fostering regular leadership meeting cadence to customize the platform and optimize the mentorship experience.

Conclusion: We found that by using a virtual platform, the DMI enhanced the efficiency of mentor-mentee pairing, tailored matches based on participants' interests and the bandwidth of mentors, and successfully established cross-institutional connections to support the mentorship needs of URiM trainees. [West J Emerg Med. 2023;24(4)662–667.]

BACKGROUND

Trainees underrepresented in medicine (URiM)* face challenges seeking community in predominantly White academic spaces, as they juggle the effects of institutional, interpersonal, and internalized racism throughout medical training.[1–12] These effects can contribute to increased

*The Association of American Medical Colleges (AAMC) defined the term underrepresented minority (URM) to reflect the racial groups of Black, Mexican-American, mainland Puerto Rican, and Native American (American Indian and natives of Alaska and Hawaii). In 2003, to encompass the racial and ethnic populations within medicine who are underrepresented when compared to their respective numbers in the context of the greater population, this was further clarified to "underrepresented in medicine" (URiM or UIM). Although we recognize the use of URiM or UIM interchangeably, for consistency, we have used the term URiM throughout this paper.

experiences of the imposter phenomenon among URiM trainees, which can negatively affect performance.[13–20] Lack of social networks within medicine and informal knowledge due to differences in parental education and resources contribute to barriers to inclusion and career success.[21–25] To offer support and a space to share these unique experiences, mentorship for URiM trainees is essential in academic medicine, in addition to its benefits of promoting greater career satisfaction, productivity, and physician wellness.[26–36]

However, there is a scarcity of mentorship for URiM trainees, who especially benefit from faculty of diverse gender identities and racial and ethnic backgrounds.[37,38] URiM faculty are instrumental in promoting inclusive training environments and have been shown to increase residency programs' ability to recruit Black, Latinx, and Native American residents and increase graduation rates among URiM students.[39–43] Unfortunately, this mentorship is limited by the small number of URiM faculty, who already take on a disproportionate burden of mentorship.[44–47] This minority tax contributes to increased burnout, decreased productivity, and decreased career promotion.[48–51]

To address this gap, we developed a national virtual mentoring program that strategically pairs URiM trainees interested in EM with mentors familiar with medical education and career development. We describe how to implement a model to expand mentorship access for URiM trainees and advance representation, inclusion, and belonging in EM.

OBJECTIVES

The virtual Diversity Mentoring Initiative (DMI) aimed to (1) provide an accessible and safe environment for URiM participants to share experiences; (2) connect with other URiM trainees and mentors in EM; and (3) provide practical strategies to thrive personally and professionally as future emergency physicians. We measured these objectives by self-reported surveys regarding satisfaction with the DMI and mentees' ability to achieve mentorship goals. This study was deemed exempt from institutional review board (IRB) review by the Stanford IRB.

INNOVATION DESIGN

The American College of Emergency Physicians (ACEP) and the Emergency Medicine Residents' Association (EMRA) partnered to form the DMI in September 2019. Faculty and trainees beta-tested several virtual mentoring platforms. The primary need for a virtual format was the ability to scale the DMI for large cohorts by enhancing the efficiency of matching mentor-mentee pairs, as opposed to manual pairing. Other important features included a user-friendly interface, a single-sign-on feature using existing ACEP logins, and the ability to collect data on participant interactions and mentor-mentee pairs for reportable outcomes.

We chose the Chronus software (Chronus LLC, Bellevue, WA) for its comprehensive platform with the ability to perform artificial intelligence-enabled matching of mentor-mentee pairs, enroll participants, facilitate participant communication, and collect longitudinal data.[52] Chronus included an account manager that generated reports, oriented users, and troubleshooted issues, beyond the information technology support that most other platforms offered.

Upon program initiation, mentors and mentees completed a questionnaire in the Chronus platform indicating their goals, areas of expertise and, for mentors their number of desired mentees. Chronus then suggested pairings based on responses. Mentees had the final choice to select their mentor from a short list.

Three mentorship cycles were completed: August 2020–February 2021, March 2021–September 2021, and October 2021–June 2022. We advertised through Twitter, EM medical education networks (e.g., Council of Residency Directors in EM), the EMRA Diversity and Inclusion committee, and targeted outreach to Historically Black Colleges and Universities' EM interest groups to recruit participants.

To supplement individual mentor-mentee relationships, nine 60-minute educational and networking events for program participants, called "#MixMatchMingle," were held throughout the three cycles to create a communal space to share experiences. The format of the #MixMatchMingle events ranged from invited guest speakers to facilitator-led discussions on a topic. Event themes are listed in Table 1 and were chosen by the leadership team, who had various levels of training and faculty experience, diverse racial and ethnic backgrounds, members who were first-generation in medicine, and faculty specializing in medical education. By strategically pairing mentors and URiM mentees based on their goals and interests and fostering a wider community with the #MixMatchMingle curriculum, DMI uses mentorship as a pedagogical approach to EM career guidance. It also leverages strategies grounded in social capital and social network theory to address potential disparities in informal networks and knowledge in academia.[53,54]

Monthly quantitative and qualitative data were collected via Chronus throughout each cycle to measure program efficacy and inform subsequent iterations (full survey in Supplemental Material). Incremental iterations of workflow and customization of the platform were necessary as unexpected challenges arose. For example, when the number of enrollees did not match the number of participants paired, we found that it was largely due to lack of participant profile completion. Thus, we adjusted automated e-mail reminders and more explicitly communicated the importance of profile completion to participants.

Table 1. Topics of #MixMatchMingle events.

Cohort Introduction (orientation to Chronus, The Why's and How's of Effective Mentorship)
Addressing Impostor Phenomenon
Residency Application Preparation and Tips
COVID-19 Pandemic Reflections and Practicing Self-Compassion
Thriving Professionally and Financially: Building your Wealth in the Stock Market
"Life Hacks" and Time Management
Transitions in Medicine and the Role of Mentorship
Mentor/Mentee-ship at Different Career Levels
Pathways to Leadership in EM

COVID-19, coronavirus disease 2019; *EM*, emergency medicine.

IMPACT/EFFECTIVENESS

A total of 87 mentors and 270 mentees participated in the DMI. The average mentor to mentee ratio was 1 to 1.6. Anonymous surveys were distributed to participants. Of the 270 mentees, 215 (79.6%) responded to the end-of-cohort survey. Successful implementation of the DMI required funding and staff support, platform troubleshooting, and early scheduling of events for participants. We leveraged an existing partnership between ACEP and an acute care staffing company Vituity (CEP America, Inc, Emeryville, CA) to fund Chronus. Administrative and physician program leaders met biweekly to discuss data generated by the platform, troubleshoot issues with mentor-mentee pairing, and design the #MixMatchMingle curriculum.

The virtual mentoring format successfully provided access to mentors dedicated to increasing representation in

Table 2. Characteristics of unique participants of the virtual Diversity Mentoring Initiative across three cohorts (August 2020–June 2022).

	Total N (%)	Mentors	Mentees
N (%)	357	87 (24.4)	270 (75.6)
Gender			
Men	96 (26.9)	41 (47.1)	55 (20.4)
Women	251 (70.3)	42 (48.3)	209 (77.4)
Non-Binary	6 (1.7)	1 (1.2)	5 (1.9)
Transgender	3 (0.8)	2 (2.3)	1 (0.4)
Undisclosed	1 (0.3)	1 (1.2)	0
Level of Training			
MS Year 1 or 2	92 (25.8)	0	92 (34.1)
MS Year 3 or 4	135 (37.8)	0	135 (50.0)
PGY1	36 (10.1)	15 (17.2)	21 (7.8)
PGY2	10 (2.8)	3 (3.4)	7 (2.6)
PGY3	15 (4.2)	7 (8.0)	8 (3.0)
PGY4	6 (1.7)	5 (5.7)	1 (0.4)
Fellow	19 (5.3)	18 (20.7)	1 (0.4)
Attending (1–5 years post-residency)	14 (3.9)	13 (14.9)	1 (0.4)
Attending (5+ years post-residency)	6 (1.7)	6 (6.9)	0
Other*	24 (6.7)	20 (23.0)	4 (1.5)
Race or Ethnicity			
Asian	63 (17.6)	11 (12.6)	52 (19.3)
Black	121 (33.9)	24 (27.6)	97 (35.9)
Latino/a	74 (20.7)	13 (14.9)	61 (22.6)
Middle Eastern	14 (3.9)	4 (4.6)	10 (3.7)
Native American	5 (1.4)	0	5 (1.9)
Native Hawaiian or Pacific Islander	2 (0.6)	1 (1.2)	1 (0.4)
White	60 (16.8)	33 (37.9)	27 (10)
Other	18 (5.0)	1 (1.2)	17 (6.3)

*Participants who listed "other" for level of training cited roles such as MD-PhD, MBBS, osteopathic medical student, and chief resident.
MS, medical student; *PGY*, postgraduate year.

medicine. Travel limitations during the pandemic especially impacted medical students enrolled at institutions without associated EM programs.[55–57] One participant noted, *"I really appreciated the virtual format, especially since my mentor is across the country. It made for a unique opportunity that wouldn't have been possible otherwise."* The virtual format lent itself to participant flexibility, with another mentee noting, *"The online format made it convenient for me to participate despite my hectic and unsure schedule."*

In the survey distributed upon cohort completion, 105 of 117 (89.7%) mentee respondents rated that they were "satisfied" or "strongly satisfied" with their mentorship, and 107 of 117 (91.5%) mentee respondents stated that they achieved the goals set for their mentorship relationship. Mentees described the impact of their mentoring relationships on both personal and professional levels, with one sharing, *"[Mentor name] really changed the game for me. I was not sure if I wanted to continue with medical school. Now I know that I not only want to become a doctor, but I want to be in emergency medicine for sure."* Another participant noted, *"[Mentor name] is amazing and not only do I feel like I have a mentor for life, but I've also gained a good friend."*

The fluidity of the mentorship structure had mixed feedback. While some participants enjoyed organically building relationships with their mentors through more casual interactions, others suggested benefiting from a more structured curriculum and concrete goal setting. We found that engagement with the #MixMatchMingle events waned as the pandemic continued, which may in part have been due to "Zoom fatigue."[58,59] Given that participants cited positive experiences during one-on-one mentor-mentee meetings, we reallocated efforts by decreasing the number of program-wide events.

We were encouraged that the proportion of URiM mentors was disproportionately higher than their representation in EM. Balancing the benefits of having racially concordant mentors with mitigating the minority tax on these mentors was challenging.[60,61] However, compensation and academic incentives for mentor participation could be effective.[62–64]

LIMITATIONS

This study had limitations. First, physician leaders did not have protected time for this pilot initiative, limiting their availability for meetings and recruitment efforts. Dedicated administrative staff and protected time for physician leaders is critical for program sustainability. Furthermore, a mentorship platform with automated matching may be cost-prohibitive for many institutions, at a cost of $42,000 annually. Because participants were only able to select one race or ethnicity, we were unable to capture the perspectives of multiracial participants. Finally, the data did not include intersectional identities such as sexual orientation, religion, disability status, and being first-generation, which may have contributed to participants' experiences.[65] With added support, targeted recruitment could have been expanded to Hispanic-serving institutions and other national student organizations.

CONCLUSION

The national virtual Diversity Mentoring Initiative successfully provided access to cross-institutional connections and supported the specific mentorship needs of URiM trainees. Using a virtual platform enhanced the efficiency of mentor-mentee pairing and allowed for tailored matches based on participants' interest and bandwidth of mentors. The majority of mentees reported satisfaction with their mentor relationships, highlighting support for their personal and professional growth. Support from national organizations to fund virtual DMI for EM interest groups and residency programs can bridge geographical gaps in mentorship and sponsorship. We hope that this model is translated beyond EM and inspires the launch of personalized mentorship resources for URiM trainees to further inclusion and a sense of belonging, while broadly advancing representation in medicine.

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Skin Tone and Gender of High-Fidelity Simulation Manikins in Emergency Medicine Residency Training and their Use in Cultural Humility Training

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Introduction: It is important for physicians to learn how to provide culturally sensitive care. Cultural humility is defined as a lifelong process with a goal of fixing power imbalances and creating institutional accountability through learning about another's culture as well as performing self-exploration about one's own beliefs, identities, and biases. One way to teach cultural humility in medicine is simulation. However, there are no peer-reviewed published studies that examine whether the skin tone or gender of the high-fidelity simulation manikins (HFSM) used by emergency medicine (EM) residency programs reflects the US population nor whether high-fidelity simulation is used to teach cultural humility. We aimed to address that gap in the literature. Our primary objective was to evaluate what proportion of EM residency programs use HFS to teach cultural humility. Our secondary objective was to evaluate whether the skin tone and gender breakdown of the EM residency program HFSM is representative of the US population.

Methods: We conducted a simple random sample of 80 EM residency programs to characterize HFSM and cultural humility training. Selected programs were emailed a questionnaire. Key outcomes included HFSM skin tone and gender and whether cultural humility was taught via HFSM. We calculated point and interval estimates for the proportion of dark-, medium-, and light-toned skin and the proportion of female and male manikins. Confidence intervals were employed to test the null hypothesis that dark/medium/light skin tone was 20/20/60 and that the female/male ratio was 50/50. Both ratios were extrapolated from the US Census data.

Results: Our response rate was 74% (59/80). Fifty-five of 59 EM residency programs that had manikins (0.93, 95% confidence interval [CI] 0.88–0.99) reported data on a total of 348 manikins. Thirty-nine of the 55 programs with manikins reported using HFS to teach cultural humility (0.71, 95% CI 0.60–0.82). Proportions of light-, medium-, and dark-toned manikins were 0.52 (0.43–0.62), 0.38 (0.29–0.47), and 0.10 (0.07–0.14), respectively. Proportions of male and female HFSM were 0.69 (0.64–0.76) and 0.31 (0.24–0.36), respectively. The null hypotheses that skin tone follows a 60/20/20 split and gender follows a 50/50 split were rejected, as not all confidence intervals contained these hypothesized values.

Conclusion: While most EM residency programs surveyed use high-fidelity simulation to teach cultural humility, the manikins do not reflect either the skin tone or gender of the US population. [West J Emerg Med. 2023;24(4)668–674.]

INTRODUCTION

The current United States political climate and recent, racially charged events, coupled with evidence that minority groups often face higher rates of chronic diseases and worse medical outcomes, have highlighted the importance of diversity, equity, and inclusion (DEI) efforts within the medical field.[1] Cultural humility is defined as a lifelong process with a goal of fixing power imbalances and creating institutional accountability through learning about another's culture as well as performing self-exploration about one's own beliefs, identities, and biases. The Accreditation Council for Graduate Medical Education (ACGME) requires cultural humility training in medical residency curricula. Many emergency medicine (EM) residency programs, however, have no formal DEI curricula.[2,3] While lectures are the primary method of complying with ACGME teaching requirements, high-fidelity simulation (HFS) is used as well.

Although there is debate about the definition of HFS and high-fidelity simulation manikins (HFSM),[4] for this study we used the definition provided by the simulation resource website HealthySimulation.com, which states that "high fidelity simulation is a healthcare education methodology that involves the use of sophisticated life-like manikins (sometimes called mannequins) in realistic patient environments."[5] Studies have shown that HFS results in improved clinical performance and provides a safe space to practice high-risk clinical scenarios and procedures.[6,7] Despite this utility, there is a dearth of literature on whether HFSMs are used to teach cultural humility.

Faronda et al conducted an integrative review of simulation learning themes and found that while cultural sensitivity and competence, insight and understanding, communication, and confidence and comfort were mentioned, there were no studies that mentioned cultural humility.[8,9] In addition, there is limited published research on the skin color and gender of simulation manikins. This is of particular importance in establishing a realistic environment in which the manikins reflect the patient population encountered by the trainee. In one study, 94% of manikins and simulation body parts in an advertisement brochure were white while only 6% were black.[10] Another study reported that 68.75% of the simulation centers that responded to a survey distributed via listserves and Google Groups had manikins of color and 65.63% had body parts/task trainers of color.[11] Of note, none of these studies focused on the use of HFSM in EM residency programs.

Our search found only one study demonstrating the use of simulation to teach cultural humility in EM training. Ward-Gaines et al used mass simulation to teach EM residents key concepts in healthcare disparities such as race/ethnicity, gender bias, stereotyping, and privilege. These residents reported increased perceived confidence of these concepts after the simulation.[2] This study, however, was focused on standardized patients and did not include HFSM. Nor are there any peer-reviewed, published studies that explore the skin tone or gender diversity of HFSM at EM residency programs or whether these programs use HFSMs to teach cultural humility.

Our first objective in this study was to evaluate what proportion of EM residency programs with HFS use HFSMs to teach cultural humility. Our second objective was to evaluate whether the skin tone and gender breakdown of the HFSMs used by these programs reflects that of the US population and, therefore, the potential patient population. We hypothesized that there would be a small percentage of EM programs that use HFSMs for cultural humility training and that the gender and skin-tone breakdown of manikins would differ from that of the overall US population.

Population Health Research Capsule

What do we already know about this issue?
Cultural humility training is a required aspect of EM resident training. High-fidelity simulation manikins (HFSM) are a useful modality for resident education.

What was the research question?
Do the HFSM skin color and gender proportions reflect the US population? Do EM residency programs use HFSM to teach cultural humility?

What was the major finding of the study?
Light-, medium-, and dark-colored HFSM were 0.52 (95% CI: 0.43, 0.62), 0.38 (0.29, 0.47), and 0.10 (0.07, 0.14), respectively. Male and female HFSM were 0.69 (0.64, 0.76) and 0.31 (0.24, 0.36), respectively. The HFSM do not reflect the US population gender nor skin color.

How does this improve population health?
HFSM is a means to teach cultural humility in EM. Having HFSMs representative of the US population can potentially help trainees better care for diverse populations.

METHODS

Study Design and Setting

We administered a questionnaire to a subset of EM residency programs across the country determined by simple random sampling (see Appendix 2 for details on sampling methods) from April 2021–September 2021. The study was deemed exempt by the Atrium Health Carolinas Institutional Review Board and was designed to comply with quality standards for survey reporting in medical literature.[12]

Survey Design

As there were no questionnaires that addressed our study objectives, we collaborated with an expert survey methodologist on the creation of the survey, which we piloted to our intended audience with 25 responses. Several improvements were made through this process, including clarifying that survey questions were specific to HFSM. In addition, to reflect purchasing options, skin color was changed from ethnicity defined (eg, Black or African American) to skin tone defined (light, medium, and dark), and gender was simplified to male vs female. Response burden was decreased through skip patterns and breaks. The final questionnaire (see Appendix 1) consisted of 10 questions grouped into 1) EM residency program demographics, 2) HFSM skin tone and gender breakdown, and 3) utilization of simulation manikins to teach cultural humility. Participants generally completed the questionnaire within five minutes. The questionnaire did not include any identifying information requiring blinding.

Data Analysis

We conducted a simple random sample of 80 of the total (220) EM residency programs in the US. Our survey was distributed via email to program directors with two follow-up phone calls for non-respondents. Several programs used a simulation center that was not affiliated with the program institution. In those cases, we distributed our survey via the methods above to the respective simulation center directors. No two programs from the simple random sample, however, used the same simulation center.

The sample size was chosen to yield confidence intervals (CI) with acceptable a priori precision for estimation (see Appendix 2). Consent was obtained electronically. We estimated proportions of EM residency programs offering scenarios with cultural humility as a primary or secondary learning goal, using survey sampling methodology described in Thompson.[13]

As we were unable to identify accurate data on the variations in skin tones in the US population, we extrapolated skin tone from the 2020 US Census race and ethnicity data.[14] The proportion of "White alone (not Hispanic)" was classified as light skin, and the proportion of people who identified as "Asian alone," "American Indian," "Pacific Islander," "two or more races," "Hispanic or Latino," and "Black alone" was split into approximately evenly proportioned groups of medium- and dark-skin-toned manikins (20% each of the population).

As manikin skin tone (light, medium, dark) and gender (female, male) are multinomial data clustered by simulation center, the data is likely correlated.[15] To estimate the proportions of interest, we fit a generalized linear mixed model with an intercept as a fixed effect and simulation center random effects. We conducted likelihood ratio tests on the random effects variance component(s) of simulation center to test for significant center-to-center variability with respect to the multinomial data. We then marginalized and refit the model and inverted the link function to recover estimates of the proportions. We used stratified block bootstrapping to obtain a set of 98.30% bootstrap percentile CIs where, importantly, resampling was done by simulation center to preserve the correlation structure among the data.[16] We employed 98.3% CIs to preserve familywise alpha at 0.05. We tested hypotheses about representation (50/50 male/female and 60/20/20 light/medium/dark) by examining whether or not the null hypothesized values were contained by the bootstrap CIs.

RESULTS

Survey response rate was 74% (59/80). Demographics of the responding EM residency programs are reported in Table 1. Responding programs most frequently were in the Northeast (37%), followed by the South (27%), Midwest (19%), and West (17%) and were most frequently three-year programs (71%).

Of the 59 EM residency programs that responded to the survey, 55 reported using HFSM as a part of their residency curricula (0.93, 95% CI 0.88–0.99) (Table 2); and 39 of those 55 programs with manikins reported having HFS cases where cultural humility was a primary or secondary learning

Table 1. Descriptive summary of 59 survey respondents.

Demographic information of respondent program	Respondents (n = 59)
Region	
South	16 (27%)
Northeast	22 (37%)
Midwest	11 (19%)
West	10 (17%)
Type of Program	
3-year EM	42 (71%)
4-year EM	16 (27%)
Other	1 (2%)
3–5-year EM/IM	0 (0%)
3–5-year EM/Peds	0 (0%)

EM, emergency medicine; *IM*, internal medicine; *Peds*, pediatrics.

Table 2. Quantitative analysis of high-fidelity simulation manikins (HFSM) used by emergency medicine residency programs with regard to the skin tone and gender diversity of the HFSMs and their use in cultural humility training.

Phenotypic appearance of HFSM used by respondent programs	Total Manikins (n = 348)
Manikin gender	
Male	242 (70%)
Female	106 (30%)
Manikin skin tone	
Light	183 (53%)
Medium	130 (37%)
Dark	35 (10%)
Cultural humility as a learning objective for HFS cases (n = 55)	
Yes	39 (71%)
No	16 (29%)
Percent of HFS cases with cultural humility as a primary or secondary learning objective (mean ± standard error among 35 responders)	15.9 (SE: ± 2.2)

HFSM, high-fidelity simulation manikins.

objective (0.71, 95% CI 0.60–0.82). Of those 39 programs, 35 responded with the percentage (0–100) of total HFS cases using cultural humility as a primary or secondary learning objective, and the mean response was 15.9 (95% CI 11.4–20.4).

The 59 responding EM programs reported data on a total of 348 manikins. There were 5.9 manikins per EM residency program, with a range of 0–23. The generalized, linear mixed model rejected the null hypothesis of no center-to-center variability for skin tone ($P = <0.000$) and gender ($P = <0.0001$). Therefore, we proceeded with bootstrapping as described previously to estimate proportions and obtain appropriate CIs.

Proportions of manikins with light, medium, and dark skin tones were 0.52 (0.43–0.62), 0.38 (0.29–0.47), and 0.10 (0.07–0.14), respectively. Proportions of male and female HFSM were 0.69 (0.64–0.76) and 0.31 (0.24–0.36), respectively. The null hypotheses that skin tone follows a 60/20/20 split and gender follows a 50/50 split were rejected, as not all CIs contained these hypothesized values. Results are graphically summarized in Figure 1.

When respondents were asked why their programs did not have diversity in terms of HFSM skin tone (Table 3), 20% (11/55) reported the high cost of HFSM, 22% (12/55) reported not knowing that different skin colors were available, 16% (9/55) said that at the time of purchase only one skin tone was available, and 7% (4/55) stated they did not think that having different skin colors mattered. When asked for potential reasons for the lack of diversity in terms of HFSM gender (Table 3), 20% of respondents (11/55) reported the high cost of HFSM, 13% (7/55) stated they did not think that having different genders mattered, and 11% (6/55) reported that female manikins were not available at the time of purchase. In addition, 22% (12/55) of respondents reported that some manikin genitalia can be altered to represent different genders; so, purchasers did not think it was necessary to buy manikins that, genitalia aside, represented specific genders.

DISCUSSION

Although HFS is used in many aspects of graduate medical education, this is the first published study to our knowledge reporting the use of HFSM to teach cultural humility. Additionally, this is the first published study that reports on the skin color and gender diversity of HFSM used

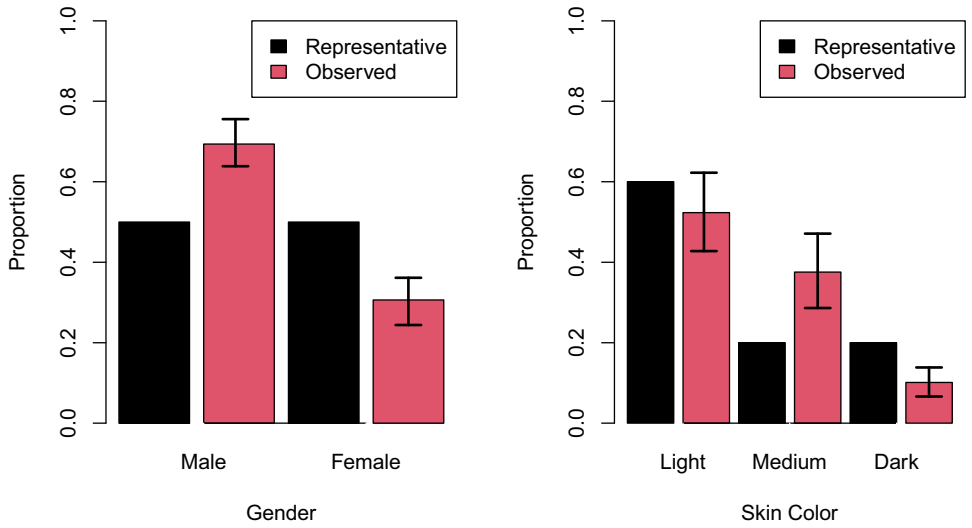

Figure 1. Representativeness of high-fidelity simulation manikin gender and skin tone. Error bars represent 95% confidence intervals.

Table 3. Qualitative analysis of themes regarding why high-fidelity simulation manikins do not match the US population in terms of skin tone and gender.

Survey question	Respondents (n = 55)
If you noticed that you have very few high-fidelity simulation manikins with one skin color, why do you believe that is the case?	
Costs too much	11 (20%)
Did not know there were different skin colors available	12 (22%)
Did not think that having different skin colors mattered	4 (7%)
Other skin colors not available at time of purchase	9 (16%)
Other[1]	14 (25%)
Missing[2]	5 (9%)
If you noticed that you have very few high-fidelity simulation manikins from one gender, why do you believe that is the case?	
Costs too much	11 (20%)
Did not know there were different genders available	2 (4%)
Did not think that having different genders mattered	7 (13%)
Gender is interchangeable	12 (22%)
Female manikins not available at time of purchase	6 (11%)
Other[1]	11 (20%)
Missing[2]	6 (11%)

[1]Free response that did not fit other themes.
[2]No response.

by EM residency programs. The findings of this study add value to the advancement of DEI initiatives in EM training.

We investigated the proportion of EM residency programs that use HFSMs to teach cultural humility as well as whether the HFSM used reflected the skin color and gender of the US population. We hypothesized that most EMRPs would not use HFSMs to teach CH and that the skin color and gender breakdown of the HFSMs would not be representative of the US population.

Our study found that while the majority of EM residency programs used HFSM to teach cultural humility, the skin tone and gender breakdown of the manikins used did not reflect the US population. More specifically, significantly, more manikins were found to be medium-colored (38%) in comparison to extrapolation of US Census data (20%). In addition, only 10% of the HFSM had dark skin tone compared to the 20% of the US population from the extrapolation of US Census data. Lastly, we found that there were significantly more male- than female-gendered HFSM. This also differs from the US Census data of an estimated 50% of the population who identify as male and female, respectively.[14]

There are numerous potential benefits to programs having diverse HFSM. First, one of the main benefits of HFS is the realistic nature of the manikins. A simulation-based learning environment should not overwhelm the learner with extraneous props and items that may create an effect of realism at the expense of cognitive burden.[4] From our own experiences, it is very hard to stay "in character" when a phenotypically male manikin has a pink dress on to signify that it is actually female. To simplify the learning environment while ensuring realism, it is more appropriate to use the actual gender and skin color of manikins rather than adding props such as a dress.[15]

Second, as the physician workforce becomes more diverse, so is the importance of inclusivity. Faronda et al found that diversity in simulation can lead to feelings of inclusivity in trainees and aids in the creation of a more inclusive learning environment.[11] In addition, using HFSMs to teach cultural humility can potentially act as a bridge to the exploration of topics related to disparities in care that are related, among other things, to religious backgrounds, spiritual beliefs, and the impact of one's culture on healthcare delivery. For example, having diverse HFSM may lead to a resident becoming aware of an ethnic or gender bias that they possess. Perhaps a resident may realize that they assumed that a light-skin mannequin has high health literacy.

Ultimately, we believe that teaching cultural humility with HFSMs that reflect the actual patient population served is an important supplement to classroom lectures and will help EM trainees learn how to interact with diverse patients and provide quality healthcare through a cultural lens to patients from different values, beliefs, and behaviors.

Common themes among our survey respondents to explain the skin tone and gender disparity between HFSM and the US population were that they did not believe that "having HFSM of different skin colors or genders mattered," "it costs too much to purchase HFSM" and that "at the time of purchase, diverse options were not available." At present, many companies such as Laerdal Medical, CAE Health, and Gaumard Scientific make male- and female-gendered HFSM with various skin-color options. These, however, have only recently been offered or are of limited availability.[11] For example, although simulation manikins have been available for many years, one major manufacturing company introduced a simulation mannequin available in medium and dark skin tones in 2018. In a similar vein, an African-descent upgrade kit was also made available for manikins in 2020 through this company. In terms of cost, the average price can range from $10,000–$100,000 depending on the model, type,

and functionality.[17] It is important to note, however, that for companies that offer diverse HFSM, the cost is generally the same regardless of skin color or gender.

Other programs talked about the common use of props, accessories, and vernacular to simulate the female gender and ethnicities with dark skin tones. For example, survey respondents also noted using interchangeable genitalia on a stereotypically masculine HFSM to portray a female patient. Throughout our training, we have personally seen the use of Afro wigs on manikins with light skin tones to portray a Black patient and the use of pink shirts or "stick on" female genitalia on a HFSM with a stereotypically masculine body to portray a female patient, the latter of which were commonly reported by our survey respondents. While these are a cost-effective way to "change" the gender or ethnicity of a HFSM, they may promote harmful stereotypes. In addition, these practices decrease the realism of the scenario, which undermines one of the main benefits of HFS: the ability to practice in a realistic environment.

While we acknowledge the barriers, particularly cost and availability, to obtaining diverse HFSM, we still advocate for the investment in diverse HFSM. We encourage regional and national EM and simulation societies to create grants to provide individual institutions with the funds to increase the diversity of their simulation products. In addition, programs should budget and set aside funds with a goal to increase diversity within simulation. When funds are not available, we recommend programs consider the purchase of interchangeable "headskins," such as those by Laerdal Medical, which can serve as realistic masks to change the age or skin tone of the HFSM.[18] While not ideal, these are a reasonably affordable option for programs interested in acquiring more diverse simulation models at a lower cost. When even these options are not available, programs should consider sharing resources with other institutions with diverse simulation products.

We also advocate for manufacturers to increase the diversity of their product offerings by creating HFSM that truly reflect various genders and ethnicities (in addition to differing body sizes/shapes and ages) rather than just "merely changing the pigment of the skin" as one respondent noted. It is not enough, however, to increase product offerings. It is important that advertising be conducted through a lens of equity as well.

In addition to ensuring diversity of simulation products, it is important to use HFSM to teach cultural humility. We were unable to find any open-access HFSM scenarios with cultural humility as a learning goal. Therefore, in addition to increasing diversity of products, we also advocate for the creation of an open-access database of HFSM scenarios focused on cultural humility that can be used by EM residency programs. One survey respondent suggested the use of "scenarios that are conducted using our translator line, if needed, and discuss language and social/cultural norms in the debrief."

LIMITATIONS

There are several limitations of our study. First, the photographs used in our survey as examples of light-, medium-, and dark skin tone manikins were only from one company (Figure 2), although in our review they were consistent with product offerings from other companies. An additional limitation was our necessary extrapolation of the US Census data on ethnicity to skin color. This inherently can lead to bias but, unfortunately, was the only method to statistically categorize data. In addition, there were 21 EM residency programs that did not respond to our survey. There are many possible explanations for not responding. These EM programs may not have had HFSM (which could impose a bias on the estimate of the proportion of all EM programs that have HFSM), they may have unfortunately suffered from "diversity fatigue,"[19] or may have just not had time to complete the survey. In addition, several respondents noted having manikins with interchangeable genitalia. To limit confusion, however, we clarified that survey responses should be based on the overall appearance of the manikin. Lastly, we also want to acknowledge that gender was reduced to a binary only to reflect the limited purchasing options for HFSMs.

CONCLUSION

Our study found that while most EM residency programs used high-fidelity simulation manikins to teach cultural humility, the manikins used did not reflect either the skin color or gender proportions of the US population. Further studies will explore the various uses of HFS to teach cultural

Figure 2. Laerdal SimMan 3G in light, medium, and dark skin tones.

humility and comprehensively evaluate the effectiveness of cultural humility training in EM residency programs.

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Social Determinants of Health Screening at an Urban Emergency Department Urgent Care During COVID-19

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Introduction: Social determinants of health (SDoH) impact patients' health outcomes, yet screening methods in emergency departments (ED) are not consistent or standardized. The SDoH-related health disparities may have widened during the coronavirus 2019 (COVID-19) pandemic, especially among patients who primarily receive their medical care in EDs. We sought to identify SDoH among ED urgent care patients during the COVID-19 pandemic at an urban safety-net hospital, assess the impact of the pandemic on their SDoH, study the feasibility of SDoH screening and resource referrals, and identify preferred methods of resource referrals and barriers to accessing resources.

Methods: Research assistants screened ED urgent care patients using a validated SDoH screener, inquiring about the impact of COVID-19 on their SDoH. A printed resource guide was provided. Two weeks later, a follow-up telephone survey assessed for barriers to resource connection and patients' preferred methods for resource referrals. This study was deemed exempt by our institutional review board.

Results: Of the 418 patients presented with a screener, 414 (99.0%) patients completed the screening. Of those screened, 296 (71.5%) reported at least one adverse SDoH, most commonly education (38.7%), food insecurity (35.3%), and employment (31.0%). Housing insecurity was reported by 21.0%. Over half of patients (57.0%) endorsed COVID-19 affecting their SDoH. During follow-up, 156 of 234 (67%) attempted calls were successful and 36/156 (23.1%) reported attempting to connect with a resource, with most attempts made for stable housing (11.0%) and food (7.7%). Reasons for not contacting the provided resources included lack of time (37.8%) and forgetting to do so (26.3%). Patients preferred resource guides to be printed (34.0%) and sent via text message to their mobile devices (25.6%).

Conclusion: Many urgent care patients of this urban ED reported at least one adverse SDoH, the majority of which were exacerbated by the COVID-19 pandemic. This finding further emphasizes the need to allocate more resources to standardize and expand SDoH screening in EDs. Additionally, hospitals should increase availability of printed or electronic SDoH resource guides, resource navigators, and interpreters both during and after ED visits. [West J Emerg Med. 2023;24(4)675–679.]

INTRODUCTION

Background

Social determinants of health (SDoH) impact patients' health outcomes,[1,2] yet attempts to capture this information in the emergency department (ED) have not been consistent or standardized.[3–5] Prior research confirms that the ED serves a particularly vulnerable population with high rates of social needs.[6] By law, emergency physicians are mandated to care for every patient who seeks care from the ED, whether for medical or social needs, further necessitating better understanding of patients' SDoH.[7,8] However, most EDs currently screen for SDoH at a much lower rate than for other social risks including violence, substance use, or mental health.[4] In 2017, an electronic health record (EHR)-based SDoH screening and referral program was developed at our urban, safety-net hospital for the adult ambulatory care clinics.[9] This program validated a screener assessing eight SDoH domains: housing; food; transportation; utilities; employment; medication; dependent care; and education. A partial SDoH screening implemented in 2019 in the adult ED at our institution was limited to patients covered by Medicaid and those who were uninsured. With these criteria only a small fraction of total ED patients was screened for SDOH, thereby missing many safety-net hospital patients facing tenuous social circumstances.

Population Health Research Capsule

What do we already know about this issue?
Social determinants of health (SDoH) impact patients' health outcomes, especially with the widened disparities during the COVID-19 pandemic.

What was the research question?
We identified SDoH among a cohort of patients in a safety-net urgent care and the feasibility of SDoH screening and referrals.

What was the major finding of the study?
Screening feasibility was 99%, and 71.5% reported at least one SDoH, most commonly education (38.7%) and food (35.3%).

How does this improve population health?
More resources need to be allocated to standardize and expand SDoH screening in the ED and to further optimize the social resource provision process.

Importance

Although the ED cares for many patients with significant social needs negatively affecting their health outcomes, little is known about the prevalence of unmet social needs of this patient population. Additionally, the coronavirus disease 2019 (COVID-19) pandemic has penetrated every aspect of daily life and may disproportionately affect the SDoH of the patients cared for at safety-net hospitals.[10]

Goals of this Investigation

In this study we aimed to understand the burden of SDoH among ED urgent care patients during the pandemic and evaluate the feasibility of implementing a SDoH screening and a standard referral guide provision in the ED urgent care setting.

METHODS

Study Design and Setting

This observational study assessed the number of patients who screened positive for adverse SDoH. For patients who endorsed at least one adverse SDoH, the study assessed the impact of COVID-19 on SDoH. We evaluated the feasibility of screening for SDO0H in ED urgent care by determining the proportion of patients who agreed to participate and completed the screening process. The demographics of the participating urgent care patients were compared to those of the general adult ED patients. This study was deemed exempt by the our institutional review board.

Selection of Participants

A convenience sample was taken by trained research assistants (RA) who approached all patients ≥18 years old in the ED urgent care for 3–4 hours between the peak hours of 8 AM–4 PM on weekdays. Participants were excluded if they were experiencing altered mental status, had been screened within the last six months, or if screening would interfere with necessary medical care. Patients with limited English proficiency were screened using a professional telephone interpreter.

Screening, Referral, and Assessments

Patients who agreed to participate were screened for eight SDoH domains: housing; food; transportation; utilities; employment; medication; dependent care; and education. For clarification of terminology, a positive screening for a SDoH domain (ie, "yes" for housing insecurity) in this study is referred to as an adverse SDoH.[11] Patients who reported at least one adverse SDoH were provided with a printed referral guide comprised of a list of community resources frequently used by the ED social work team. We then assessed patients' perceived impact of COVID-19 on their SDoH. All screening data were recorded both in REDCap electronic data capture tools hosted at Boston University Medical Center and in the electronic health record. Two to three weeks after the

screening, RAs completed follow-up surveys by telephone to identify patients' preferred methods of resource referral and any barriers to resource connection and utilization. A maximum of five attempts for contact (phone call or text) were made before a patient was deemed lost to follow-up.

Outcomes

The primary outcome featured the prevalence and distribution of eight SDoH of ED urgent care patients during the COVID-19 pandemic. The secondary outcomes included feasibility of SDoH screening and referral in ED urgent care, assessment of patient-perceived impact of the COVID-19 pandemic on SDoH, and the preferred methods of resource referral.

Analysis

Descriptive statistics were obtained using SAS v 9.4 (SAS Institute Inc, Cary, NC) software for patient age, gender, race, ethnicity, preferred language, and ZIP code. We then analyzed prevalence of each SDoH was by demographic using chi-square and Fisher exact tests, and we analyzed the impact of COVID-19 on reporting one adverse SDoH using logistic regression.

RESULTS

Characteristics of Study Subjects

Of the total estimated 2018 ED urgent care patients during the times of screening over the course of 13 weeks, 418 patients (20.7%) were presented with a screener via the convenience sample method. Of those presented with a screener, 414 (99.0%) patients completed the screening. The participants were predominantly male (229, 55.3%), averaging 43 years old. The participants self-identified as Black non-Hispanic (58.7%), Hispanic (19.8%), White (16.2%), and other (Table 1). Preferred languages of the participants included English (89.1%), Spanish (6.0%), Haitian Creole (2.2%), and other. The population captured in this study, when compared to that of the general patient population seen in the adult ED of this hospital, was found to have differences including more Black non-Hispanic (this study 58.7% vs adult ED 41.0%), less Hispanic (19.8% vs 26.4%), as well as more English-speaking (89.1 vs 71%), among others.

Table 1. Demographics of the emergency department urgent care patients who participated in social determinants of health screening.

Demographic Information	Adverse SDoH, n (%)	No Adverse SDoH, n (%)
Age	n = 296	n = 118
18–35	106 (35.81)	39 (33.05)
36–50	97 (32.77)	36 (30.51)
51–65	80 (27.03)	37 (31.36)
66–75	12 (4.05)	5 (4.24)
75–80	1 (0.34)	1 (0.85)
Gender		
Male	167 (56.4)	62 (52.4)
Female	129 (43.6)	56 (47.5)
Race and ethnicity		
Black Non-Hispanic	174 (58.78)	69 (58.47)
Hispanic/Latino	56 (18.92)	26 (22.03)
White Non-Hispanic	51 (17.23)	16 (13.56)
Unknown	8 (2.7)	2 (1.69)
Asian	4 (1.35)	4 (3.39)
Other	3 (1.01)	1 (0.85)
Preferred Language		
English	268 (90.54)	101 (85.59)
Spanish	16 (5.41)	9 (7.63)
Haitian Creole	7 (2.36)	2 (1.69)
Portuguese	2 (0.68)	0 (0)
Other	2 (0.68)	3 (2.54)
Cape Verdean Creole	1 (0.34)	3 (2.54)

SDoH, social determinants of health.

Main Results

Of those screened, the majority (71.5%) reported at least one adverse SDoH. The most commonly reported SDoH was interest in further education (38.7%), followed by food insecurity (35.3%), and unemployment (31.0%). Housing insecurity was reported by 21.0%. Of those who reported at least one adverse SDoH, 83.5% requested help and further resources during the visit.

As for the COVID-19-related results, a total of 236 (57.0%) patients reported that their SDoH were negatively impacted by the pandemic. Within each category of SDoH, caregiving for the elderly and children was most likely to have been negatively impacted by the pandemic (86%), followed by employment (84%) and paying for medication (84%) (Table 2).

As for the feasibility of the SDoH screening, the reported time taken from recruiting a patient to completing the screening ranged from 5–10 minutes. Almost all patients (414/418, 99%) completed the screening when approached by trained RAs. Of the 234 attempted follow-up calls, 156 (67%) patients were successfully reached during follow-up phone calls. Of those, 36 (23.1%) reported attempting to connect with a resource, with most attempts made for housing (11.0%) and food (7.7%). Reasons for not contacting the provided resources included lack of time (37.8%) and forgetting to do so (26.3%). Patients preferred resource guides to be printed (34.0%), sent via text message to their mobile devices (25.6%), and explained in person by a resource navigator (23.1%).

Table 2. Effect of COVID-19 pandemic on each social determinant of health domain.

Social Determinant of Health Domain (SDoH)	Adverse SDoH, n (%)	No Adverse SDoH, n (%)	*P*-value
Education	n = 160	n = 254	
COVID-19 Impacted	111 (69.38)	125 (49.21)	<.0001
COVID-19 not impacted	49 (30.63)	129 (50.79)	
Food	n = 146	n = 268	
COVID-19 impacted	117 (80.14)	119 (44.40)	<.0001
COVID-19 not impacted	29 (19.86)	149 (55.60)	
Employment	n = 128	n = 286	
COVID-19 impacted	107 (83.59)	129 (45.10)	<.0001
COVID-19 not impacted	21 (16.41)	157 (54.90)	
Utilities	n = 96	n = 318	
COVID-19 impacted	77 (80.21)	159 (50.00)	<.0001
COVID-19 not impacted	19 (19.79)	159 (50.00)	
Living Situation	n = 85	n = 329	
COVID-19 impacted	69 (81.18)	167 (50.76)	<.0001
COVID-19 not impacted	16 (18.82)	162 (49.24)	
Transportation	n = 83	n = 331	
COVID-19 impacted	65 (78.31)	171 (51.66)	<.0001
COVID-19 not impacted	18 (21.69)	160 (48.34)	
Medicines	n = 74	n = 340	
COVID-19 impacted	62 (83.78)	174 (51.18)	<.0001
COVID-19 not impacted	12 (16.22)	166 (48.82)	
Caregiving	n = 37	n = 377	
COVID-19 impacted	32 (86.49)	204 (54.11)	<.0001
COVID-19 not Impacted	5 (13.51)	173 (45.89)	

COVID-19, coronavirus 2019.

DISCUSSION

This study supports the hypothesis that many patients of this urban, safety-net hospital's ED urgent care have notable adverse SDoH, thereby signifying a much-needed continued effort in implementing universal SDoH screening in ED urgent care settings. More than half of all screened ED urgent care patients endorsed COVID-19's impact on their SDoH, shedding light on the tangible toll the pandemic has taken on this patient population. When a dedicated, trained staff member approaches patients, the SDoH screening process was shown to be feasible. However, the follow-up survey reveals a clear discrepancy between referral guide provision and patients' likelihood to connect with a resource.

To address this gap, departments should increase availability of printed or electronic SDoH resource guides and consider engaging resource navigators with interpreter services both during and after ED visits. Next steps in this endeavor include optimizing the time point of screening (triage, waiting room, patient room), more training of RAs to minimize bias and improve rapport, and deciding who should perform the screening for practicality and efficiency in the ED. Another next step is to consider digital screening tools (tablet, computer kiosk), as prior studies have shown feasibility and acceptability of digital screening for social risk.[12,13]

LIMITATIONS

Limitations of this study include the lack of randomization and potential bias in the selection of convenience samples in ED urgent care between the hours of 8 AM–4 PM. Given that patients who frequently visit the general adult ED of this safety-net hospital during evening hours anecdotally have higher rates of housing and food insecurity, and different illness acuity, the fact that they were not included in the urgent care study means we may have underestimated the prevalence of certain SDoH; it may also explain the difference in race, ethnicity and preferred languages seen in this cohort when compared to the general adult ED population. This limits the applicability of our findings to the general population.

CONCLUSION

Many ED urgent care patients in this study reported at least one adverse social determinant of health, the majority of which were exacerbated by the COVID-19 pandemic. Hospitals should factor in the findings of this study as they prepare for the negative social impacts from the COVID-19 pandemic, highlighting the need to allocate more resources to standardize and expand SDoH screening in EDs and to increase availability of printed or electronic SDoH resource guides, resource navigators, and interpreters both during and after ED visits.

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A National Snapshot of Social Determinants of Health Documentation in Emergency Departments

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Introduction: Documentation and measurement of social determinants of health (SDoH) are critical to clinical care and to healthcare delivery system reforms targeting health equity. The SDoH are codified in the *International Classification of Disease 10th Rev* (ICD-10) Z codes. However, Z codes are listed in only 1-2% of inpatient charts. Little is known about the frequency of Z code utilization specifically among emergency department (ED) patient populations nationally.

Methods: This was a repeated cross-sectional analysis of ED visit data in the United States from the Nationwide Emergency Department Sample from 2016–2019. We characterized the use of Z codes and described associations between Z code use and patient- and hospital-level factors including the following: age; gender; race; insurance status; ED disposition; ED size; hospital urban-rural status; ownership; and clinical conditions. We calculated unadjusted odds ratios for likelihood of Z code reporting for each ED visit.

Results: Of approximately 140 million ED visits per year, 0.65% had an associated Z code in 2016, rising to 1.17% by 2019. Visits were more likely to have an associated Z code for adults age <65, male, Black, Medicaid or self-pay patients, and patients admitted to the hospital. Larger EDs, those in metropolitan areas, academic centers, and government-run hospitals were more likely to report Z codes. The most commonly associated clinical conditions were as follows: schizophrenia spectrum and other psychotic disorders; depressive disorder; and alcohol-related disorders.

Conclusion: There is a paucity of Z code documentation in the health records of ED patients, although use is uptrending. Further research is warranted to better understand the drivers of clinicians' use of Z codes and to improve on their utility. [West J Emerg Med. 2023;24(4)680–684.]

INTRODUCTION

Documentation and measurement of social determinants of health (SDoH) are critical to high-quality clinical care, population health research, and to healthcare delivery system reforms targeting health equity. In 2014, the Institute of Medicine recommended that social and behavioral domains be incorporated into patients' electronic health records. In 2015, these domains were codified in the *International Classification of Disease, Tenth Rev* (ICD-10) Z codes, designating "health hazards related to socioeconomic and psychosocial circumstance" inclusive of inadequate housing, unemployment, education and literacy, social environment, and financial instability. The ICD-10, which is used by all member nations of the World Health Organization, is translated into 43 languages

and serves as the basis for reporting health status, mortality, and medical reimbursements.[1] The ubiquitous use of ICD-10 codes makes the Z codes a logical mechanism for documentation and data collection on SDoH.[2]

Documentation of Z codes has increased since their introduction in October 2015.[3] However, despite this increase, prior studies have shown that Z codes are listed in only 1–2% of inpatient charts—identifying a much smaller population than in corresponding population-level statistics for homelessness, unemployment, and low educational attainment.[3]

A high prevalence of social vulnerability among emergency department (ED) patients[4] demands accurate documentation of SDoH. The existing literature has focused primarily on inpatient samples, single healthcare systems, or states. The frequency of Z code use specifically among ED patient populations in a national sample has not been examined. In this work, we describe the frequency of ICD-10 Z code documentation in ED charts using the Nationwide Emergency Department Sample (NEDS).[5] We examine patient- and hospital-level characteristics associated with documentation of Z codes in EDs in the United States from 2016–2019.

Population Health Research Capsule

What do we already know about this issue?
Z codes for social determinants of health (SDoH) are documented in only 1–2% of charts—identifying a much smaller population than in corresponding population-level statistics.

What was the research question?
How frequently are Z codes documented in ED visits? What characteristics are associated with their use?

What was the major finding of the study?
While documentation of Z codes for ED visits is infrequent, it has increased from 0.65% of ED visits in 2016 to 1.17% by 2019.

How does this improve population health?
The high prevalence of social vulnerability among ED patients demands accurate documentation of SDoH to address drivers of health inequity.

METHODS

This was a repeated cross-sectional analysis of ED visit data in the US from NEDS from 2016–2019.[5] The NEDS, which is the largest all-payers claims dataset representing 900+ EDs across the US, employs complex survey weights designed to provide reliable estimates for nationwide ED visit trends. We characterized Z code use and described associations between the use of Z codes and patient- and hospital-level factors. Variables included were age, gender, race, insurance status, ED disposition, ED size, hospital urban-rural status, ownership, and US Census Region. We calculated unadjusted odds ratios for likelihood of Z code reporting for each ED visit. Additionally, we examined the most common clinical conditions, according to Clinical Classifications Software Refined (CCSR) codes, associated with patient encounters that had at least one Z code documented. The CCSR aggregates ICD-10 diagnosis codes into 530 categories for clinical conditions. Survey weights were implemented for nationally representative estimates,

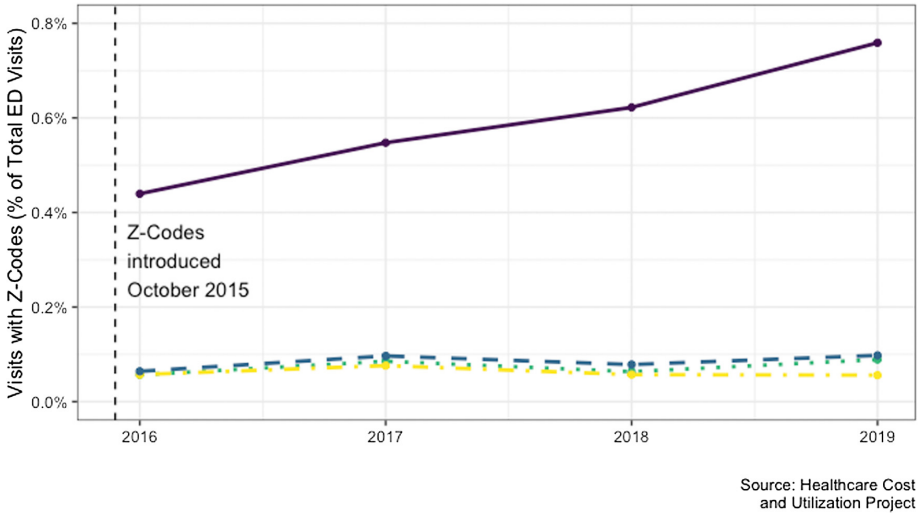

Figure 1. Documentation of social determinants of health among emergency department visits nationwide.

and standard errors were adjusted for complex sampling design. All analyses were performed in R 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Of the approximately 140 million ED visits in each year, 0.65% had an associated Z code in 2016, rising to 1.17% by 2019. The most reported category was "problems with housing and economic circumstances," and use of this code grew precipitously from 2016 to 2019 (from 0.44% to 0.78%) (Figure 1).

Visits were more likely to have an associated Z code for adults aged 41–64 compared to aged 19–25, male compared to female patients, those who identified their race as Black or Native American compared to those who identified White, those with Medicaid or self-pay compared to private insurance, and those who were admitted to the hospital (Table 1). Examination of hospital-level characteristics showed the Z codes were more likely to be used at larger EDs with more than 80,000 annual visits compared to smaller EDs with fewer than 20,000 visits, and academic compared to non-teaching hospitals. Z codes were less likely to be used at hospitals in micropolitan and small metropolitan areas compared to large metropolitan areas, and not-for-profit and investor-owned hospitals compared to government-run hospitals (Table 1). The most commonly associated clinical conditions were as follows: schizophrenia spectrum and other psychotic disorders (3,747; 7.4%); depressive disorder (3,521; 6.9%); and alcohol-related disorders (,479, 6.9%) (Table 2).

DISCUSSION

Our findings demonstrate the paucity of Z code documentation[3] specifically among ED patients, although the use of Z codes is generally uptrending. Nearly all the growth in Z code use is attributable to "issues related to housing and economic circumstances." Z codes are more likely to be used in EDs at larger, urban, teaching hospitals and among adults age <65, male, Black, Medicaid recipient, or uninsured. Previous studies on inpatient samples have similarly found that hospitals that use Z codes are more likely to be larger, private, not-for profit, urban, teaching hospitals and that patients are more likely to be male, Medicaid recipients, or uninsured.[6,7] The clinical conditions most associated with Z code use in EDs were psychiatric- and substance use-related codes. This is similar to previous work on inpatient samples that showed admissions for mental health and substance use disorders are more likely to include Z codes.[3,6,7] Despite the uniquely high prevalence of social vulnerability among ED patients, the documentation of Z codes in the ED appears to follow a pattern similar to inpatient Z code documentation.

Table 1. Factors associated with use of Z codes.

	Unadjusted ORs
Visit-level characteristics	
Primary payer (insurance status)	
Private insurance	(ref)
Medicaid	4.23 [3.79–4.72]
Medicare	2.53 [2.28–2.81]
Self-pay	3.83 [3.38–4.34]
Other	3.86 [2.49–5.99]
Gender	
Female	(ref)
Male	2.21 [2.09–2.33]
Race	
White	(ref)
Black	1.26 [1.11–1.44]
Hispanic	0.72 [0.63–0.82]
Native American	1.53 [1.11–2.10]
Asian/Pacific Islander	0.60 [0.50–0.72]
Other	0.98 [0.78–1.23]
Age	
0–18	0.39 [0.34–0.45]
19–25	(ref)
26–32	1.55 [1.47–1.64]
33–40	1.91 [1.79–2.03]
41–64	2.20 [2.05–2.37]
65-	0.69 [0.62–0.76]
Admission	3.89 [3.48–4.35]
Hospital-level characteristics	
Region	
Northeast	1.17 [0.87–1.59]
Midwest	(ref)
South	1.03 [0.75–1.41]
West	2.29 [1.72–3.04]
Urban/Rural Designation	
Large metropolitan	(ref)
Small metropolitan	0.79 [0.64–0.98]
Micropolitan	0.33 [0.26–0.42]
Hospital control	
Government*	–
Private, not-for-profit	0.56 [0.41–0.78]
Private, investor-owned	0.57 [0.38–0.85]
Teaching status	
Metropolitan teaching	1.69 [1.39–2.06]
Metropolitan non-teaching	(ref)

(*Continued on next page*)

Table 1. Continued.

	Unadjusted ORs
Total ED visits	
<20,000	(ref)
20–40,000	1.44 [0.92–2.24]
40–60,000	1.72 [1.09–2.72]
60–80,000	1.75 [1.10–2.77]
80,000+	2.06 [1.30–3.24]

Binary logistic regression models were estimated using the Nationwide Emergency Department Sample 2019 data with adjustment for weighting and complex sample design and with standard errors clustered by hospital.
ORs, odds ratios; *ref*, reference category; *ED*, emergency department.

Table 2. Most commonly associated primary Clinical Classifications Software Refined codes among patients with any code for social determinants of health.

	Count	Percent	Cumulative
Schizophrenia spectrum and other psychotic disorders	3,747	7.4%	7.4%
Depressive disorders	3,521	6.9%	14.3%
Alcohol-use related disorders	3,479	6.9%	21.2%
Suicidal ideation/attempt/ intentional self-harm	1,944	3.8%	25.0%
Bipolar and related disorders	1,538	3.0%	28.0%
Musculoskeletal pain, not low back pain	1,477	2.9%	30.9%
Skin and subcutaneous tissue infections	1,462	2.9%	33.8%
Septicemia	1,318	2.6%	36.4%
Nonspecific chest pain	1,212	2.4%	38.8%
Diabetes mellitus with complication	1,048	2.1%	40.9%
Trauma- and stressor-related disorders	975	1.9%	42.8%
Stimulant-use related disorders	972	1.9%	44.7%

Prior studies have proposed that low rates of Z code use are related to clinician uncertainty on Z code relevance to a given medical encounter, ambiguity in Z codes themselves, and a lack of systematized connections to clinical screening instruments and activities.[8] Connecting SDoH to billing structures and payment models may address some of these barriers to documentation and more substantively address the needs of patients with high social acuity.[8] Future implementation must also be sensitive to the risk of incorporating stigmatizing language or codifying stereotypes within the medical record.[9]

LIMITATIONS

This repeated cross-sectional analysis of NEDS has multiple limitations. First, the absence of a documented Z code for a patient encounter does not necessarily mean there was no documentation of SDoH elsewhere in the patient's health record. However, such granular data was unavailable. Furthermore, in this analysis we were unable to characterize how strongly the medical decision-making for the clinical encounter was related to the SDoH documented in the Z codes. Finally, as there were no clinical or patient-oriented outcomes, we were unable to comment of the associations among documenting SDoH, clinical care, and outcomes.

CONCLUSION

The ED should play a critical role in monitoring and responding to evolving health disparities by serving as a bellwether for shifts in local socioeconomic landscapes, analogous to syndromic surveillance systems where ED documentation is used to track shifting infectious disease burden.[10] In this study we found that documentation of Z codes for ED visits is infrequent but has increased from 0.65% of ED visits in 2016 to 1.17% by 2019. Further research is warranted to better understand the drivers of clinicians' use of Z codes and to improve on their utility. Emergency departments are uniquely positioned within the house of medicine and the social safety net to identify and address social determinants of health. Only by improved measurement can we begin to craft policy solutions to address these important drivers of health inequity.

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A Real-World Experience: Retrospective Review of Point-of-Care Ultrasound Utilization and Quality in Community Emergency Departments

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Introduction: Point-of-care ultrasound (POCUS) is commonly used in the emergency department (ED) as a rapid diagnostic tool. Emergency medicine (EM) has been an early adopter of POCUS with indications expanding over the last 10 years. While the literature describes widespread use among academic sites, there is little data on clinical POCUS utilization at non-academic EDs. We sought to describe community emergency physician (EP) use of POCUS by quantifying the number and type of studies performed, characteristics of the performing physician, and quality metrics.

Methods: Prior to the study period, all EPs underwent a standardized training and credentialing program. A retrospective review of all POCUS studies across 11 non-academic EDs from October 1, 2018–September 30, 2020 was performed by fellowship-trained physicians, who identified physician, exam type, and residency graduation year. The studies were then cross-referenced with quality review reports that assessed image acquisition, image interpretation, and image labeling. We performed descriptive statistics.

Results: During the study period, 5,099 POCUS studies were performed by 170 EPs. Exams most frequently performed were cardiac (24%), focused assessment of sonography in trauma (21.7%), and pregnancy (16.2%). Recent EM residency graduates (<10 years) were higher utilizers of POCUS with a group mean of 1.3 exams per 100 patients. Of the studies done, 86% had no quality issues.

Conclusion: Community POCUS demonstrates a heavy focus on core exams performed by recent EM residency graduates with minimal quality issues after a standardized training program. This study is the first to quantify actual community POCUS use in multiple EDs and may impact credentialing and skills maintenance requirements. [West J Emerg Med. 2023;24(4)685–692.]

INTRODUCTION

Point-of-care ultrasound (POCUS) use in bedside patient care is growing exponentially among multiple medical specialties and is a common modality used by emergency physicians (EP).[1–4] In emergency medicine (EM), POCUS has been considered a valuable tool at the bedside since well before 2009, when the American College of Emergency Physicians (ACEP) adopted guidelines recommending formal residency training in POCUS.[1,5,6] Trainees in EM are thus graduating with extensive experience in POCUS,

and the frequency of use in clinical practice has grown.

While the literature describes the widespread use of POCUS among academic emergency departments (ED) and an expanding repertoire of novel indications, there is little data on clinical use among community EPs in locations without residency- or fellowship-training programs. In a 2011 study in which EM program directors were surveyed, researchers found that greater than half of graduating residents (57.1%) pursued careers directly in the community after graduation.[7] Another study in 2019 confirmed this finding, reporting that 63% of residency graduates from a 10-year cohort accepted non-academic, community EM positions.[8] Academic physicians are eager to expand POCUS. As it becomes more frequently used, it is essential to examine the use of this modality in community EM settings. In addition, it is important to determine current use of POCUS, the factors that affect its use, and potential quality issues since most EPs work in non-academic settings. This may help guide the implementation of training and quality programs for community POCUS and identify future training needs, credentialing, skills maintenance, infrastructure, and resources as POCUS expands across multiple specialties and among practitioners of various training levels.

For a variety of reasons POCUS has been enthusiastically adopted in academic settings, including the embracing of a novel technique, the presence of trainees, ED crowding, limited availability of radiology-based ultrasound or other imaging, and the ability to make a rapid bedside diagnosis. It is unclear whether a community setting with its associated demands on the clinicians, as well as potentially more resources, would engender widespread adoption of POCUS.

In our healthcare system, multiple community EDs have POCUS readily available to EPs. To standardize the POCUS program across multiple sites in the community and establish a reliable quality assurance (QA) program, a systemwide POCUS credentialing program was developed to assess the privileges of EPs between January 1, 2017–July 1, 2018. During this period, all academic, urban, suburban, and freestanding EDs were standardized in information technology workflow, machine purchasing, privileges, credentialing, coding/billing, and QA review.[9] This allowed our physicians to move from ED to ED without any significant workflow or privileging changes and ensured the same level of quality across multiple departments (high reliability). A formal QA program was established at the end of this period.

In this study our objective was to review actual POCUS use among community EPs in a large healthcare system after implementing a standardized credentialing program. We assessed the types of studies performed, demographic data of physicians, number of years since residency graduation, number of studies performed per 100 patients, and quality metrics of POCUS studies. In addition, we aimed to determine the frequency of studies, the most-used exams, the effect of residency graduation year on use, and whether quality issues exist in the community, non-academic setting.

Population Health Research Capsule

What do we already know about this issue?
Point-of-care ultrasound (POCUS) is commonly used in academic EDs as a diagnostic tool.

What was the research question?
What is the scope of POCUS use by community emergency physicians, by the quantified number and exam types, physician characteristics, and quality metrics?

What was the major finding of the study?
Most common exams performed were cardiac, FAST, and pregnancy. Recent residency completion was associated with higher POCUS use; 86% of studies had no quality issues.

How does this improve population health?
This study may help guide implementation of training and quality programs for community POCUS and identify future training needs, credentialing, and infrastructure.

METHODS

Study Design

This retrospective, multicenter study involved 11 EDs across a large, integrated healthcare system in which all hospitals are located within one state. This study was implemented as part of a POCUS quality improvement project for the healthcare system and was institutional review board approved as exempt.

Description of Credentialing Program Prior to Intervention Period

To obtain high quality data on community usage and quality measures, we performed the study after a standardized POCUS program was implemented across EDs in the system, as described in a previous paper.[9] Briefly, this POCUS credentialing initiative was implemented from January 1, 201–July 1, 2018 across five urban community EDs, three suburban community EDs, and three freestanding EDs with a combined total of >500,000 patient encounters per year. Prior to the beginning of this program,

all hospitals had different guidelines for POCUS privileges. To standardize POCUS privileges across the hospitals, a centralized credentialing process was created in which privileges were made identical across all hospitals. Uniform POCUS privileging was instituted based on current ACEP guidelines[6] (Table 1). Each hospital's medical executive committee approved privileges, thereby creating standardization across the healthcare system. Additionally, discrete electronic health record (EHR) orders, image archival workflow, templated documentation for study interpretation, and requirements for billing were identical across the hospitals. All hospitals were standardized to the same ultrasound machine, the Mindray TE-7 (Mindray North America, Mahwah, NJ) and the same EHR (Epic Systems Corporation, Verona, WI).

With regard to physician training, due to the large number of physicians a tier-based ultrasound credentialing system was employed such that physicians had to demonstrate competency in all exams within the tier to become credentialed for those studies. This was done to simplify the tracking of >150 EPs at 11 hospitals. To determine initial privilege groups, physicians were classified into two groups based on the date of residency graduation to determine a residency-based pathway group and a practice-based pathway group. Per previous publication, as recommended by the residency-based pathway of the ACEP policy statement, if a physician graduated during or after 2008, the physician was granted intermediate POCUS privileges.[9] Physicians who graduated prior to 2008 were asked to provide a letter from their residency director, their residency program ultrasound director, or a supervisor at a previous job documenting previous POCUS training that met ACEP requirements.

The remainder of the physicians who did not meet the above criteria were required to attend an internal departmental POCUS course and undergo a practice-based pathway to obtain basic and/or intermediate credentialing. This practice-based POCUS credentialing pathway was supervised by the director of emergency ultrasound. This was a highly monitored program with details described in a prior paper.[9] Additionally, to determine competency, physicians were allowed to schedule one-on-one scanning sessions with the director of emergency ultrasound if they had been actively scanning before the upgrades, and standardization made it possible for ultrasound leadership to track scans.

Participants for Study

Any community EP working at an urban, suburban, or freestanding ED within the healthcare system who completed the ultrasound credentialing program described above was included in the study. We excluded physicians who primarily practiced at the main academic quaternary care hospital where an EM residency program was based and that also had POCUS fellowship-trained physicians on the faculty. If an EP worked at the academic site and a community site during the study period, the physician was included in the study and only their POCUS studies from the community sites were included in the dataset. In addition, any EP who joined the

Table 1. Point-of-care ultrasound privileges.

Credentialing tier	Applications	Number of exams required
Basic ultrasound (all exam types required for completion)	**General applications:** focused assessment with sonography in trauma (FAST); ultrasound-guided venous access placement; abdominal aorta aneurysm	**FAST: 25 exams** **AAA: 25 exams** **Central Line: 10 exams**
Intermediate ultrasound (all exam types required for completion)	**General applications:** pregnancy; echo; biliary; urinary tract; DVT; thoracic; soft tissue/ musculoskeletal; ocular; and procedural guidance	**150 total exams** **(90 exams if completed Basic Credentialing Tier)**
Advanced ultrasound (ability to credential for individual exam types in this category)	Adnexal pathology Advanced echo Appendicitis Bowel (including intussception) Diverticulitis Pyloric stenosis Small bowel obstruction Testicular Transcranial Doppler Transesophageal echo	**25 exams per exam type**
Requirements for point-of-care ultrasound study		
Adequate image acquisition Adequate image interpretation Appropriate labeling of each image		

AAA, abdominal aortic aneurysm; *DVT*, deep vein thrombosis; *POCUS*, point-of-care ultrasound.

EM group practice after completion of the ultrasound credentialing program in 2018 was required to take the internal departmental POCUS course (the same course required for new physicians who underwent the practice-based credentialing pathway). This course was taught by EM POCUS leadership and reviewed the recommended image acquisition requirements for each POCUS exam: EHR orders, image archival, documentation, and chart requirements for billing.

POCUS Workflow

A standard workflow was implemented across the system. Physicians placed an order in the EHR for the specific POCUS exam subtype desired: focused assessment of sonography in trauma (FAST); right upper quadrant for gallbladder pathology; pelvic for early pregnancy, etc. The order then generated a patient worklist on the POCUS machine within that individual ED. Those EDs with multiple machines used a shared worklist. The performing EP accessed the patient medical record for the exam and at the end of the exam, the images were pushed directly to the picture archiving and communicating system and to the EHR. No middleware was used. This image was immediately viewable and available for quality review to all EHR users across the system. In the EHR, the order created a reminder to interpret the image using an exam-specific and focused template recommended by the ACEP standardized reporting guidelines.

Each week, an automated report of all POCUS orders was generated and exported to a secure server. Information extracted include patient name, medical record number, date and time of study, type of study subtype as defined by the order placed in the EHR, and image interpretation of study. This database was used for QA by ED POCUS leadership.

Concurrently, a recommended POCUS image compendium was distributed to all EPs (Appendix 1). The compendium identifies standard views to be obtained as well as labeling nomenclature to be used when scanning. Additionally, each machine at all hospitals was loaded with standardized, preset descriptor labels to affix on the images.

Intervention, Data Collection, and Quality Assurance Process

All POCUS studies performed by credentialed EPs from October 1, 2018–September 30, 2020 were included in the analysis. We excluded studies that were performed for educational purposes, performed by non-EPs (consultant), or non-credentialed EPs' ultrasound exams. We conducted statistical analysis using SAS software (SAS Institute, Inc., Cary, NC). We computed descriptive statistics as well as medians and means.

Data extracted included the date of the POCUS exam, location, POCUS exam type, attending physician, physician interpretation, and QA findings. Additionally, each physician's date of hire and residency graduation date was identified. The POCUS exam type was categorized by the EHR entry order. The POCUS exam was assigned to the attending physician who ordered the study through the EHR. For this study, we examined the number of residency cohort groups in five-year increments to determine how POCUS usage has changed over small increments of time.

The ED POCUS QA program required an ultrasound fellowship-trained EP to review all studies. All studies were reviewed within four weeks of acquisition. Each was reviewed for three focus areas: 1) image acquisition, defined as the "ability to acquire the required images for a particular POCUS study as defined by the image compendium"; 2) image interpretation, defined as "the ability for the physician to make the correct interpretation to answer the defined clinical question"; and 3) labeling of images, defined as "labeling of images such that independent reviewers of POCUS images can determine the anatomical location of the study." When a reviewer doubted one of the qualitative quality measures, an additional POCUS reviewer was consulted.

A monthly QA report summarizing all exams and pertinent teaching points was sent to all EPs. As needed, specific feedback was sent to the performing physician, and cases were sent to peer review if a significant quality issue was identified.

RESULTS

During the two-year study period, a total of 5,099 POCUS studies were performed across 11 community EDs within the healthcare system. A total of 170 EPs met inclusion criteria; 29 were excluded as they worked exclusively at the academic center. Table 2 demonstrates the number and percentage of the most common exams performed. In the community, limited cardiac, FAST, and limited pregnancy exams were the most common exams, accounting for 61.9% of total studies. The most infrequently performed exams in the community were deep venous thrombosis (DVT), appendix, and testicular ultrasound.

Of the 170 community EPs performing POCUS, years of residency graduation were recorded as a determinant of exposure to POCUS. As demonstrated in Table 3, more recent EM residency graduates were higher utilizers of POCUS with a group mean of 1.3 exams per 100 patients. Residency graduates in EM from 2005-2009 and 2010-2014 had 0.83 exams per 100 patients and 0.80 exams per 100 patients, respectively. There was a significant decrease in exams per 100 patients for the 2000-2004 graduates. In the pre-2000 residency group, the mean number of POCUS exams per 100 patients was 0.78. However, when examining this physician group, two physicians who worked at trauma hospitals performed 85% (900/1,062) of exams in this category, which skewed the results. When we excluded these two physicians from the dataset, as they were thought to be

Table 2. Frequency of point-of-care ultrasound exam types in community hospital emergency departments.

Exam category	POCUS exams	% of Total
Cardiac	1,222	24.0%
FAST	1,109	21.7%
Ob	826	16.2%
Skin	491	9.6%
Lung	356	7.0%
Aorta	181	3.5%
Ocular	179	3.5%
Kidney	127	2.5%
Bladder	123	2.4%
Biliary	118	2.3%
E-FAST	113	2.2%
Abdomen other	110	2.2%
Other	59	1.2%
Joint	45	0.9%
DVT	25	0.5%
Appendix	7	0.1%
Procedural ultrasound	7	0.1%
Scrotum	1	0.0%
GRAND TOTAL	**5,099**	**100.0%**

POCUS, point-of-care ultrasound; *OB*, obstetrics; *FAST*, focused assessment with sonography in trauma; *E-FAST*, extended focused assessment with sonography in trauma; *DVT*, deep vein thrombosis.

outliers, the mean number of POCUS exam per 100 patients was 0.26.

When reviewing the QA data, we found that 4,395/5,099 (86%) of POCUS studies had no quality issues (86%) (Table 4). With regard to the specific quality concern, 245/5,099 (4.8%) had inadequate image acquisition, 51/5,099 (1.0%) had inadequate image interpretation, and 210/5,099 (4.1%) had images that were either not labeled or labeled inappropriately. Less than 4% (166/5,099) did not have any interpretation associated with the study. Therefore, these could not be assessed for image interpretation. Less than 0.01% had more than one quality concern (32/5,099).

DISCUSSION

We present the first objective study to quantify POCUS studies performed by community EPs. We found that core studies are performed most often, and there is a higher propensity for these studies to be performed by recent residency graduates.

Many studies have used survey methods to assess exam type without retrospective data to demonstrate actual utilization. For example, a recent Canadian study surveyed EPs and found that FAST, cardiac arrest, and pregnancy were the most commonly reported applications used. In addition, the physician's age was negatively associated with POCUS use.[10] A study from 2006 found that respondents who worked in community settings reported using POCUS primarily for FAST, cardiac arrest, and pericardial effusion.[11] Lastly, a recent survey study assessing non-academic EDs in Arizona found that the most common studies performed at community sites were trauma, cardiac, and line placement.[12] Our study, using retrospective methods, objectively confirms previous survey data that community EPs perform core exams for life-threatening concerns in community EDs. Additionally, FAST, cardiac, and obstetrical exams were the most common scans performed in our community ED healthcare system, which aligns with previous studies.

Our study also found that less commonly performed exams, such as biliary, joint, DVT, appendix, and testicular ultrasound, were rarely done. There could be many reasons for this, which include an EP's lack of confidence in performing the exam, difficulty in acquiring correct images, risk of incorrect interpretation, and the amount of time needed to perform a bedside exam. Some of these exams may not routinely be done in EM residency training and, thus, there is limited experience. Additionally, it could be that a

Table 3. Physician residency graduation year in relation to point-of-care ultrasound exams performed per 100 patients.

Residency group (Yr)	Physician count (N)	Patients (N)	POCUS exams (N)	POCUS exams per 100 patients		
				Group rate	Group mean	Group median
Pre-2000	36	96,556	1,062	1.10	0.78	0.11
2000–2004	21	58,913	127	0.22	0.21	0.03
2005–2009	27	68,674	906	1.32	0.83	0.19
2010–2014	36	120,098	1,019	0.85	0.80	0.33
2015–2019	43	147,202	1,941	1.32	1.30	0.74
2020+	7	2,776	44	1.59	2.03	0.77
Grand total	**170**	**494,219**	**5,099**	**1.03**	**0.91**	**0.31**

POCUS, point-of-care ultrasound; *Yr*, year.

Table 4. Quality metrics for point-of-care ultrasound performed.

		Number of studies (N)
No quality issues		4,395
Quality issue	Image acquisition (IA)	245
	Image interpretation (II)	51
	Image labeling	210
	No interpretation	166
>1 Quality issue	IA + no label	16
	II + no label	7
	IA, II, and no label	9
Total		5,099

physician's lack of confidence with more complex exams led to opting to obtain radiology-based ultrasound studies. Lastly, it may be that these exams require more time at the bedside, which may prevent community EPs from performing them routinely.

Previous survey studies describe line placement as a more common exam type reported. Given that it is strongly recommended in our system that ultrasound be used for central line placement, we do suspect that there is likely undercounting of its use for line placement. This may be because many of the community EDs do not have the personnel or resources to assist physicians with saving the images during sterile procedures or that it may not have been seen as of critical importance during the procedure and was thus neglected. Therefore, our numbers are likely low as image acquisition into the EHR may limit our ability to truly assess the incidence of POCUS for line placement. However, POCUS for line placement is not a diagnostic modality but rather a procedural aid, and our data does reflect the use of POCUS as a diagnostic modality in the community.

Although we did not perform any statistical comparison analyses to determine statistically significant differences across residency groups in this cohort, the data from our study points to a possible trend suggesting that the greater the number of years from residency graduation, the less likely the EP was to perform POCUS per 100 patients. We suspect physicians who graduated without formal POCUS training during residency are not as likely to pick up this new skill and use it at the bedside. While there is sparse data linking EM residency graduation with the utilization of POCUS in practice, there are smaller studies that demonstrate POCUS training during residency positively impacts clinical utilization within one year after a dedicated course.[13,14]

Our study attempted to examine all community EPs in our healthcare system and their POCUS utilization. Objective study numbers performed per 100 patients suggest a trend toward an overall decrease in POCUS utilization with greater number of years from residency graduation. The data may be useful to institutions developing POCUS curricula, training, and credentialing programs for practicing EPs as the data suggests that this population will likely not use POCUS as frequently as EM residency graduates who were trained in POCUS.

One area that deserves discussion from our dataset was the pre-2000 residency graduate group. Our data found an uptick in the group who graduated prior to 2000. To better understand this outlier in the dataset, we performed a detailed analysis, which revealed that two EPs in this group performed 85% of the POCUS exams. These two physicians work at Level 2 trauma centers, which may explain their high utilization of POCUS. When these two physicians were excluded from the pre-2000 cohort, the total number of exams performed dropped from 1,072 to 172 with a group mean of 0.26 POCUS exams per 100 patients. This likely is more representative of this EP group who graduated prior to 2000 and is consistent with the 2000-2004 cohort. However, it raises the question of whether older residency graduates may develop an affinity for POCUS in the proper clinical setting and whether universal POCUS credentialing of EPs is beneficial. Additionally, another question that occurs is whether it is beneficial to train modalities most used in the clinical environment in which the physician practices or whether training should consist of all ACEP-recommended studies.

Finally, quality is a metric that is of utmost importance when performing POCUS exams. Our study demonstrates that POCUS in the community ED produces high-quality, reliable POCUS studies. After a comprehensive credentialing program with imaging compendium recommendations and a standardized reporting system, most exams performed met basic quality metrics for image acquisition, image interpretation, and labeling. This demonstrates that quality studies with compliance can be achieved in the community ED when a comprehensive credentialing program with standardization of POCUS is implemented. This program could be helpful for other specialties or for community hospitals with new or novice scanners trying to implement guidelines and best practices with regard to POCUS.

Overall, the findings from our community assessment are that core POCUS exams are most commonly performed with few quality issues. Hospital systems or new POCUS programs may benefit from focusing on core training, solid competency assessment programs, best practices for privileging and credentialing, and standardizing workflow to ensure high-quality outcomes. Further studies will need to continue to assess the use of POCUS in community EDs to further examine patient outcomes.

LIMITATIONS

One potential limitations of our study is that the data includes only studies ordered through the EHR with images

that were saved and documented within the system and had billing notes completed. It is possible that other studies, known as "phantom scans," could have been performed at the bedside without image acquisition into the EHR with appropriate documentation. We had no way of assessing the number of "phantom scans" using our current EHR, but we acknowledge that this could be a potential confounder to our study. Along this theme, we believe that most of our community EPs did not save images for central line placement and, thus, there is no data on their performance. However, the healthcare system recommends POCUS as best practice for central line placement.

Another limitation was that a small group of EPs practiced at both academic and community sites within our system. While the study only included their community POCUS exams, these physicians may be more apt to use POCUS due to their exposure at the academic site where residents train in POCUS and perform frequent exams. This may skew this physician group's POCUS numbers in the community, and we could not account for these few physicians in our study group. In terms of additional limitations related to the physician group, we were unable to obtain retrospective information about how many studies or how frequently the physician group was scanning from the time of their residency graduation to the beginning of the study or continued competency.

Lastly, another variable that could have affected the use of POCUS in community EDs was the availability of 24-hour, radiology-performed and interpreted ultrasound studies. Many of our sites had a 24-hour on-site radiology ultrasound, while others had some limited on-call access during overnight hours. Unfortunately, there was no reliable way to tell when radiology-based ultrasound was unavailable. Possible reasons for community EPs' limited use of POCUS may be the heavier workload, absence of trainees, and ease of access to radiology-based ultrasound exams, especially when requested by consulting services.

CONCLUSION

The use of point-of-care ultrasound in community EDs demonstrates a heavy focus on the core exams in EM practice with increased utilization by recent residency graduates. Most studies had no quality issues with image interpretation, image acquisition, or labeling as defined by the guidelines within our privileging program. Our study demonstrates that POCUS can be reliably performed in community EDs and that as our workforce continues to shift toward more recent residency graduates, the use of POCUS in the community EDs will continue to grow. Building standardized infrastructure in community sites to allow for further use of POCUS may be advantageous for healthcare systems.

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Applying a Smartwatch to Predict Work-related Fatigue for Emergency Healthcare Professionals: Machine Learning Method

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Introduction: Healthcare professionals frequently experience work-related fatigue, which may jeopardize their health and put patient safety at risk. In this study, we applied a machine learning (ML) approach based on data collected from a smartwatch to construct prediction models of work-related fatigue for emergency clinicians.

Methods: We conducted this prospective study at the emergency department (ED) of a tertiary teaching hospital from March 10–June 20, 2021, where we recruited physicians, nurses, and nurse practitioners. All participants wore a commercially available smartwatch capable of measuring various physiological data during the experiment. Participants completed the Multidimensional Fatigue Inventory (MFI) web form before and after each of their work shifts. We calculated and labeled the before-and-after-shift score differences between each pair of scores. Using several tree-based algorithms, we constructed the prediction models based on features collected from the smartwatch. Records were split into training/validation and testing sets at a 70:30 ratio, and we evaluated the performances using the area under the curve (AUC) measure of receiver operating characteristic on the test set.

Results: In total, 110 participants were included in this study, contributing to a set of 1,542 effective records. Of these records, 85 (5.5%) were labeled as having work-related fatigue when setting the MFI difference between two standard deviations as the threshold. The mean age of the participants was 29.6. Most of the records were collected from nurses (87.7%) and females (77.5%). We selected a union of 31 features to construct the models. For total participants, CatBoost classifier achieved the best performances of AUC (0.838, 95% confidence interval [CI] 0.742–0.918) to identify work-related fatigue. By focusing on a subgroup of nurses <35 years in age, XGBoost classifier obtained excellent performance of AUC (0.928, 95% CI 0.839–0.991) on the test set.

Conclusion: By using features derived from a smartwatch, we successfully built ML models capable of classifying the risk of work-related fatigue in the ED. By collecting more data to optimize the models, it should be possible to use smartwatch-based ML models in the future to predict work-related fatigue and adopt preventive measures for emergency clinicians. [West J Emerg Med. 2023;24(4)693–702.]

INTRODUCTION

Work-related fatigue is a major concern in the workplace. Work-related fatigue among medical personnel can affect the health and well-being of emergency healthcare professionals (EHP) and put patient safety at risk.[1–6] Causes of fatigue in the workplace may be due to either physiological factors, such as long work shifts or heavy workload, or psychological aspects such as stress.[2,7] Researchers found that if employees worked more than 55 hours per week, the chances of getting a stroke or coronary heart disease would increase by 33% and 13%, respectively, compared to employees whose working hours met the 55-hour standard.[8] Another study showed that doctors in Taiwan might have greater occupational pressure and a higher depression rate (13.3%) than that found in the general population (3.7%).[9] To reduce healthcare workload and prevent human errors during clinical practice by determining how to detect work-related fatigue earlier and adopt preventive measures is worthy of careful study.

Numerous studies have focused on work-related fatigue; however, most were conducted subjectively by using self-report measures such as questionnaires, surveys, or rating scales completed after work.[10–12] Until now, few studies have looked at objective ways of collecting real-time data from EPs and other healthcare workers while on shift. With the advancement of information technology and the advent of wearable devices capable of unobtrusively collecting real-time biosensor data without affecting the workflow of medical staff, it is possible to develop a smartwatch-based prediction model of work-related fatigue for EHPs. In the past, wearable devices focused more on health monitoring for the elderly or fall detection in patients with movement disorders.[13] Now, wearable devices are used with machine learning (ML) to determine whether a patient has depression or to facilitate the delivery of high-quality cardiopulmonary resuscitation.[14,15]

A recent review article by Martins et al focused on fatigue monitoring through wearables. They retrieved a total of 612 articles in their literature search and included 60 articles for analysis. Of the included research, the most common studies were related to drowsiness detection for drivers (33), followed by the detection of physical fatigue, mental fatigue, muscle fatigue and, lastly, vigilance detection. Although four studies focused on the healthcare domain, none looked at healthcare professionals. Three of those studies were related to fatigue detection for rehabilitation patients, and one examined mental fatigue detection in a healthy population. Of the 60 studies included in the review by Martins et al, only five reported on the use of a smartwatch as the signal source for fatigue detection.[16]

Apart from that review, one study described the use of a wearable photoplethysmography (PPG) biosensor to evaluate the feasibility of collecting and analyzing PPG data for burnout in EPs while they work. Since this study showed no significant changes in pulse rate and pulse rate variability over the course of an EP's academic year, it suggested that alternative methods would have to be explored to measure stress among EPs at work.[17]

A smartwatch is a wearable device with the function of both telling time and acting as a source for collecting physiologic data derived directly from the wearer's body because of its proximity to the skin. Today most of the commercially available smartwatches claim to have the ability to track the wearer's health by providing data, such as number of footsteps, heart rate, blood pressure, and oximetry via the embedded biosensors. Although the accuracy of the measured data derived from smartwatches varies depending on the device manufacturer, most mainstream devices can reliably measure heart rate, steps, and other health evaluation indicators.[18]

It is reasonable to conclude that we can collect real-time physiologic data transmitted from the smartwatch worn by healthcare workers to build a work-related fatigue prediction model. By combining objective data collected from a wearable device with the subjective results of the well-validated Multidimensional Fatigue Inventory (MFI) (filled out by the participants as a tool for fatigue labeling),[19] we sought to apply ML approaches to construct a work-related fatigue prediction model for emergency healthcare professionals. We hypothesized that a smartwatch-based ML model could serve as a reliable method to detect fatigue for EHPs working in the emergency department (ED).

Population Health Research Capsule

What do we already know about this issue?
Emergency healthcare professionals frequently experience work-related fatigue, which can impact their health and put patients at risk.

What was the research question?
Can machine learning based on smartwatch data predict work-related fatigue in emergency healthcare professionals?

What was the major finding of the study?
CatBoost classifier achieved an area under the curve of 0.838 (95% CI 0.742–0.918) for identifying work-related fatigue in study participants.

How does this improve population health?
By using smartwatch data and machine learning, work-related fatigue can potentially be identified and prevented, improving patient safety and healthcare professionals' health.

METHODS

Study Settings

This prospective observational study was conducted March 10–June 20, 2021 at the ED of National Taiwan University Hospital (NTUH), a 2,400-bed, university-affiliated, tertiary teaching hospital with a daily census of ≈300 emergency visits. We recruited emergency care professionals, including EPs, nurses, and nurse practitioners >20 years of age, excluding anyone who could not tolerate wearing a smartwatch. Each participant was provided with an ASUS VivoWatch SP (ASUSTeK Inc, Taipei, Taiwan), a commercially available smartwatch capable of measuring heart rate, blood pressure, oxygen saturation, and footsteps using the embedded sensors. The smartwatch also features calorie consumption, heart rate variability (HRV), and stress index based on proprietary algorithms not shown to the public. Participants were not allowed to remove the smartwatch while they were at work. Nine smartphones (ASUS Zenfone 7) were set up in the ED, acting as gateways to synchronize and transmit data with a private cloud via Bluetooth protocol (Bluetooth SIG, Inc, Kirkland WA). Each phone was paired with 50 smartwatches over the course of the study.

The Multidimensional Fatigue Inventory

The MFI is a 20-item self-report scale designed to evaluate five dimensions of fatigue: general fatigue; physical fatigue; reduced motivation; reduced activity; and mental fatigue. This instrument was originally developed in the Netherlands for patients with cancer and chronic fatigue and has been translated and validated in several other languages (including Mandarin) for different populations.[19–21] Each dimension contains four items (two items in a positive and two in a negative direction) to be scored on a five-point Likert scale ranging from 1 (yes, that is true) to 5 (no, that is not true). The negative items (items 2, 5, 9, 10, 13, 14, 16, 17, 18, 19) must be recorded before the scores are added up. The summation of the obtainable score ranges from 20 (absence of fatigue) to 100 (maximum fatigue).

For this study, the original MFI scale was translated into a Traditional Chinese version based on previous publications[19,20] (Supplementary Table 1). Participants were asked to complete an MFI web form before and after each of their work shifts. We calculated the differences between each pair of work-shift scores for the subsequent ML task of labeling work-related fatigue. We set the between-score difference of MFI with more than 10, more than one SD, or more than two SDs as positive labels of work-related fatigue. The research method was approved by the institutional review board (NTUH-REC No.: 202011024RIND) of NTUH. All participants signed an informed consent form before participating in the study.

The Machine-Learning Method

In addition to participants' demographic data and the time series data of blood pressure, heart rate, HRV, footsteps, and calorie consumption, we retrieved the stress index transmitted from the smartwatches to the private cloud as the main features for constructing ML models. We used a set of time windows (first, second, and fourth hours) and statistical functions (eg, minimum, maximum, mean, slope, SD, etc) to create more features as the input variables. In the feature space we also included the one-hot-encoded (a way to convert variables for use in ML algorithms) demographics of the study participants. Missing data were automatically imputed with dummy variables by the ML models. Initially, 696 features were included as the input variables for the subsequent ML task.

We used several tree-based algorithms—including random forest (RF), gradient boosting (GB), eXtreme gradient boosting (XGBoost) (an open source software library), light gradient boosting machine (LightGBM) (an open source for a distributed gradient-boosting framework for ML developed by Microsoft Corp, Redmond, WA), and categorical boosting (CatBoost) classifiers—to construct the prediction models of work-related fatigue for clinical staff in the ED. We defined the between MFI score differences of more than two SDs in each pair of work shifts as work-related fatigue and used them as the binary classification label for this study. We divided all records into two sets chronologically, 70% of which were assigned to the training and validation set and 30% to the test set. We used k-fold cross-validation during the model training process by setting k from 7 to 10 to obtain the best performances.

We adopted a two-step method as our feature selection strategy. First, we deselected those features with high correlation. Second, we ranked the selected features by using entropy measures based on information gain theory.[22] Iteratively, we built our models by trying from the top fifth important features and added one more until the last selected features, and finally found a set of features to construct the best models in terms of the performance of area under the curve (AUC) measure of receiver operating characteristic (ROC). Features of continuous data were expressed as mean and SD (or mode and interquartile range depending on the normality test), whereas categorical data were expressed as counts and proportions. We also presented univariate descriptive statistics to evaluate differences between classes by using Student *t*-test, chi-squared test, Fisher exact test, or Mann-Whitney U test depending on the distribution.

To resolve the class imbalance problem for work-related fatigue prediction, we used the synthetic minority oversampling technique method (SMOTE), which oversampled the minority class during the training process.[23] The selection of the models was based on the AUC performance in the test set, which was set as the primary evaluation metric of the study. For each model we also

reported other performance measures, including area under the precision-recall curve (AUPRC), accuracy, negative predictive value (NPV), precision (or positive predictive value [PPV]), recall (or sensitivity, or true positive rate), specificity (true negative rate), kappa, and F-1 score, The entropy measures for feature ranking were performed using Weka 3.8, a collection of ML algorithms for data-mining tasks (University of Waikato, Hamilton, New Zealand).[24] Other ML analyses were performed using Python 3.8 with the package scikit-learn 0.23.1 installed (Python Software Foundation, Fredericksburg, VA).[25]

RESULTS

We included 110 participants in this study, with a set of 1,542 effective records collected. Each participant contributed to at least one record, ranging from 1–23 records. Of them, 85 (5.5%) were labeled as having work-related fatigue (two SDs as the threshold) based on our study definition. The mean age of the participants was 29.6 years (SD 6.3), and 77.5% of the records were for females. Most of the collected records were from nurses (87.7%), followed by nurse practitioners (7.7%) and EPs (4.5%) ($P < 0.001$). Up to 47.7% of the collected records were on the evening shift, 44.5% on the day shift, and 7.8% on the night shift ($P < .001$). The characteristics of the demographic features in the study population are shown in Table 1.

The characteristics and univariate analyses of the selected features between participants with or without work-related fatigue are summarized in **Supplementary** Table 2, shown respectively for the training and testing sets. Based on our feature selection strategy, finally there was a union of 31 features selected to construct the models. Of them, the work start time was the only demographic feature selected. The other 30 features were derived from the smartwatch, of which 11 were related to heart rate, seven to blood pressure, five to stress index, three to HRV, three to calorie assumption, and one related to footsteps.

The entropy measures for the ranking of the 31 selected features are shown in Figure 1. The initially included 696 features and the percentages of data missing are shown in **Supplementary** Table 3. The description of the three types of the candidate features (demographics, sensor data from the smartwatch, and statistical data derived from the sensor data) are shown in **Supplementary** Table 4.

For total participants, the classification results (based on the best AUC in terms of the different thresholds for labeling), including AUC, AUPRC, appa, accuracy, F1-score, precision (PPV), specificity, and NPV on the training and testing sets are presented in Table 2. By adjusting the threshold of work-related fatigue labeling from two SDs to one SD or 20 points of the between differences of the MFI score, here we show merely the top classifier in terms of AUC. By using the CatBoost classifier, the best performances of AUC and AUPRC in the test set were 0.838 (95% confidence interval [CI] 0.742–0.918) and 0.527 (95% CI 0.344–0.699), respectively (Figure 2). Conducting further subgroup analysis when focused on nurses <35 years of age, XGBoost classifier achieved the best performance in terms of AUC of 0.928 (95% CI 0.839–0.991) when setting the threshold for work-related fatigue as two SDs. Meanwhile, other performance measures for this subgroup are presented in Table 3. In this model, AUPRC was 0.781 (95% CI 0.617–0.0.919) (Figure 2).

DISCUSSION

In this study we applied ML techniques to predict work-related fatigue for clinical staff who worked at the ED in a tertiary hospital in Taiwan. Using 31 selected features derived from a wearable device, we successfully built ML models capable of classifying the risk of work-related fatigue in the ED environment. Instead of using base models like decision tree learning, we used several tree-based algorithms to construct the prediction models. We chose these algorithms for their ability to manage the non-linear relation with better performance in coping with a small amount of data. These algorithms were also less affected by missing values and were independent to feature scale and normalization as well.[26] While setting the work-related fatigue threshold as two SDs difference between the before-and-after-work MFI scores, we obtained good discriminatory performance to predict work-related fatigue taking AUC as the performance indicator. Of the algorithms we used, CatBoost (AUC 0.838) outperformed RF, GB, XGBoost, and LightGBM classifiers when applied to the testing set for the whole cohort of participants. Since younger participants may have been more likely to have work-related fatigue[27] and nurses made up the majority of the research group (and their work content might be different from EPs and nurse practitioners), we performed a subgroup analysis by focusing on nurses <35. In this subgroup analysis, the XGBoost classifier (AUC 0.928) outperformed the others on the testing set in this subgroup (Figure 2).

Feature Selection Using Entropy and Information Gain

Entropy is a measure of the uncertainty or randomness in the data. It is calculated as the sum of the negative of the probability of each class multiplied by the logarithm of the probability of each class. In decision tree algorithms, entropy is used to determine how much information a feature can provide us with in reducing the uncertainty of the target variable.[24] The entropy is zero when all the instances in a set belong to the same class and is maximum when the instances are equally divided among all classes. Information gain is a measure of how much a particular feature helps in reducing the uncertainty of the target variable. In other words, it tells us how useful a particular feature is in classifying the target variable. Information gain is calculated by subtracting the weighted average entropy of the target variable after the

Table 1. Characteristics of the demographic features in the study population.

Variables (features)	Total (N = 1,542)	Training cohort (n = 1,079)	Testing cohort (n = 463)	*P* value
Gender				.07
Female	1,195 (77.5)	850 (78.8)	345 (74.5)	
Male	347 (22.5)	229 (21.2)	118 (25.5)	
Age, mean (SD)	29.6 (6.3)	29.6 (6.4)	30.5 (3.5)	.84[§]
Role				<.001
Doctor	70 (4.5)	38 (3.5)	32 (6.9)	
Nurse practitioner	119 (7.7)	104 (9.6)	15 (3.2)	
Nurse	1353 (87.7)	937 (86.8)	416 (89.8)	
Work type				<.001
Night shift	121 (7.8)	34 (3.2)	87 (18.8)	
Evening shift	735 (47.7)	519 (48.1)	216 (46.7)	
Day shift	686 (44.5)	526 (48.7)	160 (34.6)	
Work hours, mean (SD)	8.3 (0.8)	8.2 (0.7)	8.4 (1.0)	<.001
Seniority[ϕ], mean (SD)	6.3 (5.1)	6.4 (5.1)	5.3 (6.7)	.76
Day of week				.012
Monday	222 (14.4)	171 (15.8)	51 (11.0)	
Tuesday	232 (15.0)	170 (15.8)	62 (13.4)	
Wednesday	249 (16.1)	153 (14.2)	96 (20.7)	
Thursday	222 (14.4)	153 (14.2)	69 (14.9)	
Friday	213 (13.8)	155 (14.4)	58 (12.5)	
Saturday	198 (12.8)	135 (12.5)	63 (13.6)	
Sunday	206 (13.4)	142 (13.2)	64 (13.8)	
Work start time				<.001
7:00 AM	60 (3.9)	53 (4.9)	7 (1.5)	
7:30 AM	569 (36.9)	437 (40.5)	132 (28.5)	
8:00 AM	44 (2.9)	29 (2.7)	15 (3.2)	
9:00 AM	13 (0.8)	7 (0.6)	6 (1.3)	
2:30 PM	57 (3.7)	49 (4.5)	8 (1.7)	
3:30 PM	678 (44.0)	470 (43.6)	208 (44.9)	
8:00 PM	26 (1.7)	9 (0.8)	17 (3.7)	
11:30 PM	95 (6.2)	25 (2.3)	70 (15.1)	

[§]We used the Student *t*-test as the statistical method to compare the variable age and chi-squared test for remaining variables.
[ϕ]Seniority means years of working as a healthcare professional.

feature is used for classification from the entropy of the target variable before the feature is used. The feature with the highest information gain is chosen as the root node of the decision tree.

We used entropy and information gain as a method of feature selection (instead of the commonly used univariate analysis), given its ability to rank the features in the order of their respective information gains, so that we could select features based on the threshold in the ML algorithms. As shown in Figure 1, we can see the relatively low information gain of 0.00525 given by the feature "maximum of heart rate for the last 1-hour time interval" and the relatively higher information gain of 0.036543 given by the feature "minimum of systolic pressure divided by diastolic pressure for the first 4-hour time interval." In summary, entropy and information gain could be used to determine the best feature to use for classification, with the goal of reducing the uncertainty of the target variable and maximizing the information gain.

Comparison with Previous Studies

Work-related fatigue might have both physical and psychological adverse effects on ED clinical staff, which

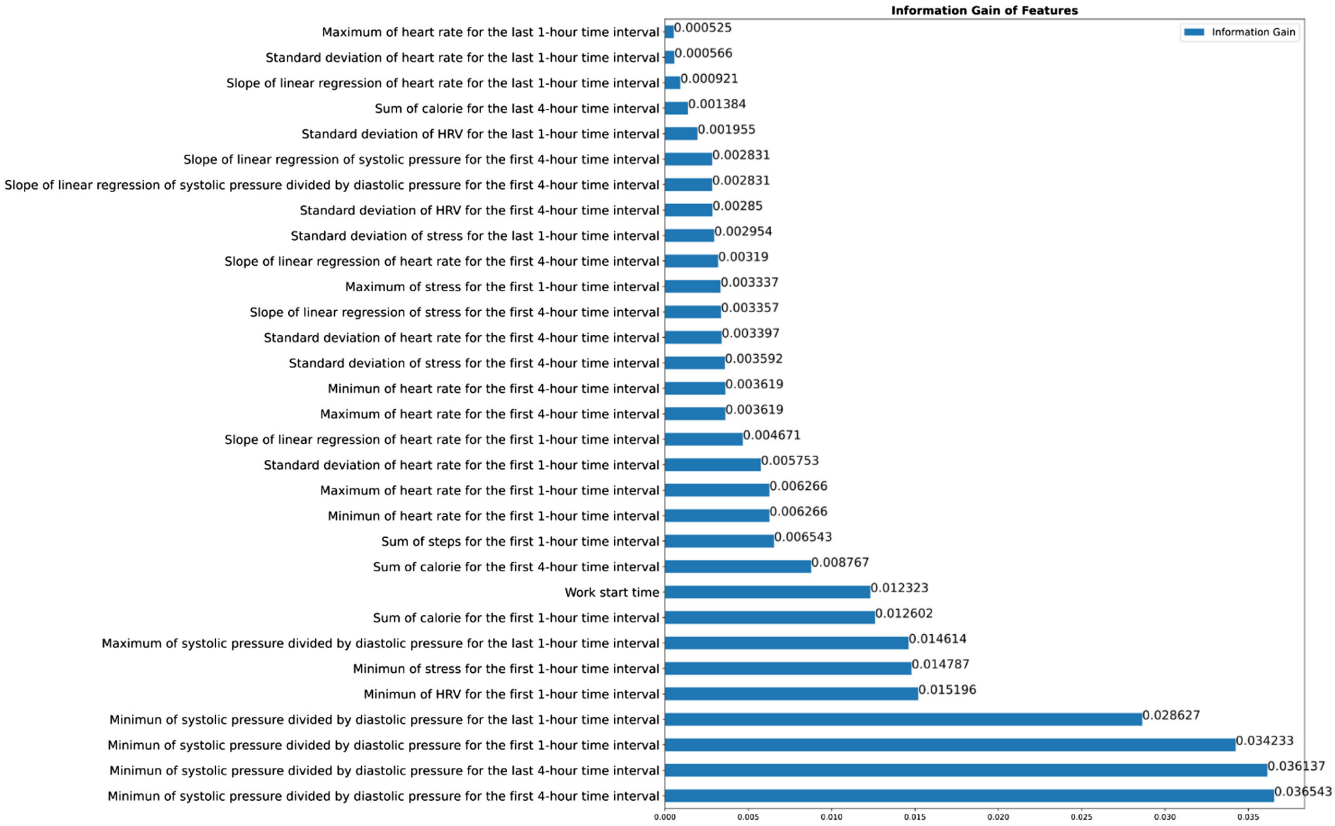

Figure 1. Feature importance ranked by the information gain (entropy). Arranged in an ascending order (from top to bottom), the relatively low information gain of 0.00525 was given by the feature of "maximum of heart rate for the last 1-hour time interval" and the relatively higher information gain of 0.036543 was given by the feature "minimum of systolic pressure divided by diastolic pressure for the first 4-hour time interval."

Table 2. Performance measures for the total participants.

	Total participants					
	Training			Testing		
Threshold	2 SDs (=35.8)	1 SD (=17.9)	20	2 SDs (=35.8)	1 SD (=17.9)	20
Model	CatBoost	GradientBoosting	XGBoost	CatBoost	GradientBoosting	XGBoost
Positive count	57	163	277	28	46	96
AUC	1	1	0.996	0.838	0.759	0.647
AUPRC	0.991	0.998	0.989	0.527	0.43	0.354
F1	0.837	0.979	0.953	0.5	0.372	0.352
Kappa	0.829	0.975	0.937	0.477	0.288	0.182
Sensitivity	0.719	0.982	0.96	0.393	0.457	0.354
Specificity	1	0.996	0.981	0.989	0.89	0.828
PPV	1	0.976	0.947	0.688	0.313	0.351
NPV	0.985	0.997	0.986	0.962	0.937	0.831
Accuracy	0.985	0.994	0.976	0.952	0.847	0.73

AUC, area under the receiver operating characteristic curve; *AUPRC*: area under the precision recall curve; *PPV*, positive predictive value; *NPV,* negative predictive value.

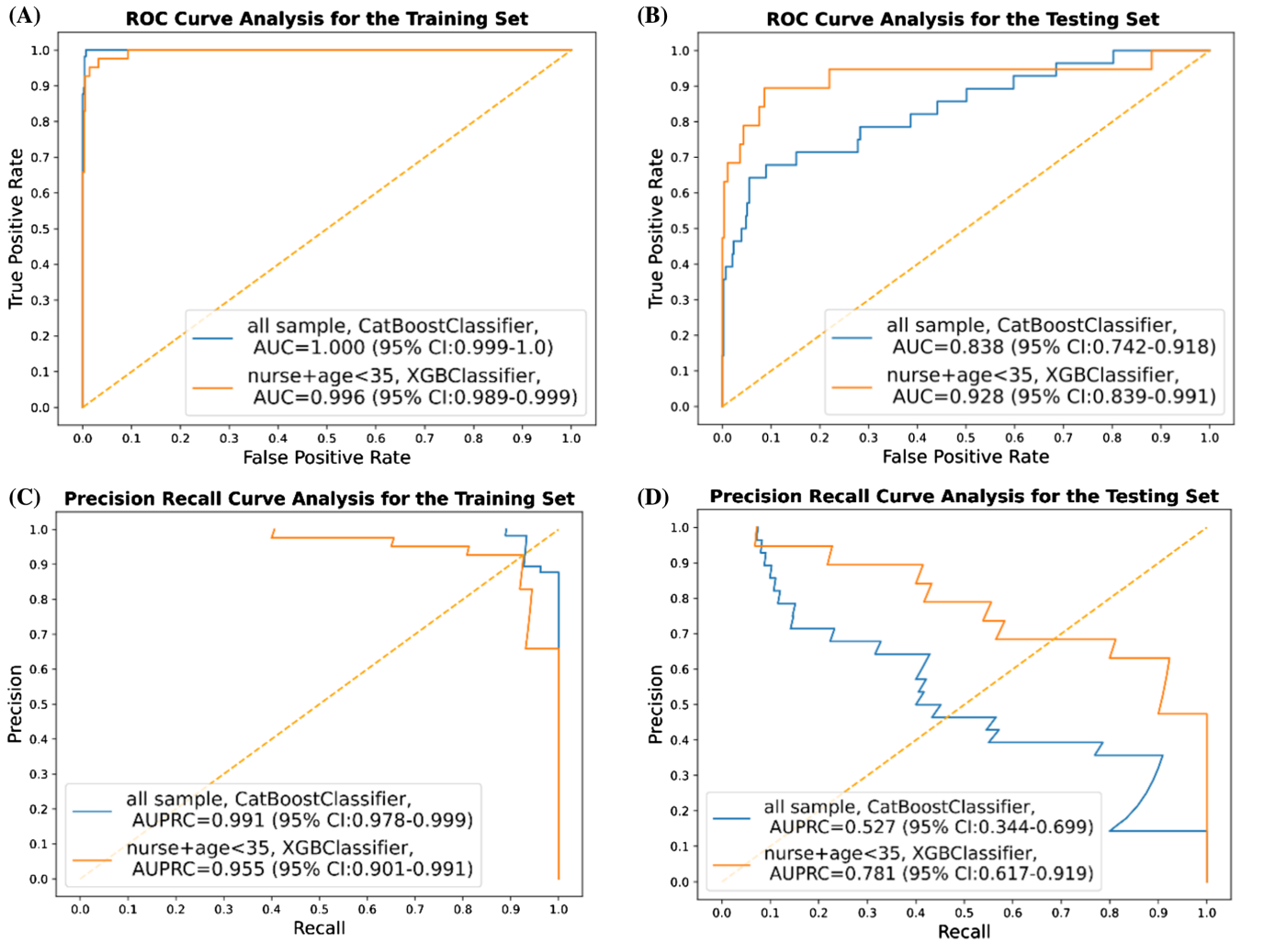

Figure 2. Performance measures of the best machine learning model in terms of AUC and AUPRC for all samples and for subgroup of nurses <35 years in age. (A) AUC on the training cohort (B) AUC on the testing cohort (C) AUPRC on the training cohort (D) AUPRC on the testing cohort. *AUC*, area under the receiver operating characteristic (ROC) curves; *AUPRC*, area under the precision recall curve.

could lead to harmful events both for them and their patients. Until now, previous research studies for work-related fatigue in healthcare practitioners were mostly conducted in the form of a questionnaire survey rather than real-time monitoring.[10–12] With the advancement of wearable devices and the development of artificial intelligence in medicine, novel technology may facilitate real-time identification of work-related fatigue in the healthcare domain. However, previous studies using wearable monitoring methods have focused more on drowsiness detection for drivers' occupational health, or fatigue detection for rehabilitation patients rather than for healthcare professionals.[16] With the combination of wearable technology and ML algorithms, these models were considered to perform better than traditional methods of detecting fatigue. However, little was known about the data quality during the phase of model development.[16] In this study, we successfully constructed ML models based on a smartwatch to identify work-related fatigue, which can serve as a basis to implement a work-related fatigue prediction model for emergency healthcare professionals.

Interpretation of Current Study

In addition to self-reported symptoms, the autonomic nervous system, especially HRV, was thought to be an indicator related to work-related fatigue.[28] In our study, of 31 features selected to construct the ML models, three features were related to HRV, 11 to heart rate, seven to blood pressure, five to stress index, three to calorie assumption, and one was related to footsteps.

Our study included 1,542 before-and-after MFI scales completed by participants who wore a smartwatch while on shift from March 10–June 20, 2021. Of the participants, 85 (5.5%) showed work-related fatigue and were judged to have work-related fatigue by our study definition. The training/validation and testing sets were divided chronologically by a

Table 3. Performance measures for the subgroup of nurses younger than 35 years old.

	Nurses <35 years old					
	Training			Testing		
Threshold	2 SDs (=38.2)	1 SD (=19.1)	20	2 SDs (=38.2)	1 SD (=19.1)	20
Model	XGBoost	RandomForest	XGBoost	XGBoost	RandomForest	XGBoost
Positive count	41	97	174	19	34	66
AUC	0.996	0.998	0.928	0.928	0.813	0.738
AUPRC	0.955	0.989	0.881	0.781	0.609	0.577
F1	0.905	0.926	0.75	0.556	0.429	0.462
Kappa	0.899	0.913	0.685	0.515	0.328	0.357
Sensitivity	0.927	0.969	0.638	0.789	0.618	0.364
Specificity	0.992	0.98	0.979	0.928	0.837	0.939
PPV	0.884	0.887	0.91	0.429	0.328	0.632
NPV	0.995	0.995	0.889	0.985	0.944	0.838
Accuracy	0.988	0.978	0.893	0.919	0.811	0.811

AUC, area under the receiver operating characteristic curve; *AUPRC*, area under the precision recall curve; *PPV*, positive predictive value; *NPV*, negative predictive value.

ratio of 70:30 to simulate a prospective, randomized controlled trial. Our study achieved good AUC results for all populations and obtained excellent performance in the subgroup analysis for nurses <35 years old.

The rate of work-related fatigue in our population was low (5.5%), which does not coincide with previously reported rates of burnout for EPs. As addressed in two review articles, EPs' burnout rates were estimated to be 25–60% depending on the study.[29,30] However, most of the reviewed studies focused on research papers that used the Maslach Burnout Inventory (MBI) to assess the prevalence of burnout. Although the MBI is a well-validated tool and addresses three scales (emotional exhaustion, depersonalization, and personal accomplishment), it mainly focuses on the psychological aspect of burnout rather than the five dimensions of fatigue per the MFI, which we used in our study.

In addition to AUC, we evaluated a series of performance measures in our constructed models, including accuracy, NPV, PPV (precision), sensitivity (recall), specificity, kappa, and F1 score (Tables 2 and 3). Precision refers to how often the predictions for positive class are true, while recall refers to how accurately our model can retrieve the relevant records. The class imbalance problem exists in this study. The incidence of work-related fatigue is only 5.5% in our study. Although we obtained an extremely high specificity value (0.828 to 0.989) and NPV (0.831 to 0.962) in the constructed ML models for all populations, our results showed that the sensitivity values (0.354 to 0.457), precision (0.313 to 0.688), and AUPRC (0.354 to 0.527) were relatively low (Table 2). This implies that we must pay more attention to the clinical staff with predicated work-related fatigue, rather than those without.

Due to the excellent performances in specificity and NPV, our ML models may also be used as a tool for identifying clinical staff who are not at risk for work-related fatigue. When such a high specificity tool yields a positive prediction, we can confidently rule in the risk of work-related fatigue for this EP or nurse. When we focused on nurses <35 years old, our prediction models showed some degree of improvement depending on the models we used, which means that different healthcare professionals may have different patterns of work-related fatigue (Table 3).

Feasibility for Clinical Application

Work-related fatigue would exert both physical and psychological stress on clinical staff, which could further lead to harmful events to healthcare professionals and patients as well. From the previous research, work-related fatigue was mainly reported in a form of a questionnaire survey rather than detection in a timely fashion.[10–12] With our constructed ML model, work-related fatigue could be monitored and documented in real time, and even in the early period of the work shift because many of the 31 selected features were extracted in the first one-hour or four-hour time interval (Figure 1). When clinical staff are thought to have work-related fatigue predicted by our model, we should try to understand their physical and psychological health and initiate risk assessment and preventive measures.

Moreover, we can even adjust and systemize the demand of the workforce according to the frequency of the positive output of work-related fatigue. Work-related fatigue may result in a workforce shortage because of sick leave or resignations.[31] An insufficient workforce could lead to increasing work-related fatigue due to additional stress from

having to share a greater workload or unfamiliarity with the work to be done. To escape the vicious circle, detecting clinical staff who have work-related fatigue and then adjusting workforce demand flexibly is of paramount importance for the medical personnel in the ED and their patients.

LIMITATIONS

There are limitations to this study. First, we labeled work-related fatigue by using a self-assessment scale, the MFI, which could be subjective to reporting bias. However, the bias may have been minimal since MFI is a well-validated tool worldwide.[20–21] Second, this study was conducted in an ED of a single, tertiary teaching hospital with a small sample size that included only a few overnight workers (7.8%), and focused mostly on nurses who were <35 years in age (the predominant nurse group working in our ED). Selection bias may have been introduced since participants were enrolled voluntarily and not all types of clinical staff in the ED were enrolled. For the generalizability of the models, further study may be required to collect more data from diverse medical staff not included in this study.

Third, because of the low positivity rate of work-related fatigue in our population, our constructed ML models encountered the problem of imbalanced classification and false negatives.[32] To obtain better performances, we used the SMOTE method during the model training process to balance the dataset. In addition, we evaluated the prediction performances of our models with most of the available performance measures, including AUC, AUPRC, precision, and recall, thereby avoiding over-interpretation by any of the results. Fourth, our models achieved perfect performance (AUC near one) in the training set but obtained only excellent performance in the testing set, and that raised the concern of overfitting. Such overfitting concern can also be seen in the results of high variance (large confidence interval) in the prediction model we built. In our next step, we plan to collect more data and adopt more robust algorithms before our model can be generalizable to the target population.

Fifth, we evaluated only the short-term, work-related fatigue for a shift given that we labeled it by using the between MFI difference as the labeling method. Further study is needed to investigate the method that could measure the longitudinal fatigue, stress, or burnout effects of working in the ED. Finally, due to the policy of intellectual property protection in the consumer electronics industry, the product manufacturer would not disclose any detail related to the data quality. We believe that even though the accuracy of the signal derived from the sensor of the smartwatch is uncertain, the trend and changes of the signal can still serve as the features for building a fatigue-detection model.

CONCLUSION

We successfully constructed smartwatch-based, machine learning models to predict work-related fatigue with great discrimination ability based on the features monitored by a smartwatch. Implementation of this tool may be useful to identify ED clinical staff at risk of work-related fatigue. Given the small sample size in this study, more data collection and further prospective validation to determine the effectiveness of usage of this prediction model will be necessary before it can be applied in daily clinical practice.

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Impact of Care Initiation Model on Emergency Department Orders and Operational Metrics: Cohort Study

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Introduction: Emergency departments (ED) employ many strategies to address crowding and prolonged wait times. They include front-end Care Initiation and clinician-in-triage models that start the diagnostic and therapeutic process while the patient waits for a care space in the ED. The objective of this study was to quantify the impact of a Care Initiation model on resource utilization and operational metrics in the ED.

Methods: We performed a retrospective analysis of ED visits at our institution during October 2021. Baseline characteristics were compared with Chi-square and quantile regression. We used *t*-tests to calculate unadjusted difference in outcome measures, including number of laboratory tests ordered and average time patients spent in the waiting room and the ED treatment room, and the time from arrival until ED disposition. We performed propensity score analysis using matching and inverse probability weighting to quantify the direct impact of Care Initiation on outcome measures.

Results: There were 2,407 ED patient encounters, 1,191 (49%) of whom arrived during the hours when Care Initiation was active. A total of 811 (68%) of these patients underwent Care Initiation, while the remainder proceeded directly to the main treatment area. Patients were more likely to undergo Care Initiation if they had lower acuity and lower risk of admission, and if the ED was busier as measured by the number of recent arrivals and percentage of occupied ED beds. After adjusting for patient-specific and department-level covariates, Care Initiation did not increase the number of diagnostic laboratory tests ordered. Care Initiation was associated with increased waiting room time by 1.8 hours and longer time from arrival until disposition by 1.3 hours, but with decreased time in the main treatment area by 0.6 hours, which represents a 15% reduction.

Conclusion: Care Initiation was associated with a 15% reduction in time spent in the main ED treatment area but longer waiting room time and longer time until ED disposition without significantly increasing the number of laboratory studies ordered. While previous studies produced similar results with Care Initiation models accessing all diagnostic modalities including imaging, our study demonstrates that a more limited Care Initiation model can still result in operational benefits for EDs. [West J Emerg Med. 2023;24(4)703–709.]

INTRODUCTION

Emergency departments (ED) often experience significant crowding, which can lead to prolonged patient wait times and worse outcomes.[1,2] This has been exacerbated by increasing numbers of admitted patients boarding in the ED while waiting for an inpatient bed. These inpatient boarders

consume ED resources including beds and staff and slow the department's ability to manage newly arriving patients.[3,4] Multiple strategies have been employed by EDs across the country to prevent delays in care, including the use of Care Initiation and clinician-in-triage models.[5,6]

Care Initiation and clinician-in-triage models involve placing an emergency physician or physician assistant (PA) at the point of triage who can rapidly screen patients and determine initial plans of care.[7] The clinician is often empowered to treat and directly discharge patients with straightforward complaints and initiate evaluation and treatment for patients with more complex complaints.[8] Multiple studies in the literature describe single-site implementation of these models in different ED settings,[9–11] but their impact may depend on capabilities and resources dedicated to these front-end models and may also depend on specific characteristics of the individual sites, such as patient populations, staffing levels, and bottlenecks in care.[7] Moreover, their primary focus has been on operational metrics such as left without being seen (LWBS) rates, door-to-clinician time, and ED length of stay,[12] and few of these studies attempted to quantify the effect of Care Initiation models on utilization of ED resources.

The Care Initiation system at our institution differs from many others in that it is restricted to laboratory diagnostic testing and is deployed at an academic medical center with a highly complex transplant and oncologic population. Our objective in this study was to assess the impact of Care Initiation at our institution by comparing the number of diagnostic tests ordered and to assess whether this strategy offers the same operational improvements seen in other studies.

Population Health Research Capsule

What do we already know about this issue?
Many emergency departments (ED) have implemented Care Initiation to start the diagnostic work-up of patients while they are still in the waiting room.

What was the research question?
We analyzed how Care Initiation impacts the number of lab orders and ED operational metrics.

What was the major finding of the study?
Care Initiation did not increase lab order numbers and was associated with 0.6 fewer hours in an ED bed.

How does this improve population health?
Care Initiation can help address ED capacity constraints without significantly increasing the cost of care.

METHODS

Study Design and Setting

We performed a retrospective cohort study of patients presenting to our academic ED in the Northeastern United States in the month of October 2021. The ED is a Level I trauma center, comprehensive stroke center; it is affiliated with a comprehensive oncologic treatment center and had an annual census of ≈65,000 ED visits in 2021. The study was approved by the institutional review board (Protocol 2022P000264) and performed according to STROBE guidelines.[13]

The Care Initiation program in the ED was implemented in January 2021 and was designed to start laboratory work-up including blood and urine studies on waiting room patients. The program operated from noon to midnight on weekdays and was staffed by a PA with at least two years of experience working in the ED. The PA would screen all triaged patients in the waiting room and based on their clinical evaluation would order lab studies based on what they determined would be needed as part of the ED work-up. The required blood and urine samples would be obtained and the patient returned to the waiting room, where the patient continued to wait for a care space in the ED (Figure 1). The Care Initiation PA was not authorized to order radiologic studies in this program. When Care Initiation was not active, patients would wait in the waiting room until an open care space was available in the ED as per usual care.

Outcome Measures and Data Collection

We obtained data were obtained from the electronic health record (Epic Systems Corporation, Verona, WI) for all ED encounters at our institution in October 2021. The ED encounters were categorized based on whether Care Initiation was active and whether the encounter proceeded through the Care Initiation program. We excluded ED encounters in which patients arrived via emergency medical services (ground or air) or no lab work was ordered as they were not considered for Care Initiation at triage. Individual patient variables included patient age, gender, race/ethnicity, and Emergency Severity Index (ESI). Operation-level variables included number of ED arrivals in the prior four hours at time of patient presentation and percentage of ED bed occupancy at time of ED presentation. Timestamps were obtained for each patient encounter, which included ED arrival, ED rooming, and ED disposition. Primary outcome variables included the number of diagnostic lab tests ordered prior to ED disposition and the length of time the patient spent in the main ED. The lab tests included were compiled from a list of the 25 most frequently ordered lab tests in the

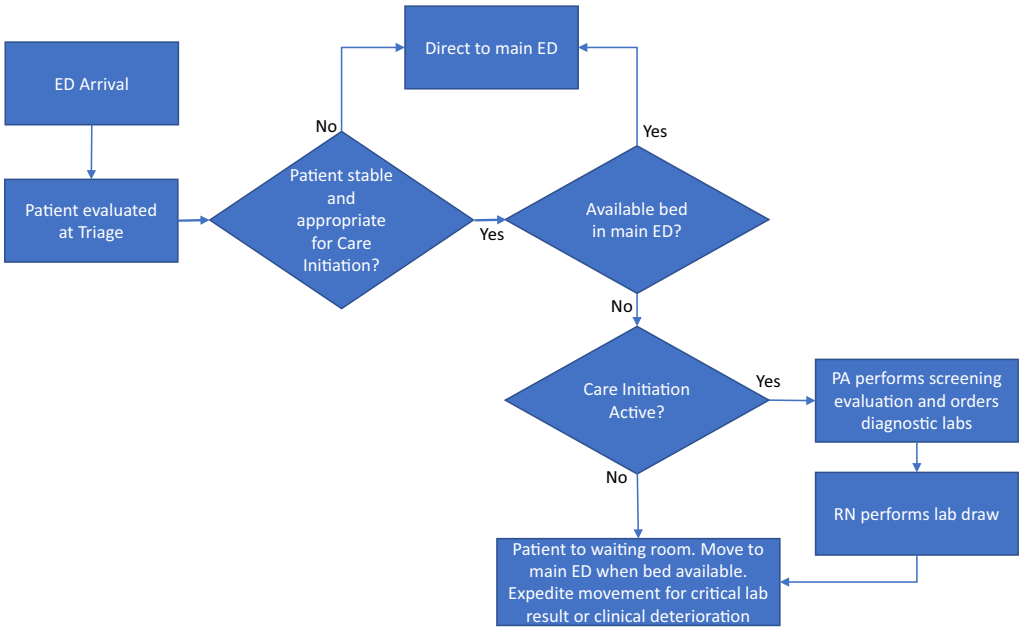

Figure 1. Care Initiation model.

ED at our institution (Supplement 1). Secondary outcome variables included ED waiting time and time from ED arrival to ED disposition.

Data and Statistical Analysis

We analyzed data at the encounter level and performed statistical analyses in Stata 15 (StataCorp, College Station, TX). Comparisons between continuous variables were calculated for demographic variables using medians and quantile regressions and for outcome variables using Student *t*-tests. We calculated comparisons between categorical variables using chi-square tests, and we used logistic regression to calculate the unadjusted and adjusted treatment effect of Care Initiation. Because of the observational nature of the data and unequal probability of selection for Care Initiation, which can introduce bias, we performed several sensitivity analyses. Propensity score matching was performed based on patient age, gender, ESI, number of ED arrivals within the prior four hours, and percentage occupancy of ED beds as covariates in a logistic model to quantify the matched effect of Care Initiation on outcome measures. Additional sensitivity analysis of the outcome measures was performed using inverse probability weighting.

RESULTS

Excluding patients who arrived via EMS, there were 2,407 ED patient encounters at our institution where lab testing was ordered (Table 1). Of those 2,407 encounters, 1,191 occurred when the Care Initiation program was active, and 811 (68%) underwent Care Initiation while the other 380 encounters (32%) proceeded directly to the ED. Among patients who arrived during Care Initiation hours, patients who underwent Care Initiation were more likely to be female (65% vs 54%), had lower acuity by ESI (median 3 vs 2), and were less likely to be admitted to the hospital (37% vs 45%) ($P < 0.05$ for all comparisons). Patients were also more likely to bypass Care Initiation when there were fewer ED arrivals in the prior four hours (medians 61 vs 64) and when the percentage of occupied ED beds was lower (median 85% vs 86%) ($P < 0.05$ for all comparisons). Moreover, patients who arrived during Care Initiation hours were more likely to be White than Black and tended to have higher acuity by ESI and rate of admission compared to patients who arrived outside Care Initiation hours. Outside Care Initiation hours, there also tended to be fewer arrivals in the prior four hours and a smaller percentage of occupied ED beds.

Patients who proceeded through Care Initiation had fewer lab tests ordered prior to ED disposition than patients who proceeded directly to the main treatment area (6.8 vs 7.3 lab orders, $P < 0.01$). This difference was not statistically significant after accounting for patient-specific variables of age, gender, and ESI acuity (Table 2). Patients who arrived during Care Initiation hours had more lab tests ordered than those who arrived outside of Care Initiation hours (7.0 vs 6.5, $P < 0.01$).

Patients who experienced Care Initiation had a significantly longer time in the waiting room (3.2 vs 1.2 hours, $P < 0.01$) and longer time from ED arrival to ED disposition (6.7 vs 5.1 hours, $P < 0.01$) compared to patients who did not proceed through Care Initiation (Table 3). These differences decreased in magnitude but persisted even after adjusting for patient-specific variables of age, gender, and ESI acuity. However, they had a shorter length of time spent in the main ED treatment area (3.6 vs 3.9 hours, $P < 0.01$), and this persisted

Table 1. Patient demographics.

	Patients arriving during Care Initiation hours		Patients arriving outside Care Initiation hours
	Patients proceeding through Care Initiation	Patients proceeding directly to main ED	All patients
Number of patients (N)	811	380	1,216
Age: median (IQR)	49 (32, 66)	53 (34, 69)	51 (33, 66)
Gender: N (%)			
Female	530 (65)*	206 (54)*	746 (61)
Male	281 (35)*	174 (46)*	470 (39)
Race: N (%)			
Asian	34 (4)	12 (3)	48 (4)
Black	138 (17)	63 (17)	280 (23)
White	473 (58)	238 (63)	646 (53)
Other/multiple	166 (20)	67 (18)	242 (20)
Ethnicity: N (%)			
Hispanic	157 (19)	75 (20)	256 (21)
Non-Hispanic	654 (81)	305 (80)	960 (79)
ESI Acuity: N (%)			
1	0 (0)*	4 (1)*	0 (0)
2	303 (37)*	233 (61)*	509 (42)
3	496 (61)*	128 (34)*	660 (54)
4	12 (1)*	14 (4)*	45 (4)
5	0 (0)*	1 (0)*	0 (0)
Number of ED arrivals in the prior 4 hours: median (IQR)	64 (59, 71)*	61 (52, 69)*	38 (24, 53)
Percentage ED bed occupancy at ED arrival: median percentage (IQR)	86 (83, 89)*	85 (81, 89)*	69 (59, 76)
ED disposition: N (%)			
Admission	301 (37)*	170 (45)*	384 (32)
ED observation	5 (1)*	12 (3)*	23 (2)
Discharge	505 (62)*	198 (52)*	809 (67)

*$P < 0.05$.
ED, emergency department; *IQR*, interquartile range; *ESI*, Emergency Severity Index.

after accounting for patient-specific variables of age, gender, and ESI acuity. During hours when Care Initiation was not active, patients experienced shorter length of time in the waiting room (1.2 vs 2.5 hours, $P < 0.01$) and less time from arrival to ED disposition (5.4 vs 6.2 hours) but longer time in the main treatment area (4.2 vs 3.7 hours, $p < 0.01$).

Given intrinsic differences between patient groups based on time of arrival and whether they proceed through Care Initiation, we performed propensity score analysis with matching and inverse probability weighting to evaluate the direct impact of Care Initiation on outcome measures. After matching patients based on individual patient factors of age, gender, and ESI and based on ED-level operational variables of number of ED arrivals in prior four hours and percentage occupancy of ED beds, we found that Care Initiation did not significantly affect the number of lab studies ordered. However, Care Initiation did significantly impact time metrics for patients by on average shortening time in the main treatment area for patients by 0.6 hours ($P < 0.01$) and lengthening time in the waiting room by 1.8 hours ($P < 0.01$) and time from arrival to ED disposition by 1.3 hours ($P < 0.01$). This overall shortened the length of time that patients occupied a bed in the ED by 15%. Covariate balance was acceptable based on standardized differences and variance

Table 2. Study outcome measures without cohort matching.

	Patients arriving during Care Initiation hours		Patients arriving outside Care Initiation hours		
	Patients proceeding through Care Initiation: average (SD)	Patients proceeding directly to main ED: average (SD)	All patients: average (SD)	Care Initiation unadjusted average treatment effect: unadjusted ATE (95% CI)	Care Initiation adjusted average treatment effect: adjusted ATE (95% CI)
Number of patients (N)	811	380	1216	1191	1182
Number of lab orders prior to ED disposition	6.8 (2.8)*	7.3 (3.8)*	6.5 (3.2)	−0.6 (−1.0 to −0.1)	−0.3 (−0.8 to 0.1)
Waiting room time in hours	3.2 (1.6)*	1.2 (1.6)*	1.2 (1.4)	2.0 (1.8 to 2.2)	1.7 (1.5 to 1.9)
Time in main ED in hours	3.6 (2.0)*	3.9 (2.1)*	4.2 (2.1)	−0.4 (−0.6 to −0.1)	−0.5 (−0.8 to 0.2)
Total time from arrival to disposition in hours	6.7 (2.6)*	5.1 (2.6)*	5.5 (2.5)	1.6 (1.0 to 1.9)	1.2 (0.8 to 1.5)

**$p < 0.05$.
ED, emergency department; *ATE*, average treatment effect; *CI*, confidence interval.

ratio (Supplement 2). Repeating this analysis using inverse probability weighting produced similar results (Table 3).

DISCUSSION

Emergency departments considering the implementation of Care Initiation and clinician in triage often have concerns that these processes will increase the overall number of lab tests ordered for a patient. This concern is understandable, as emergency clinicians try to anticipate the likely diagnostic work-up after performing only a brief assessment of the patient. In our study, Care Initiation did not significantly increase the number of lab orders before ED disposition, even after propensity score matching of patient cohorts. We found no broad consensus in previous literature on this topic. When Care Initiation is applied to a broad population, some studies suggest that it is associated with more diagnostic testing including radiology imaging.[11,14] Other studies focusing specifically on patients with abdominal pain have found either no difference or higher use of diagnostic imaging.[15,16] There may also be substantial differences depending on the type of clinician (emergency physician vs advanced practice practitioner [APP] vs triage nurse) performing this Care Initiation role. Two studies found that triage nurses order more tests than physicians,[17,18] while another showed no differences in total number of tests between APPs compared to physicians.[19] Our study, although limited to a front-end model that involves a PA ordering only lab tests, did not show an increased utilization of laboratory diagnostic testing for patients who proceed through Care Initiation even after accounting for patient-specific factors through propensity score matching. Our results support the role of APPs in Care Initiation and

Table 3. Propensity score and inverse probability weighting analysis.

	Propensity score matching		Inverse probability weighting	
	Average treatment effect of Care Initiation (95% CI)	*P*-value	Average treatment effect of Care Initiation (95% CI)	*P*-value
Number of lab orders prior to ED disposition: average (SD)	−0.2 (−0.7 to 0.3)	0.39	−0.4 (−0.9 to 0.1)	0.11
Waiting room time in hours: average (SD)	1.8 (1.3 to 2.0)	<0.01	1.6 (1.4 to 1.9)	<0.01
Time in main ED in hours: average (SD)	−0.6 (−0.9 to −0.3)	<0.01	−0.5 (−0.8 to −0.2)	<0.01
Total time from arrival to disposition in hours: average (SD)	1.3 (0.9 to 1.6)	<0.01	1.1 (0.8 to 1.5)	<0.01

ED, emergency department; *CI*, confidence interval.

provide reassurance against overutilization of diagnostic resources, although further monitoring particularly with regard to radiology is warranted based on the literature.

We were able to show that Care Initiation shortened the length of time patients spend in an ED bed by 0.6 hours, which is significant given this represents a 15% reduction. However, this came at the cost of increasing a patient's total time in the ED until disposition, mostly due to longer time in the waiting room. This is consistent with previous literature that showed shorter length of time in an ED bed but a longer time until disposition[20] when clinicians in triage initiate ED work-up. This is desirable for most EDs as they are able to use time in the waiting room to advance care while minimizing time in an ED bed, which is a scarcer resource. Furthermore, it is significant that while most previous studies observed this reduction of time in an ED bed when the triage clinician had full access to all lab and imaging tests including computed tomography, we were able to demonstrate a similar effect through lab orders alone.

This is notable because waiting for diagnostic imaging resources is often an operational bottleneck that is part of the "critical path" for many patients,[7] and there may also be logistic challenges for patients in the waiting room to join the queue for diagnostic imaging. These advantages of Care Initiation are in addition to improving other common ED metrics such as reducing door-to-clinician time and LWBS rates, which have been extensively studied in the literature.[21–23]

Care Initiation may also have additional benefits for patients who do not go through the process itself. Our data suggests that even the patient cohort who bypassed Care Initiation experienced shorter time in an ED bed before disposition compared to when Care Initiation was not active. This may be because faster throughput of Care Initiation patients through ED beds allows resources to be focused on higher acuity patients. Moreover, having a clinician in triage may allow more frequent reassessment of waiting room patients and identification of those who may decompensate after spending several hours waiting with relatively infrequent monitoring.

LIMITATIONS

There are several limitations to our study. First, this was a single-center, retrospective cohort study that examined ED encounters occurring over the span of a month and used an institutional-specific form of Care Initiation. Our data, therefore, may not be applicable to all EDs despite sharing many similarities with other models. We have since transitioned toward a Care Initiation model designed to discharge patients directly from the Care Initiation area, which will be the subject of further study. We were also limited in the scope of our data to after deployment of Care Initiation; additional analyses could be performed when comparing pre- and post-implementation outcomes. Moreover, propensity score matching can introduce additional bias into the dataset, but this is most likely ameliorated by reproducing the same results with inverse probability weighting methodology. Finally, our results are likely not applicable to very high-acuity or low-acuity patients due to their deliberate exclusion from Care Initiation models, which is a common practice in EDs across the country.

CONCLUSION

Overall, Care Initiation at our institution did not significantly increase the number of lab diagnostic tests ordered and resulted in shortening the average length of time spent in an ED bed by 0.6 hours, which is 15% of the average time to ED disposition. Although every ED faces unique challenges in throughput and efficiency, implementation of Care Initiation and other clinician-in-triage programs may offer some relief especially in EDs with prolonged wait times and significant crowding.

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Disparities in Emergency Department Naloxone and Buprenorphine Initiation

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Introduction: Prescribing of buprenorphine and naloxone in the emergency department (ED) has been shown to be an effective intervention. The purpose of this study was to determine the frequency of prescribing of naloxone and buprenorphine and the sub-groups that may be more or less likely to receive treatment.

Methods: We used a national electronic health record database to identify patients with opioid poisoning or overdose presenting between January 2019–December 2021. Patients who were prescribed naloxone or buprenorphine were identified in this dataset and then further segmented based on self-identified gender, age, racial and ethnic identity, income categories, and social vulnerability index in order to identify sub-groups that may be less likely to be prescribed treatment.

Results: We found 74,004 patients in the database whom we identified as presenting to the ED with an opioid poisoning or overdose. Overall, 22.8% were discharged with a prescription for naloxone, while 0.9% of patients were discharged with buprenorphine products. Patients were less likely to receive naloxone prescriptions if they were female, White or Pacific Islander, non-Hispanic, not between the ages of 18–65, and non-English speaking. We found the same pattern for buprenorphine prescriptions except that the results were not significant for ethnicity and English-speaking.

Conclusion: Despite evidence supporting its use, buprenorphine is not prescribed from the ED in a substantial proportion of patients. Naloxone is prescribed to a higher percentage, although still a minority of patients receive it. Some sub-groups are disadvantaged in the prescribing of these products. Further study may assist in improving the prescribing of these therapies. [West J Emerg Med. 2023;24(4)710–716.]

INTRODUCTION

Since the onset of the COVID-19 pandemic in 2020, the opioid overdose crisis has worsened with over 100,000 deaths in the United States between May 2020–April 2021, a grim 28.5% increase from the prior year.[1,2,3] The emergency department (ED) is a vital entry point into the healthcare system for patients seeking care for opioid use disorder (OUD) and its associated complications and offers a critical opportunity to provide lifesaving interventions such as medication to treat opioid use disorder (MOUD) and take-home naloxone.

Highly effective medications approved by the US Food and Drug Administration to treat and reduce the harmful effects of OUD and illicit opioid use are available but underused, and they are often inaccessible to people who use opioids. The MOUD with buprenorphine or methadone is evidence-based, well tolerated, retains people in treatment, reduces illicit opioid use at high doses, and reduces mortality.[4,5,6,7] Treatment for OUD initiated in the ED is feasible, leads to decreased illicit drug use and increased long-term retention and engagement when paired with follow-up addiction treatment services.[8,9] Despite an abundance of

evidence, less than 35% of adults with OUD received MOUD treatment in 2019 across all treatment settings.[10]

Take-home naloxone is another critical tool to reduce overdose mortality and requires minimal training to be used effectively.[11,12] Despite supporting evidence, studies indicate that take-home naloxone access is poor, with fewer than half of overdose patients receiving a prescription for the medication within one healthcare system and only one of 13 patients receiving a prescription nationally.[13,14] Some of the reported barriers include cost, patient receptiveness, regulatory barriers, and healthcare staff time.[15]

A recent prior study has indicated that nationally, following non-fatal overdose in the ED, only one of 12 patients are initiated on buprenorphine.[14] That study found differences in prescribing based on gender, age, geographic location, and insurance status. The database used in that study under-represented the uninsured and Medicaid patients, and there were limitations in the ability to study some subsets of patients. Our purpose in this study was to evaluate whether disparities exist for racial and ethnic minorities in naloxone and buprenorphine prescribing for patients presenting to the ED with an opioid overdose.

Population Health Research Capsule

What do we already know about this issue?
Buprenorphine is effective at reducing illicit opioid use and increases treatment retention when initiated in the emergency department.

What was the research question?
Among patients who present to the emergency department (ED) with an opioid overdose, do racial and ethnic disparities exist for prescribing naloxone and buprenorphine?

What was the major finding of the study?
These treatments are not often prescribed in the ED. Prescribing disparities are small, likely due to greater access to DEA-waivered clinicians in racially diverse ZIP codes.

How does this improve population health?
Disparities in buprenorphine and naloxone prescribing may be reduced with greater overall access to these treatments in the ED.

METHODS

The Azure Cosmos database (Microsoft Corporation, Redmond WA) is composed of submissions from organizations that participate in the Epic electronic health record system (Epic Systems Corporation, Verona, WA). Participating organizations contribute a HIPAA-defined, limited dataset for all patients into the database. Individuals from participating organizations can obtain a user license to query the database. At the time of this study, there were approximately 130,000,000 unique patients in the Cosmos dataset. The states with the highest populations include California, Texas, Illinois, Ohio, and New York. The database does not allow the identification of the specific organizations, or the characteristics of the organizations, associated with individual patients.

We used the encounter data model to query the database. Patients with an encounter type that included an ED visit without a hospital admission were selected. Patients who expired during the ED encounter were eliminated. We further categorized encounters to select those with a Systematized Nomenclature of Medicine (SNOMED) diagnosis of heroin, methadone, morphine, and fentanyl or opioid poisoning or overdose. The SNOMED is the coding terminology platform maintained by the International Health Terminology Standards Organization. These diagnoses were chosen based on an analysis of diagnoses associated with ED naloxone administration. We identified the prescribing of MOUD for naloxone or buprenorphine using the prescribing field within the database.

The Cosmos dataset includes self-identified gender, self-declared racial and ethnic identities, and age among other demographic parameters. In this database you cannot determine the exact patient age; therefore, we used various age ranges. The database contains a social vulnerability index (SVI) based on census tract data with a higher index indicating greater vulnerability.[16] The SVI includes components of estimated income, age, disability, household composition, minority status, language, housing, and transportation. We have reported our data as the absolute numbers and frequency. Because the database maintains HIPPA compliance any numbers less than 10 are reported as 10. Statistical comparisons were made using the chi-square test using a $P<0.05$ to indicate significance. The data is reported with the P-value. Our institutional review board (IRB) determined that the study did not require IRB approval as it uses a HIPPA-compliant limited dataset for analysis.

RESULTS

There were approximately 53 million ED visits contained within the Cosmos database during the study period. Of these, 74,004 met the entry criteria based on the SNOMED criteria. Patients were classified as follows: 67% were male, 76% White, and 18% Black; 95% were between the ages of 18-65; and 96% reported themselves to be English speakers.

The proportion of patients prescribed naloxone by self-reported gender, age, race, ethnicity and social vulnerability

index (SVI) are reported in Table 1. We found that that 22.8% of patients received a prescription for naloxone following an ED visit for opioid poisoning or overdose. Female patients were less likely to receive a prescription compared to males. Patients classified as White and Pacific Islander were least likely to receive naloxone prescriptions. Patients classified as non-Hispanic were least likely to receive prescriptions as were patients below the age of 18 and above the age of 65, along with non-English speakers. Although there were differences in prescribing based on the SVI it did not follow a consistent pattern.

Buprenorphine prescribing by subgroup is reported in Table 2. We found very low prescribing rates for buprenorphine overall at only 0.9%. Like our findings for naloxone, the groups least likely to receive buprenorphine were women and White patients; however, unlike naloxone prescribing, patients <18 and >65 were slightly more likely to receive a prescription for buprenorphine. The numbers for patients <18, however, were low and estimated due to the constraints of the database. There were inconsistent results based on the SVI.

DISCUSSION

The opioid overdose epidemic that started in the mid-1990s with prescription medications has progressively become more lethal as illicit substances have replaced pharmaceuticals. The face of a typical opioid user has also changed with this shift to impact a more racially diverse population. In the years preceding the COVID-19 pandemic, mortality was highest among White males; however, new data suggests this is changing. There was a 48.8% increase in overdose fatalities among Blacks compared to a 26.3% increase for Whites between 2019–2020.[17] Connecticut was the first state to report that the overdose fatality rate for Blacks had outpaced the rate for Whites in 2019; and in 2020 for the first time in over two decades the US saw an overdose death rate in Blacks that outpaced Whites by 16.3% as the COVID-19 pandemic pummeled the US.[17,18]

All-cause mortality in the 12 months after a nonfatal opioid overdose is 4.7 deaths per 100-person years.[7] Following an ED overdose, among patients on any MOUD the odds of a subsequent overdose death is reduced by 30%, and length of stay is significantly reduced.[19] Buprenorphine

Table 1. Prescribing of naloxone by sub-groups.

	Naloxone		No Naloxone		
	Number	**Percent**	**Number**	**Percent**	***P*-value**
Female	5,152	21.9%	18,398	78.1%	$P = .000$
Male	11,716	23.3%	38,662	76.7%	
Other	21	27.6%	55	72.4%	
White	12,145	21.7%	43,806	78.3%	$P < .000$
Black	3,530	27.0%	9,522	73.0%	
American Indian	227	26.8%	620	73.2%	
Asian	95	25.4%	279	74.6%	
Other	1,895	24.3%	5,890	75.7%	
Native Hawaiian	46	20.5%	178	79.5%	
Hispanic	1,304	23.3%	4,282	76.7%	$P = 0.02$
Not Hispanic	14,718	22.7%	50,173	77.3%	
Other	867	24.6%	2,660	75.4%	
<18 years	82	10.2%	720	89.8%	$P < .000$
18–30 years	4,631	23.5%	15,117	76.5%	
30–65 years	11,545	23.0%	38,724	77.0%	
>65 years	631	19.8%	2,554	80.2%	
SVI <25th	3,006	22.9%	10,097	77.1%	$P = 0.04$
SVI 25th–50th	4,532	22.3%	15,777	77.7%	
SVI 50th–75th	6,092	21.7%	21,921	78.3%	
SVI>75th	11,349	22.4%	39,367	77.6%	
English-speaking	16,328	23.0%	54,790	77.0%	$P = .000$
Non-English speaking	551	19.6%	2,267	80.4%	

SVI, social vulnerability index.

Table 2. Prescribing of buprenorphine by sub-groups.

	Buprenorphine		No Buprenorphine		
	Number	Percent	Number	Percent	*P* -value
Female	171	0.3%	49,876		$P < 00001$
Male	502	2.1%	23,379	97.9%	
Other	10	11.6%	76	88.4%	
White	444	0.8%	55,507	99.2%	$P < 00001$
Black	168	1.3%	12,884	98.7%	
American Indian	10	1.2%	842	98.8%	
Asian	10	2.6%	369	97.4%	
Native Hawaiian	10	4.3%	221	95.7%	
Other	93	1.2%	7,692	98.8%	
Hispanic	63	1.1%	5,523	98.9%	$P = .012$
Not Hispanic	573	0.9%	64,318	99.1%	
Other	37	1.0%	3,490	99.0%	
<18 years	10	1.2%	802	98.8%	$P < 0.02$
18–30 years	147	0.7%	19,601	99.3%	
30–65 years	492	1.0%	49,777	99.0%	
>65 years	34	1.1%	3,151	98.9%	
SVI <25th	149	1.1%	12,954	98.9%	$P = .00001$
SVI 25th–50th	253	1.2%	20,056	98.8%	
SVI 50th–75th	279	1.0%	27,734	99.0%	
SVI>75th	676	1.3%	50,040	98.7%	
English-speaking	656	0.9%	70,462	99.1%	$P = 0.09$
Non-English speaking	17	0.6%	2,801	99.4%	

SVI, social vulnerability index.

is associated with a decrease in all-cause mortality and opioid-related mortality.[7] Providing MOUD in the ED environment is feasible, although both real and perceived implementation barriers exist including state prescribing laws, stigma related to treating patients with addiction, insurance restrictions and reimbursement, time constraints for busy clinicians, and timely follow-up.[20,21] The US Drug Enforcement Administration (DEA) DATA-2000 waiver requirement and buprenorphine-prescribing limits posed a significant barrier to treatment access during the study period. That changed in 2023 when this requirement was eliminated by the US Congress, pavig the way for improved access to buprenorphine treatment for OUD.

The absence of opioid withdrawal in the ED should not be a barrier to prescribing buprenorphine, although it is often perceived as such. Buprenorphine may be administered to patients in the ED who are in opioid withdrawal and prescribed to any patient with moderate or severe OUD along with detailed instructions for home induction when opioid withdrawal begins.[22] Opioid withdrawal may be delayed in patients who are dependent on long-acting opioids like methadone; however, fentanyl and its analogues are the most prevalent illicit opioids leading to overdose fatality with half-lives ranging between of 0.15–7.7 hours when injected.[14,23]

For many who live in areas with poor access, the ED may be the only opportunity to initiate MOUD. A 2020 report by the Office of the Inspector General (OIG) found that 40% of US counties did not have a single clinician capable of providing MOUD with buprenorphine and 56% of counties with greatest need for MOUD had inadequate capacity to provide this care.[21] When the proportion of waivered clinicians is examined by ZIP code and race and ethnicity composition, the racially diverse ZIP codes have a greater proportion of clinicians capable of providing MOUD, suggesting that availability of a waivered clinician is less of a barrier for racially diverse populations.[24] Once initiated, treatment retention for patients on MOUD is similar for all genders, races, and ethnicities.[25]

Our study showed that White patients were less likely to receive a prescription for MOUD in the ED. This is counter

to a number of other studies that have found that Blacks or other minority patients are less likely to receive MOUD across the spectrum of treatment settings.[26] Prior research also indicated that disparities exist among racial groups' receipt of harm reduction services and medications to treat addiction, with Whites having greater access to all treatment modalities. Medications for OUD are also less likely to be offered to Blacks and Hispanics in short-term residential treatment, and they are also less likely to complete an initial treatment episode than Whites.[27–28] When the COVID-19 pandemic hit, access to MOUD and harm reduction services were disrupted among racial or ethnic minorities who self-reported that they were 8–10 times less likely to have access to clean syringes and naloxone than non-Hispanic Whites.[29] While our results are discrepant from other studies that report on treatment across the spectrum of treatment settings, ours is the first to examine prescribing disparities in the ED setting. The differences in MOUD prescribing are small and may reflect the overall increase in opioid use and overdose rate among minorities, who are more geographically concentrated in areas with higher access to DATA-waivered clinicians.[24]

As in two earlier single-center studies, we also found an increase in naloxone prescribing for Hispanic patients. In those previous studies, Hispanic patients were more likely than non-Hispanic Blacks and non-Hispanic Whites to receive a prescription for naloxone after opioid overdose. Another study did not find a difference in the receipt of naloxone among the Hispanic population.[30]

In our study, we found inconsistent differences in treatment based on the SVI. In prior work, CA Bridge, a program of the California Public Institute of Health, found that low-income patients and those with unstable housing were more likely to accept and receive treatment.[31,32] By contrast, patients with non-Medicaid insurance, stable housing, and older patients were less likely to receive treatment. The CA Bridge program attributed this to a social cognitive theory perspective; however, further study is needed to evaluate the reasons that patients with fewer resources are seemingly more likely to accept and receive treatment.[32]

We are unable to definitively determine the reason for the discrepant results between our study and prior work; however, the previous studies evaluated MOUD and naloxone access in a variety of ED and non-ED settings using different methodologies.

LIMITATIONS

This study was dependent on the accuracy of diagnosis coding that maps to SNOMED concepts. There may be other patients with opioid overdose who were coded in a different manner, such as having altered mental status without specifying an overdose. Further, patients may have presented with an overdose although they were then coded with a related medical problem such as aspiration pneumonia or any of the other complications of opioid overdose. We looked at the prescribing of MOUD co-incident with an ED encounter. Additional patients may have had counseling during the ED encounter that led to a follow-up visit where they were provided with MOUD. This study was focused on the prescribing based on an ED visit, and we excluded patients who were admitted and who may have subsequently received naloxone or buprenorphine prescriptions.

Our data searched prescribed medications and did not include patients who may have been given naloxone kits rather than having them prescribed. Our study was not designed to evaluate that possibility. Nor did it examine prescription fill rates, which would have provided additional information regarding access to these treatments and may be adversely impacted by the patient's healthcare coverage and SVI. Not all patients who are eligible to receive MOUD are willing to accept it. In this database study we could not determine the reason that patients were not prescribed medication as they may have been offered the medication and refused it. We did not exclude patients being sent to residential or long-term treatment facilities. It is possible that the emergency physicians may have deferred starting MOUD to the physicians in those settings, although we have no way to determine this.

Further, the nature of the Cosmos database did not allow us to determine characteristics of the treating hospitals nor whether they have addiction consult services. As a part of our review of the data we evaluated the diagnoses for all patients who received buprenorphine prescriptions from the ED and found that the vast majority were for initiation or continuation of OUD treatment. It is possible that some of the patients coded for opioid abuse also had an overdose, although we were unable to determine this. The nature of this database did not allow us to perform multiple regression analysis to look at relationships between, for example, gender, race, or age. The Cosmos database slightly over-represents both White and Black patients and under-represents the Hispanic population compared to the overall US population. Finally, no information regarding patients' insurance status was available to analyze.

CONCLUSION

Despite supporting evidence for their use, naloxone and buprenorphine are infrequently prescribed following an ED opioid overdose. Whites and females are least likely to receive a prescription for buprenorphine in the ED while Whites, females and Pacific Islanders are least likely to receive a naloxone prescription. Disparities exist in ED prescribing patterns for both buprenorphine and naloxone, but the disparities were small in this study and may reflect greater access to treatment in racially diverse ZIP codes and a greater

willingness to accept treatment among low-income patients with unstable housing. Further study is needed to determine what factors contribute to these disparities, what interventions can be implemented to reduce them, and whether additional disparities prevent patients from filling an ED prescription. The elimination of the DEA DATA-2000 waiver in 2023 may impact these disparities and will require future study.

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Flow through the Emergency Department for Patients Presenting with Substance Use Disorder in Alberta, Canada

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Introduction: Since 2016 the province of Alberta, Canada, has seen a significant increase in substance use disorder (SUD) presentations to the emergency department (ED) with a large surge during the COVID-19 pandemic. In this retrospective study we deconstruct the total length of stay (LOS) in the ED into stages for patients presenting with SUD and estimate the effects of covariates on the time to transition between stages.

Methods: Using the Canadian Coding Standards for International Classification of Diseases, 10th Modification, codes F10.0-F19.9 and T36.0-T50.9, we extracted data from the National Ambulatory Care Reporting System between April 1, 2019–March 31, 2020 on all ED presentations for SUD by Alberta residents. We used a multistate model to deconstruct the ED LOS into eight mutually exclusive states and determine which factors affected the time spent in each state.

Results: We analyzed 66,880 presentations (37,530 patients). The mean age was 37.2 years, and 61% were male. The median total LOS in the ED was 6 hours 13 minutes. Patients presenting with methamphetamines (METH) intoxication and patients from low-income neighborhoods had significantly increased transition times between all states. Opposite this, opiate use was associated with faster transition times between almost all states. Metro EDs experienced slower transitions when attempting to discharge or admit patients when compared to urban or rural EDs. Emergency department crowding also had a dramatic effect on physician initial assessment times, while discharge and admission times in patients presenting with SUD were also significantly affected.

Conclusion: Patients with SUD experience a variety of delays during their ED stay. Those with METH intoxication and those from the lowest income neighborhoods were most likely to experience slower transitions from state to state in the ED and may benefit from a focused approach to improve ED flow. [West J Emerg Med. 2023;24(4)717–727.]

INTRODUCTION

Emergency departments (ED) are seeing a steady increase in presentations related to substance use disorder (SUD).[1] Since 2016 the province of Alberta, Canada, has seen a significant increase of SUD presentations to the ED with a large surge during the COVID-19 pandemic.[2] These presentations are associated with increased resource utilization when compared to non-SUD presentations and increased healthcare expenditure costs, particularly in stimulant use disorder, such as methamphetamine (METH) use.[3] Methamphetamine use and subsequent ED-related presentations are rapidly increasing in the US[4–6] and

Canada,[7–9] accompanied by an increased ED length of stay (LOS) when compared to non-METH-related diagnoses.[10] Similarly, alcohol use has seen a significant increase in ED presentations[11] creating further issues due to its well-established prolonging effect on a patient's ED LOS.[12] It has been previously established that ED crowding contributes to poorer patient outcomes in all measured domains.[13] With this increasing ED burden due to SUD, more research is required to improve ED flow for the SUD patient. By identifying bottlenecks in their transition to admission or discharge, optimal targets may be identified that would produce the most impactful change on their overall ED LOS and ED crowding.

The primary objectives of this retrospective study were to deconstruct the total LOS in the ED into stages (also known as states) through the use of a multistate model and to estimate the effects of covariates on the time to transition between states. A secondary objective was to determine how ED crowding may be associated with the time spent in each state.

Population Health Research Capsule

What do we already know about this issue?
Substance use disorders are an increasingly common component of emergency department patient presentations with excessive resource utilization for their management.

What was the research question?
How does a diagnosis of substance use disorder affect a patient's flow through the emergency department?

What was the major finding of the study?
When compared to other substances, methamphetamine use specifically caused a prolonged transition time from state to state.

How does this improve population health?
Emergency department flow may be improved by targeting interventions that expedite the care of patients with methamphetamine use disorder.

METHODS

Study Design

In this population-based, retrospective cohort study we used data extracted from the National Ambulatory Care Reporting System (NACRS).[14] The Health Research Ethics Board of the University of Alberta (Pro00098444) approved this study. Alberta Health Services, the data custodians, provided operational and administrative approval. A data-sharing agreement governed data use. Informed consent was not obtained from individual patients, and only de-identified data were shared. No funding organization had any role in the conduct and reporting of this study.

Study Setting and Population

We extracted data for all presentations to all EDs in Alberta, Canada from April 1, 2019–March 31, 2020. Alberta is a province in western Canada with 109 EDs that serve a population of 4.5 million people.[15] Patients presenting with substance use disorder formed the study population. Presentations were classified as substance use if any one of the 10 diagnostic fields had International Statistical Classification of Diseases and Related Health Problems (ICD-10-CA)[16] codes of mental and behavioral disorders due to psychoactive substance use (F10.0 to F19.9) or poisoning by drugs, medicaments, and biological substances (T36.0 to T50.9). These were the same codes used by Di Rico et al.[17]

Study Protocol

The NACRS dataset included basic demographic information such as age, gender, and geography (postal code and health zone of residence). Dates/times of key points of the ED presentation (eg, start; physician initial assessment [PIA]; disposition decision), and ED facility are reported. Arrival mode (eg, ambulance), severity of a patient's condition upon arrival based on the Canadian Triage and Acuity Scale (CTAS: 1 = resuscitation, 2 = emergent, 3 = urgent, 4 = less urgent, 5 = non-urgent),[18] and up to 10 diagnosis fields using ICD-10-CA codes are provided. Presentations were categorized by substance type if any of the diagnosis fields included alcohol (any F10 [alcohol-related disorders]), MET use; any F15 [other stimulant-related disorders] or T43.6 [poisoning by, adverse effect of and underdosing of psychostimulants]), opioids (any F11 [opioid-related disorders] or T40 [poisoning by; adverse effect of; and underdosing of narcotics and psychodysleptics [hallucinogens]]), and other. Disposition included 16 categories that were grouped into discharged, admitted, transferred, left without being seen (LWBS), left against medical advice (LAMA), and died. There were few individuals who died in the ED, and they were excluded from the analyses.

We determined an indicator of ED crowding by calculating the median time from arrival to PIA for all presentations for any condition in each hour for each ED. Times over one hour were considered to be crowded in agreement with published guidelines.[19]

Linkages were made by Alberta Health Services to other Alberta Health databases to obtain additional variables. The

Charlson Comorbidity Index[20] based on a two-year lookback using NACRS and Discharge Abstract Database[21] records was dichotomized into those without comorbidities (ie, 0) and those with at least one comorbidity (ie, ≥1). Using the Pampalon Index,[22] we collapsed the average income of people aged >15 years into categories <$25,000, $25,000–$50,000, and >$50,000. And an urban status variable with four categories that were collapsed into metropolitan, urban, rural, and rural remote were provided based on local geographic boundaries of the patient's residence.

Key Outcome Measures

All patients begin in the start state. We determined the time associated with this as the minimum of the triage time and the time the patient presented to the ED. If a patient decides to leave prior to being seen by a physician, they are considered LWBS, in which case the time for transition is the time associated with patient departure from the ED. Once a patient is seen by a physician, they move to the PIA state, for which an exact time is recorded. From the PIA state, patients may move to the discharge disposition state, or the physician may decide to admit or transfer the patient instead, in which case they move to the admit/transfer disposition decision state. The time for both these transitions is given by the time to disposition. For patients whose ED presentation ends in LAMA, the time is given by the time associated with patient departure from the ED. If the decision is made to admit or transfer the patient, patients must wait again before transitioning into the admitted or transferred states. In either case, the time for this transition is given by the time of patient departure from the ED.

Data Analysis

Summary statistics such as counts, percentages, medians, and interquartile ranges (IQR) represented as 25th percentile, 75th percentile) describe the characteristics of ED presentations. We used a multistate modelling framework to model the flow through the ED by considering eight mutually exclusive states as depicted in Figure 1: start; PIA; discharge disposition decision; admit/transfer disposition decision; admitted; transferred; LWBS; and LAMA. Initial models considered one covariate at a time to provide unadjusted hazard ratios (HR). Full models used all covariates, and these models were subsequently reduced via backwards selection until maximum parsimony was achieved (as per Akaike's information criterion[23]). For all transitions, the covariates considered were gender, age, comorbidity, income category, weekend indicator (Saturday and Sunday were grouped as "weekend"), shift (day: 0800-1559, evening:1600-2359, night: 0000-0759), arrival by ambulance, urban status, CTAS, indicators for alcohol, MET, and opioid use diagnoses, and the PIA crowding indicator.

We completed analyses in the statistical software R (R Foundation for Statistical Computing, Vienna, Austria).[24] The msm package[25] was used to fit all models, and the forest plot package[26] displays HRs along with 95% confidence intervals. A HR >1 indicates that the time to transition is shorter for individuals of that group compared to the reference group, and a HR <1 indicates that the time to transition is longer for individuals of that group compared to the reference group.

RESULTS

Characteristics of ED Presentations

During the study period, there were 2,302,147 presentations to Alberta EDs, and 66,880 presentations were for substance use (37,530 patients) and available for analysis (Figure S1). The majority of patients had repeated presentations (78%), while only 22% presented to the ED once. The majority of presentations were by males (61.2%, Table 1), from the metropolitan areas (61.5%) in the health

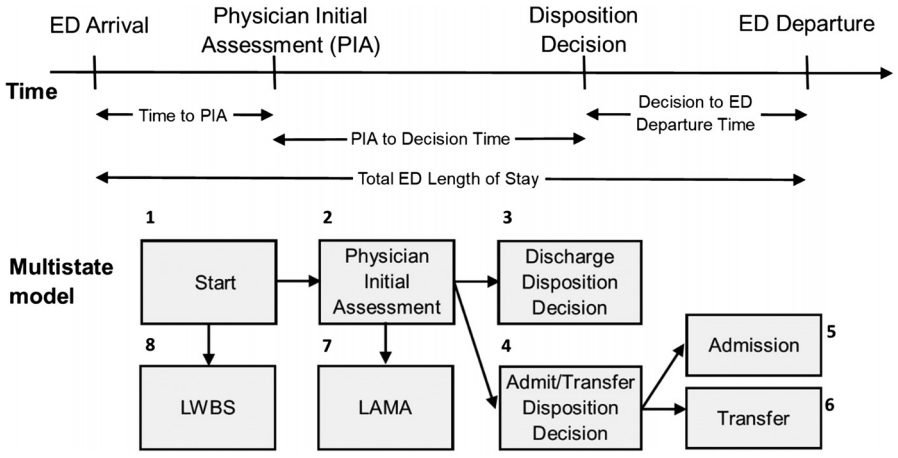

Figure 1. Multistate model of transitions through the emergency department.
LWBS, left without being seen; *LAMA*, left against medical advice.

Table 1. Characteristics of 67,416 emergeny department presentations for substance use.

	n	(%)
Age in years, mean (SD)	37.2	15.1
Gender		
Male	40,913	61.2
Female	25,961	38.8
Missing	6	0.0
Health Zone of Residence		
North	7,474	11.2
Edmonton	24,159	36.1
Central	6,510	9.7
Calgary	21,792	32.6
South	5,705	8.5
Missing	1,240	1.9
Population Centre Type of Residence		
Metro	41,119	61.5
Urban	7,256	10.8
Rural	12,379	18.5
Remote	1,816	2.7
Missing	4,310	6.4
Average Neighborhood Income		
< $25,000	5,550	8.3
$25,000–$50,000	28,020	41.9
> $50,000	29,000	43.4
Missing	4,310	6.4
Number of Comorbidities per the Charlson Comorbidity Index		
0	49,158	73.5
≥1	17,722	26.5
Arrival Mode		
Ambulance	32,731	48.9
Day of Week		
Weekday	46,319	69.3
Weekend	20,561	30.7
Time of Day		
Day (0800–1559)	21,194	31.7
Evening (1600–2359)	28,162	42.1
Night (0000–0759)	17,524	26.2
Triage Level		
1 = Resuscitation	2,222	3.3
2 = Emergent	25,063	37.5
3 = Urgent	28,671	42.9
4 = Less Urgent	9,131	13.7
5 = Non-urgent	1,236	1.8
Missing	557	0.8
Diagnostic Category		
Alcohol	32,780	49.0
Methamphetamines	10,759	16.1
Opioids	9,720	14.5
None of the above	16,837	25.2
Disposition		
Discharged	43,190	64.6
Admitted	12,921	19.3
Transferred	4,918	7.4
Left before being seen	3,652	5.5
Left against medical advice	2,199	3.3
Crowding Level		
Crowded (median time to physician initial assessment >1 hour)	48,149	72.0

ED, emergency department.

zones of Edmonton (36.1%) and Calgary (32.6%), and from neighborhoods where the average income was at least $25,000 (41.9% with $25,000–$50,000, 43.4% with >$50,000). Weekends were popular days for presentations (69.3%), and presentations were mostly considered urgent (CTAS 3 42.9%) or emergency (CTAS 2 37.5%). Based on the prior two years of ED and hospitalization data, comorbidities were not present for the vast majority of presentations (73.5%), and alcohol was the most common substance at the presentation (49.0%). Almost 65% of presentations ended in discharge, 19.3% ended in admission, and 7.4% ended in transfer.

Overall, the median time spent in the ED was 6 hours (h) 13 minutes (min) (IQR 3h 20min, 11h 36min, Table 2, Figure 2). Patients were seen by a physician in a median time of 1h 13min (IQR 32min, 2h 29min), and once seen, discharged patients had a median time to discharge of 3h 36min (IQR 1h 32min, 7h 20min) and admitted patients took longer with a median time to admission of 5h 39min (IQR 3h 8min, 9h 31min). We note that because most of the 4,204 patients who were transferred (State 6) had an instantaneous transition from the disposition decision state (State 4), the key summary statistics are 0h.

Multistate Modelling

We focused on a few transitions using the multivariable model and have provided all results for unadjusted HRs and adjusted HRs in Tables S1 and S2, respectively, with forest plots for adjusted HRs in Figures S2–S4.

For the start to PIA transition (State 1 to State 2), patients residing in urban (HR 1.27), rural (HR 1.44), and rural remote (HR 1.44) municipalities saw the physician quicker

Table 2. Summaries of the time spent in each state.

Period	n	Median	(25th percentile, 75th percentile)
Total Length of Stay	66,880	6h 13min	3h 20min, 11h 36min
Start to Physician Initial Assessment (PIA) (State 1 to 2)	61,167	1h 13min	0h 32min, 2h 29min
PIA to Discharge Disposition (State 2 to 3)	43,189	3h 36min	1h 32min, 7h 20min
PIA to Admit or Transfer Disposition (State 2 to 4)	15,763	5h 39min	3h 8min, 9h 31min
Admit or Transfer Disposition to Admission (State 4 to 5)	12,906	3h 16min	1h 4min, 14h 32min
Admit or Transfer Disposition to Transfer (State 4 to 6)	4,204	0h 0min	0h 0min, 0h 0min
Start to Left Without Being Seen (State 1 to 8)	3,652	2h 34min	1h 21min, 4h 14min
PIA to Left Against Medical Advice (State 2 to 7)	1,417	2h 35min	1h 10min, 5h 25min

h, hours; *min*, minutes.

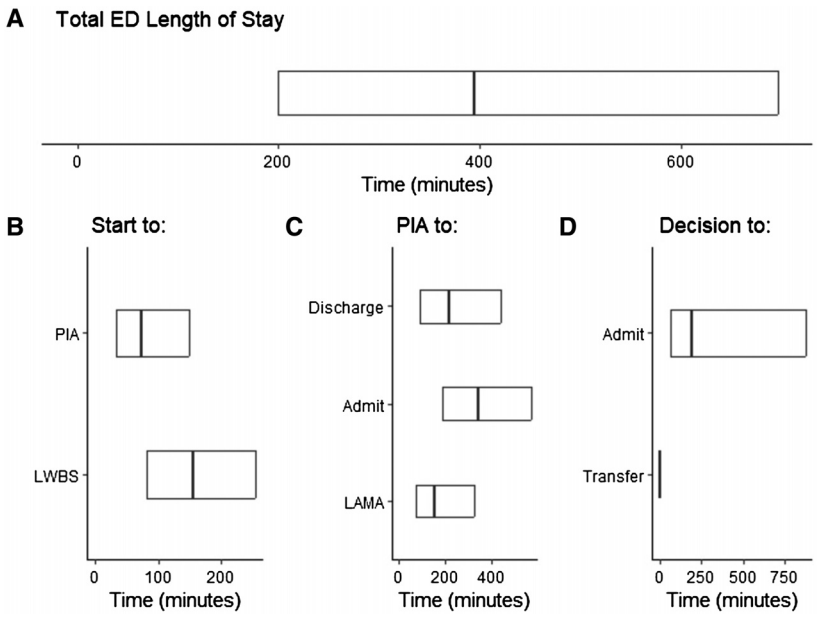

Figure 2. Summaries (25th percentile, median, 75th percentile) of the total length of stay (A) and the time spent in each state based on starting state: (B) start, (C) physician initial assessment (PIA), and (D) disposition decision.
ED, emergency department.

than patients from metropolitan municipalities. Patients with SUD were significantly affected by crowding. as patients in crowded EDs had longer times to wait to see a physician than patients presenting to uncrowded EDs (HR 0.35, Figure 3). Patients presenting with METH use also had longer times than those without METH use (HR 0.89). Lastly, patients from the lowest income neighborhoods had a longer transition time to PIA than those from neighborhoods with average incomes >$50,000 (HR 0.82).

Once seen by a physician, lower acuity (CTAS 4: HR 1.56, CTAS 5: HR 2.44) and opioid-related concerns (HR 1.30) had shorter times from PIA to discharge disposition decision (State 2 to 3, Figure 4). Longer times were associated with arriving by ambulance (HR 0.80), presenting with METH use (HR 0.79), with at least one comorbidity (HR 0.85), being female (HR 0.90), and older age (HR 0.92 per 10 years).

For patients whose disposition decision was admission or transfer (State 2 to 4), higher acuity (CTAS 1: HR 1.39; CTAS 2: HR 1.11), living in a non-metropolitan municipality (urban: HR 1.36; rural: HR 1.29; remote: HR 1.53), having at least one comorbidity (HR 1.18), and older age (HR 1.11 per 10 years) had shorter transition times (Figure 5). Living in a neighborhood with low average income (<$25,000, HR 0.73), arriving after 4 PM (evening shift: HR 0.7; night shift: HR 0.72), arriving on a weekend (HR 0.91), arriving by ambulance (HR 0.91), and presenting with alcohol (HR 0.94) or METH use (HR 0.89) was

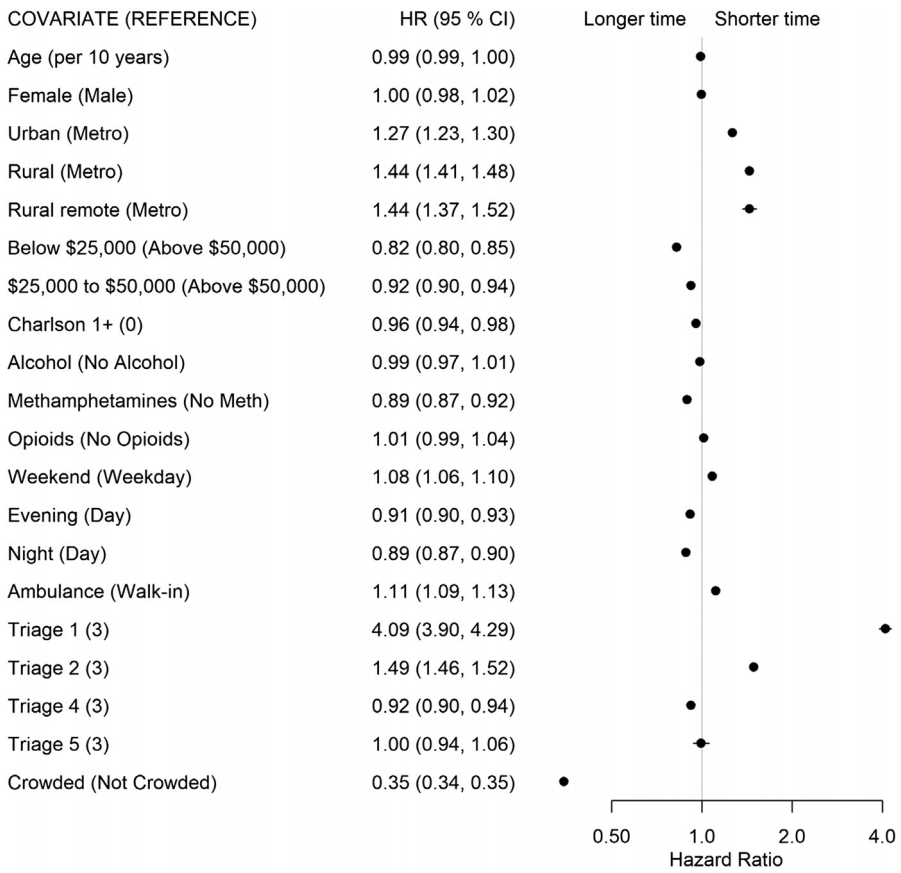

Figure 3. Forest plot of adjusted hazard ratios and associated 95% confidence intervals by covariates for the start (State 1) to physician initial assessment (State 2) transition for the multivariable model.
HR, hazard ratio; *CI*, confidence interval.

associated with longer transition times. There was no evidence of ED crowding affecting this transition.

The factors associated with a shorter time for patients to be admitted out of the ED (State 4 to 5, Figure 6) included living in a non-metropolitan municipality (urban: HR 1.76; rural: H 2.00; remote: HR 3.13), presenting with opioid- (HR 1.25) or alcohol-related concerns (HR 1.28), and being female (HR 1.17). Conversely, living in a neighborhood with a low average income (<$25,000: HR 0.79), presenting with METH-related concerns (HR 0.71), and presenting to a crowded ED (HR 0.79) were associated with longer times to admission.

DISCUSSION

In this population-based study we used over 37,000 patients with over 66,000 ED presentations to examine the flow through the ED for those presenting with SUD. The median LOS of patients included in our study (6h 13m) is comparable to the median LOS for all-cause patients presenting to major EDs in Alberta as reported by the provincial visual analytics platform Tableau (Tableau LLC, Seattle, WA) during the same time period (6h 18min).[27] The total LOS was deconstructed into an eight-state multistate model, and there were different transition-specific effects for the explanatory variables. The transition to PIA time is one often used as a benchmark to a well functioning ED.[19] Within this detailed look at SUD presentations to the ED, it is apparent that crowding particularly affects the SUD patient's PIA time. Additionally, patients from neighborhoods with the lowest median income have longer transition times to their PIA, a result that echoes a prior study examining wait times in the unhoused population.[28] A previous study[29] identified that young adults experiencing homelessness have longer total ED stays, and the data presented here may highlight one factor for this in a SUD population. A theme that became apparent with this first state transition was that METH use was associated with prolonged time in the ED. The first state transition to PIA showed a modest increase in transition time for METH use. When compounded across all state transitions however, this particular SUD presentation creates significant delays in ED flow.

The decision to discharge a patient was the second state transition analyzed and showed a predictable effect among those SUD patients with low acuity. Of all SUD patients, those with opiate use presentation were able to transition

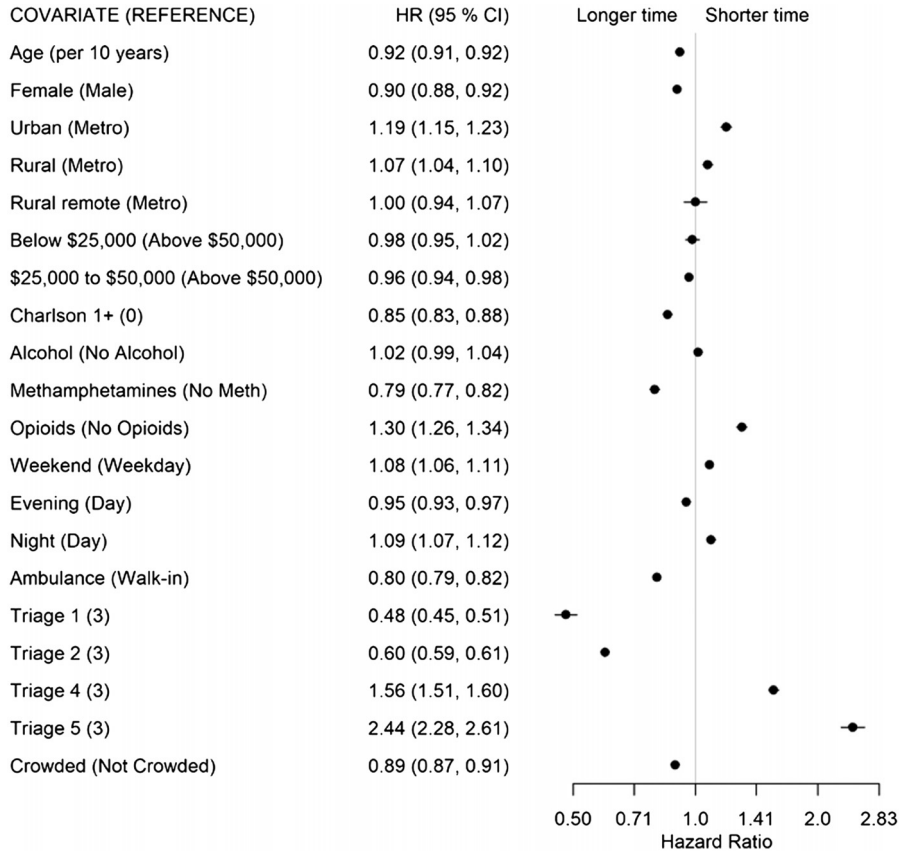

Figure 4. Forest plot of adjusted hazard ratios and associated 95% confidence intervals by covariates for the physician initial assessment (State 2) to discharge disposition decision (State 3) transition for the multivariable model.
HR, hazard ratio; *CI*, confidence interval.

to this state the fastest (HR 1.30). With the availability of a rapid reversal agent for opiates (naloxone), the medical management of opiate intoxication can potentially be completed within minutes[30] and the patient can potentially be discharged within 1–2 hours. Subsequent monitoring and addressing the underlying opiate use disorder often make up the bulk of this patient's ED LOS.[31] The effect of gender, age, and mode of arrival have previously been identified to increase a patient's ED LOS,[32] but the data presented here show that this difference may be primarily influenced by the time to physician's decision to discharge.

The effect of the Charlson Comorbidity Index on prolonging this specific transition between states is novel to our study. Previous studies addressing ED LOS have found no significant effect of a patient's disease burden on their LOS; however, these studies were performed in countries outside of North America, where non-emergency physicians may be the first treating physician and the analyses were instead focused on factors that extended the total ED LOS.[33,34] Like the previous transition analysis, METH use was associated with a prolonged decision to discharge. This could potentially be due to the clinical course of METH intoxication, where chemical restraints are more often required,[35] and the physiological effects of METH can last more than 12 hours.[36]

The emergency physician's decision to consult an admitting service for the patient was the third transition state analyzed. In EDs without an appropriate admitting service, this instead reflected the decision to transfer the patient out of the ED to a larger center that could accommodate the patient's admission. Unsurprisingly, all those patients who had a higher acuity, additional comorbidities, or were older had this transition completed more quickly. All non-metropolitan EDs were also able to make this transition more quickly. This could be due to the physician's faster recognition of a patient who cannot be managed at their smaller center and requires transfer, or a better relationship between the ED and inpatient units, which facilitates improved understanding of patients who would benefit from admission.

Those factors prolonging a decision to admit a patient include patient presentation during the evening or weekend hours and patients who arrive by ambulance. Qualitative studies have previously touched on some of these items[37,38] that highlight healthcare system impacts on patient disposition. Our study provides quantitative evidence that

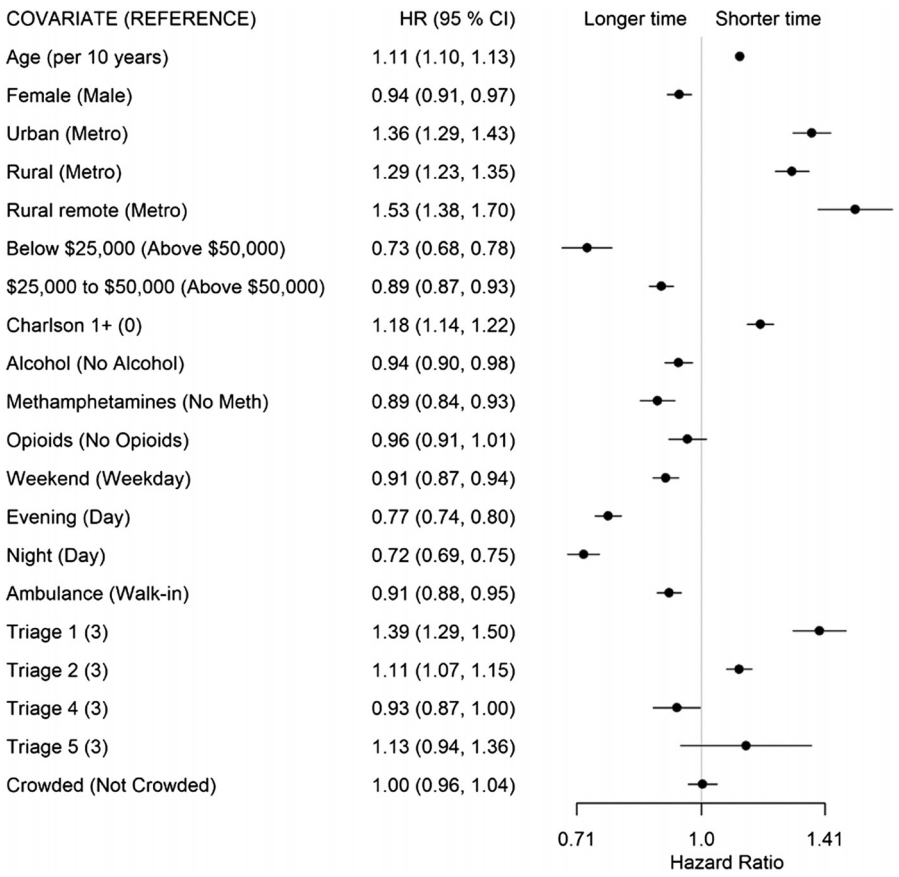

Figure 5. Forest plot of adjusted hazard ratios and associated 95% confidence intervals by covariates for the physician initial assessment (State 2) to admit/transfer disposition decision (State 4) transition for the multivariable model.
HR, hazard ratio; *CI*, confidence interval.

supports these findings in the SUD patient population. Like the transition times for a decision to discharge, those patients with alcohol or METH use disorder also exhibited prolonged time-to-admission decisions. This is likely due to the period of observation common to both presentations to determine whether their symptoms will require additional support in the form of inpatient alcohol withdrawal treatments[39] or further psychiatric assessment of the METH-use patient.[40] Lastly, those patients from the lowest income bracket (which encompasses patients experiencing homelessness) experienced significantly longer transition times between these states.

The final state transition—that of a decision to admit/transfer the patient and their departure from the ED—showed a dramatically faster transition time in the non-metro EDs. This is likely due to similar factors that influenced the previous state change, namely the smaller EDs' relationship with their admitting services or the ability to transfer the patient to another site for further management. Additionally, those patients presenting with either alcohol or opiate use were admitted much more quickly. Both presentations have well defined, nearly algorithmic management strategies consisting of alcohol withdrawal management in the form of benzodiazepines,[41] and opiate intoxication management with naloxone. The association of METH use with a longer time to admission may be due to the management uncertainty surrounding it.[42] Patients with METH use disorder can be behaviorally difficult,[43] exhibit aggressive or bizarre behaviors, and may be accompanied by more trauma[44] when compared to other SUD presentations. Emergency department crowding also negatively impacted a SUD patient's transition to the admitted state, a finding that has been echoed over numerous studies of ED crowding.[45,46] Lastly, patients from areas with the lowest median income once again spent more time in this transitory state. This patient cohort has been identified to be most at risk for poor clinical outcomes[47,48] following an ED presentation and at highest risk for leaving AMA.[49] The extended delays between numerous state transitions serve to highlight some of the shortcomings of both the ED and admitting teams in their care.

LIMITATIONS

Our study has limitations including those typical of data collected for administrative purposes. We used the times provided for each state transition and those times may have

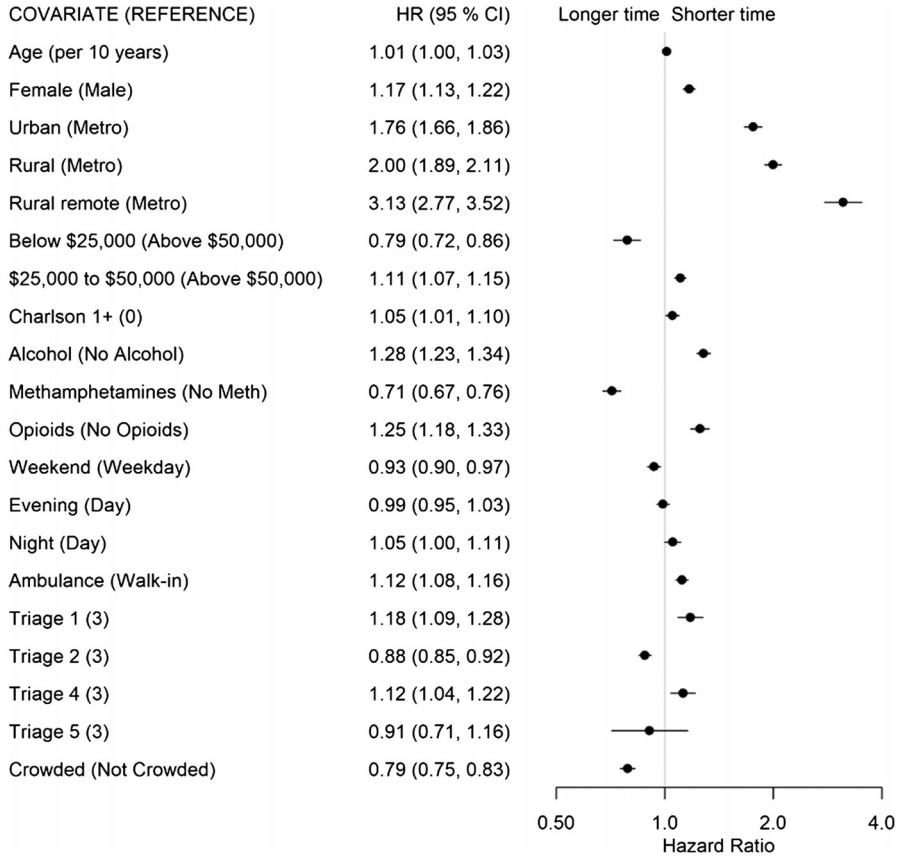

Figure 6. Forest plot of adjusted hazard ratios and associated 95% confidence intervals by covariates for the admit/transfer disposition decision (State 4) to admission (State 5) transition for the multivariable model.
HR, hazard ratio; *CI*, confidence interval.

been reported in error or may have been missing. There may be other important variables that contributed to the times spent in each state that we were unable to account for in our analysis. These may include characteristics of the patient or characteristics of the ED, such as staffing, that are not available in the data sources.

CONCLUSION

Taken together, this study demonstrated two pervasive themes across all state transitions. Patients who presented with methamphetamines use disorder had delayed transitions between all states analyzed during their ED visit. Similarly, patients from low-income neighborhoods also had delays in almost all transitions analyzed. With the data presented here, the emergency medicine community may benefit from improved ED flow by focusing on improving transition times for the low socioeconomic status patient with METH use disorder. Due to the challenges with managing METH intoxication, further research to improve treatment pathways for these patients will ultimately help ED flow as well. Additional resources may be required to assist the urban ED with managing the influx of these patients with substance use disorder and their overall effect on ED crowding.

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Perception of Quiet Students in Emergency Medicine: An Exploration of Narratives in the Standardized Letter of Evaluation

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Introduction: The Standardized Letter of Evaluation (SLOE) is designed to assist emergency medicine (EM) residency programs in differentiating applicants and in selecting those to interview. The SLOE narrative component summarizes the student's clinical skills as well as their non-cognitive attributes. The purpose of this qualitative investigation was to explore how students described in the SLOE as quiet are perceived by faculty and to better understand how this may impact their residency candidacy.

Methods: This retrospective cohort study included all SLOEs submitted to one EM residency program during one application cycle. We analyzed sentences in the SLOE narrative describing students as "quiet," "shy," and/or "reserved." Using grounded theory, thematic content analysis with a constructivist approach, we identified five mutually exclusive themes that best characterized the usage of these target words.

Results: We identified five themes: 1) quiet traits portrayed as implied-negative attributes (62.4%); 2) quiet students portrayed as overshadowed by more extraverted peers (10.3%); 3) quiet students portrayed as unfit for fast-paced clinical settings (3.4%); 4) "quiet" portrayed as a positive attribute (10.3%); and 5) "quiet" comments deemed difficult to assess due to lack of context (15.6%).

Conclusion: We found that quiet personality traits were often portrayed as negative attributes. Further, comments often lacked clinical context, leaving them vulnerable to misunderstanding or bias. More research is needed to determine how quiet students perform compared to their non-quiet peers and to determine what changes to instructional practices may support the quiet student and help create a more inclusive learning environment. [West J Emerg Med. 2023;24(4)728–731.]

INTRODUCTION

The emergency medicine (EM) Standardized Letter of Evaluation (SLOE) is a high-stakes assessment designed to assist residency programs in differentiating applicants and is considered important in the decision to interview.[1,2] The narrative component summarizes the student's knowledge, clinical skills, and non-cognitive attributes shown to be predictors of performance.[3–5] However, the narrative may be difficult to interpret due to the use of overly general language and hidden code, both common in written assessment.[6–9] Further, comments about personality often lack clinical context, which reduces their usefulness and makes them vulnerable to misinterpretation or bias.[6–8]

We became interested in SLOE narratives referencing quiet students during applicant review when we observed less enthusiasm for students described as quiet, even for those with strong objective application data. While non-cognitive attributes are important components of holistic assessment, personality traits should not necessarily hinder a strong application.[3–5] No studies show that quiet individuals are

unsuited for EM or are less successful in EM careers. However, in an internal medicine setting, "quiet" was interpreted by attendings as a "red flag" in clerkship written evaluations, [9,10] and students described as quiet in their SLOE scored lower on both global assessment and anticipated rank list.[11] We found no other research examining how quiet individuals perform or how they were perceived in EM. The purpose of this qualitative investigation was to explore how quiet students are described in the SLOE narrative and how this language may impact candidacy.

METHODS

Study Design and Population

We conducted a subgroup analysis of a retrospective cohort study of all core EM rotation SLOEs submitted through the Electronic Residency Application Service (ERAS) to one EM residency program during the 2016–2017 application cycle. We excluded SLOEs from non-Liaison Committee on Medical Education accredited schools and applicants who graduated from medical school before or during the application cycle. The study was approved by the institutional review board and the Association of American Medical Colleges.

Study Protocol and Data Analysis

Author JM downloaded SLOEs from ERAS into REDCap (Research Electronic Data Capture tools hosted at UC San Francisco). and de-identified them prior to analysis. Analysis was performed by JKQ, EHC, and JM, all with training in medical education research methodology and education leadership experience (chief resident, associate residency director, and assistant residency director). JKQ and EHC brainstormed words typically used to describe quiet individuals and chose the target-descriptors quiet, shy, and reserved (collectively termed "quiet") because passive, introverted, and timid were uncommon (3, 2, and 1, respectively) and always co-occurred with target-descriptors. We analyzed only the sentence containing the target-descriptors without exploring the entire narrative. We analyzed data using grounded theory thematic content analysis with a constructivist approach.[12] There was no pre-existing theory about the data that we aimed to prove or disprove; instead, the goal was to explore SLOE narrative-comments and construct meaning from them to provide perspective on how quiet students are perceived.

Without a preset idea of how data would be sorted, JKQ and EHC independently began the initial coding by reading each comment and considering how it was used to describe the student. As usage patterns emerged they were coded as like-comments. JM read a subset of the data. To establish that the dataset was sufficient for the purpose of the investigation, we coded the first half of the dataset and then determined that no new patterns emerged in the second half. We progressed to explaining our coding schemes, comparing them, and looking for similarities and differences. Through an iterative process of constant comparison we combined, deleted, and refined codes, merging them into overarching themes. We used a spreadsheet to visually organize codes and final themes.

RESULTS

We reviewed 1,582 SLOEs from 696 applicants. Of these, 117 SLOEs referenced quiet applicants and were analyzed. The adjective "quiet" occurred in 102 SLOEs. "Reserved" occurred in 28 SLOEs and co-occurred 14 times with "quiet." "Shy" occurred in 11 SLOEs and co-occurred five times with "quiet."

Initial coding revealed usage related to interpersonal skills, initiative, disposition, patient interactions, leadership, medical knowledge, response to feedback, work habits, and fitness for EM. Further analysis revealed that many target sentences did not fit into these categories, lacked clinical context, and were difficult to interpret. We eventually reached a consensus on a framework of five mutually exclusive overarching themes that included all comments, best represented the scope of usage patterns, and would be most meaningful in addressing our study purpose (Table 1).

Theme 1 comments, 62.4% describe quiet traits as implied-negative attributes. Comments are labeled "implied" because quiet is not explicitly called negative but is typically coupled with a contrasting positive trait that appears to be an effort to mitigate the negativity of the quiet comment (eg, "Quiet but hardworking"). The structure of the sentence makes it clear that quiet is negative, but it is not evident in what way or to what degree it is negative. A smaller number of comments linked the quiet trait with another seemingly negative attribute (eg, "Quiet and timid at times"). The implied negativity of these comments coupled with the lack of context may adversely affect the applicant's candidacy.

Theme 2 comments (10.3%) describe quiet students as being overshadowed by more extraverted peers and thus more difficult to assess. These comments also did not explain how performance was impacted by the quiet trait, only that the student was not able to demonstrate value as a candidate or perform at the level of their peers, which presumably hinders applicant candidacy.

Theme 3 comments 3.4%) question the fitness of quiet students for fast-paced clinical settings. However, these comments did not detail how, or to what degree, the student's quietness specifically affected performance, making them vulnerable to misinterpretation. These comments would likely also hinder candidacy, as the ability to perform well in all clinical settings is presumably seen as necessary in a successful EM resident.

Theme 4 comments (10.3%) "quiet" is portrayed as a positive attribute and tends to describe leadership style,

Table 1. Thematic analysis of 117 sentences containing the words "quiet", "shy" or "reserved".

Theme	Subthemes	Examples
Theme 1) Implied negative (n = 73)	1A) Quiet nature is mitigated by associating with a positive interpersonal skill.	"Quiet but was always able to communicate effectively." "Somewhat reserved but can be assertive when necessary."
	1B) Quiet nature is mitigated by associating with a positive attribute unrelated to quiet personality.	"Quiet but hardworking." "Can be reserved at times but is incredibly intelligent."
Theme 2) Quiet students may be overshadowed by others (n = 12)	2A) Quiet students overshadowed by more extraverted students.	"Quiet demeanor and presence of flashier students prevented a higher ranking." "Overshadowed, quieter than peers, disappeared into background most of the month."
	2B) Quiet students' clinical skills difficult to assess due to their quiet personality.	"Truncated presentations and quiet demeanor make it difficult to evaluate true potential." "So quiet I could not judge level of engagement."
Theme 3) Quiet students may be less suited for certain clinical settings (n = 4)	3A) Quiet students perceived as too passive, slow, or unassertive for a busy clinical setting.	"Quiet, passive nature may not be suited for high paced inner-city ED." "Quiet and unassuming personality, some noted this to be a concern, particularly in a busy county ED, others didn't."
	3B) Quiet students perceived as less adaptable to the demands of a busy clinical setting.	"Calm, quiet, reserved demeanor- some staff question adaptability to chaotic ED."
Theme 4) Positive trait (n = 12)		"Soothing demeanor and quiet confidence will suit quite well throughout their career." "Quiet demeanor, kind bedside manner which is an asset with patients."
Theme 5) Equivocal (n = 16)		"A little quiet, we do not think this will hinder ability to be a very capable EM resident." "Quiet"

ED, emergency department; *EM*, emergency medicine.

patient interactions, or ability to perform under pressure, rather than describing student personality. This additional context may have contributed to the overall perception of "quiet" as a positive attribute. Theme 5 comments (15.6%) were considered equivocal in that the investigators either did not agree on the positivity or negativity of their interpretation, or the comments lacked sufficient context to interpret the intended meaning (eg, "Student was initially quiet").

DISCUSSION

We found that quiet traits were usually portrayed as negative attributes and, therefore, had the potential to adversely affect the candidacy of a considerable number of applicants. The analysis also revealed that across themes the quiet trait was rarely described in terms of clinical competency. This is concerning because a negative comment that lacks context requires the reader to rely on inferences or assumptions that may result in unfairly judging the applicant. Providing examples that describe observed behavior and clinical skill, rather than referencing personality, will improve the quality and fairness of the assessment.[6,7]

Our findings that quiet students are described as being overshadowed by more extraverted peers, more difficult to assess, and less fit for fast-paced clinical settings suggest the possibility that current instructional practices favor more outgoing students. In a clinical setting where being assertive is viewed favorably, quiet students may be judged unfairly as being less knowledgeable or prepared.[3,13] Changes to instructional practices that may better serve quiet students include the following: providing additional student observations[6]; using standardized assessment-tools[14,15]; expanding assessment criteria to include strengths of the introvert[13]; providing faculty development to improve quality of written assessment[7]; using group-written SLOEs that may reduce bias[1,2]; and providing student mentorship.[3]

LIMITATIONS

This study was limited to SLOEs from applicants to a single institution during one application cycle. We analyzed only the sentence containing the target-descriptors; reading the entire narrative may have provided additional context. Target-descriptors may be defined differently by different evaluators and readers and may or may not be used interchangeably. Further, readers may interpret the

positivity or negativity of the usage differently than the investigators. The target-descriptors may not reflect student personality but rather how they were perceived by their evaluator in the clinical setting. Applicants did not receive a personality inventory nor did they self-report their personality type. We did not identify the gender of applicant or the SLOE writer, which prevented us from determining whether our findings were affected by gender. Nor did we identify the position or experience of the writer, or whether individual or group process was used. We did not attempt to associate quiet vs non-quiet status with an invitation to interview.

CONCLUSION

We found that quiet personality traits were often portrayed as negative attributes in the Standardized Letter of Evaluation. Additionally, clinical context was rarely provided, leaving comments open to variable interpretation and possible misunderstanding of student competency. These findings add to our understanding about quiet students in EM, but more research is needed to determine how quiet-labeled students perform compared to their non-quiet peers and to determine what changes to instructional practices may support the quiet student and help create a more inclusive learning environment where all students can thrive.

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Impact of Faculty Incentivization on Resident Evaluations

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Introduction: In the Program Requirements for Graduate Medical Education in Emergency Medicine, the Accreditation Council for Graduate Medical Education requires frequent and routine feedback. It is a common challenge for program leadership to obtain adequate and effective summative evaluations.

Methods: This is a retrospective, case-crossover, interventional study conducted in an academic medical center. This study occurred over a two-year period, with an intervention between years one and two. Throughout year two of the study, faculty incentive compensation was linked to completion of end-of-shift evaluations. We compared pre- an post-implementation data using paired sample *t*-tests with the significance level $P < .05$ applied.

Results: After implementation of the incentive metric there was an increase in the number of total evaluations by 42% ($P = .001$). The mean number of evaluations submitted by each faculty per shift increased from 0.45 to 0.86 (SD 0.56, $P < .001$). Overall, 32 of the 38 faculty members (84.2%) had an increase in the number of evaluations submitted per shift during the intervention period with an average increase of 0.5 evaluations per shift (range 0.01–1.54).

Conclusion: Incentivizing faculty to submit resident evaluations through use of bonus compensation increased the number of evaluations at our institution. This information may be applied by other programs to increase resident evaluations. [West J Emerg Med. 2023;24(4)732–736.]

INTRODUCTION

The Accreditation Council for Graduate Medical Education (ACGME) requires emergency medicine (EM) residency programs to obtain frequent feedback for resident physicians that is both summative and formative.[1] To accomplish this, many programs employ an evaluation form that is to be completed by faculty at the conclusion of each resident shift.[2,3] This formative feedback is compiled by clinical competency committees to create summative feedback for residents, comparing each resident against milestones and their peers. This assists the program director in making evaluative decisions regarding the performance and abilities of trainees.

Consistently obtaining end-of-shift feedback from faculty has been a targeted area of improvement within medical training.[2,4–7] Different strategies have been executed, with digital collection being shown to improve faculty response rates compared to paper systems.[8,9] Yet even with such implementation there is still a lack of sufficient feedback collection to construct a global, summative evaluation of residents in all milestones.[2,10] Strategies have been implemented to improve faculty engagement and participation in educational campaigns at the undergraduate medical education and graduate medical education (GME) levels.[2,4–7] There is evidence that financially based incentivization has led to improved faculty participation in learner evaluation, notably on a monthly or end-of-rotation basis.[7] Therefore, we hypothesized that employing such an incentivization process would increase the overall quantity of resident end-of-shift evaluations completed by faculty.

Our study addresses the ACGME requirement for increased frequency of evaluation, effectively on a near-daily basis, and shows that financial strategies can motivate faculty to engage in this level of participation. Our study appears to be the first of its kind in directing attention to the requirements necessary for the provision of extensive, timely feedback to our learners.

METHODS

This was a retrospective, case-crossover interventional study conducted at an academic EM residency training site. This study was reviewed and deemed exempt by the institutional review board. At our institution, end-of-shift evaluations contain the competencies from the ACGME milestone-based rating scale and space for free-text comments. Evaluations can either be requested by the resident or self-initiated by the faculty member.

This study occurred over a two-year period form October 1, 2019–September 30, 2021, coinciding with the fiscal year (FY) calendars for 2020 (FY20) and 2021 (FY2021). During the first year of the study (FY20), faculty incentive compensation was not connected to resident evaluations. At the midpoint of the study period an incentive compensation plan was introduced linking the completion of end-of-shift evaluations to the year-end bonus for FY21. Faculty bonuses, which are awarded annually, are a percentage of base salary broken down by clinical and academic metrics. Points are earned to achieve the academic bonus; completion of 40 end-of-shift evaluations earns 25% of the points needed for the full academic bonus. For a faculty member at the assistant professor level receiving the full academic bonus, meeting this fulfilment translates to approximately $4,875.

We reviewed the number of end-of-shift evaluations completed in the pre-implementation to the post-implementation period and compared by the overall number of completed evaluations and the number of completed evaluations per shift by each attending physician. We determined the overall number of completed evaluations, as well as the number of completed evaluations per shift per attending and compared the number of end-of-shift evaluations completed in the pre-implementation period to the post-implementation period.

All faculty who worked at the primary teaching site and were eligible for the annual incentive compensation bonus met study criteria. All resident-supervision shifts were included in the study. Exclusion criteria included faculty not employed during the duration of the study period and faculty who did not work with residents during the study period. Only evaluations that were completed and submitted were included in this study. We performed subgroup analysis to compare for differences between male and female physicians, and junior faculty (defined for this study as within the first 10 years of an initial faculty appointment at the completion of the study period) and senior faculty. We used our institution's residency management system, Medhub (Minneapolis, MN), which reported end-of-shift evaluations conducted by faculty of residents during the study period.

We compared the total number of evaluations completed by each faculty member during the pre- and post-implementation periods based on the Medhub data. Multiple residents may be working during a faculty shift; therefore, each faculty member may submit multiple evaluations per shift. We calculated the number of evaluations per shift based on the total number of evaluations per attending and total number of qualifying shifts. We compared each attending physician pre-implementation to post-implementation to determine any change in the total number of evaluations and the number of evaluations per shift per attending. For this initial analysis, the focus was intentionally limited to quantitative data evaluation. We analyzed data using GraphPad Prism version 9 (Graphpad Software, San Diego, CA). Pre- and post-implementation data and subgroup analysis were compared using *t*-tests with the significance level $P < 0.05$ applied.

RESULTS

During the study period, 65 physicians submitted resident evaluations. Among them, 27 did not meet inclusion criteria for the study and were excluded. Reasons for exclusion of faculty were as follows: not employed during the entire study period (14); employed as fellows (10); or did not work at the teaching hospital for the duration of the study (3). There were 38 attendings eligible for the study; 39.5% were female and 60.5% were junior faculty. Among the junior faculty, 47.8% were female; 26.7% of the senior faculty were female. We included 2,778 resident evaluations in the study. The total number of evaluations submitted pre-implementation of the incentive metric (FY20) was 1,149. After implementation, the total number submitted (FY21) was 1,629, an increase in 42% increase for year two ($P = 0.001$).

Each individual attending shift was reviewed, and the average number of evaluations submitted per shift (for any shift worked with residents) is reported in Figure 1b. The mean number of evaluations submitted per shift pre-implementation of the incentive metric was 0.45 (SD 0.47). After implementation of the incentive metric, the mean number of evaluations submitted per shift increased to 0.86 (SD 0.56), a statistically significant increase ($P < .001$). Overall, 84.2% of faculty members had an increase in the number of evaluations submitted per shift. The breakdown by female, male, junior, and senior faculty are detailed in Table 1.

Across all attendings who had an increased number of evaluations during the post-implementation period, the average increase was 0.5 evaluations per shift (range 0.01–1.54). Among the four who submitted fewer evaluations per shift during the intervention period, the average decrease was 0.19 evaluations per shift (range 0.01–0.55). Figure 2

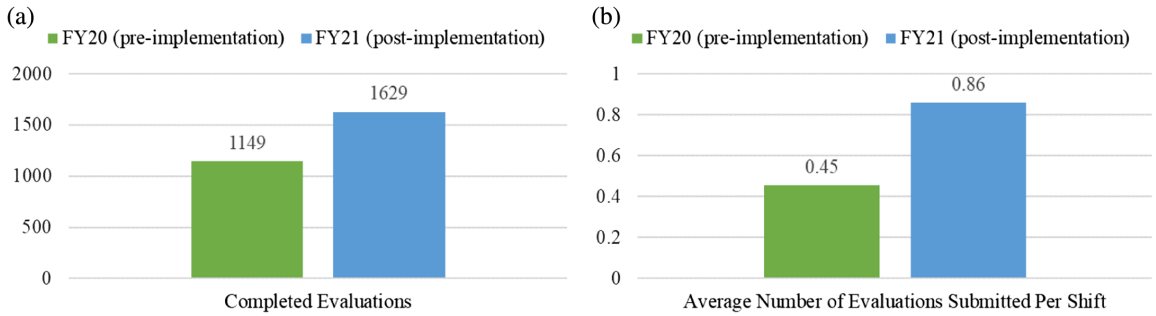

Figure 1a. Completion of resident evaluations by faculty pre- and post-implementation of a financial-incentive metric (statistically significant, $P = .001$). **1b.** Average number of evaluations submitted per shift pre- and post-implementation of the incentive metric (statistically significant, $P < .001$).

Table 1. Percentage change in number of evaluations submitted per shift after implementation of financial incentive.

	Increase	Decrease	No change
All faculty (N = 38)	84.2%	10.5%	5.3%
Female faculty (n = 15)	73.3%	13.3%	13.3%
Male faculty (n = 23)	91.3%	8.7%	0%
Junior faculty (n = 23)	82.6%	8.7%	8.7%
Senior faculty (n = 15)	86.6%	13.3%	0%

compares the average number of evaluations per shift for females vs males in the pre- and post-implementation period and junior vs senior faculty. Both female faculty and male faculty had a significant increase in the number of evaluations pre- and post-implementation ($P = .027$, $P < .0001$, respectively) (Figure 2a). However, male faculty had a greater overall increase in the average number of evaluations per shift ($P = .049$). Figure 2b shows the increase pre- and post-implementation for junior and senior faculty, which was significant within both groups ($P < 1$, $P < .001$, respectively). Senior faculty completion rate had a slightly higher increase than for junior faculty; however, this did not reach statistical significance.

DISCUSSION

In this study we identify a strategy for improving the collection of resident evaluations from faculty members at a primary academic EM residency teaching site. Specifically, the study demonstrates that the majority of attending physicians exhibited an increase in the number of evaluations they submitted per shift, resulting in a significant increase in the total number submitted by the entire study group after implementation of a faculty incentivization strategy. This incentivization strategy assisted our program to meet the ACGME requirements for frequent resident feedback. Comparison of subgroups shows that while both female and male faculty had a significant increase in the number of evaluations post-implementation, the average increase in evaluations per shift for male faculty was greater than in female faculty. This may reflect the trend of female faculty being less able to be academically productive during the COVID-19 pandemic.[11–13]

A variety of ways to increase faculty contributions to the myriad of instructional needs in the GME realm have been investigated. Such endeavors include assigning "value units" to scholastic contributions, sometimes termed "educational value units" (EVU) or "academic relative value units" (aRVU) to be used in a diverse manner based on

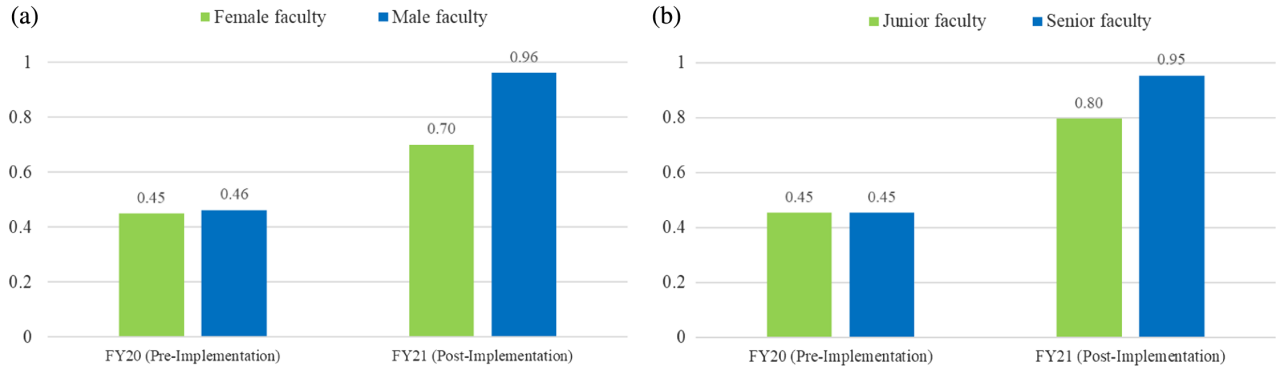

Figure 2a. Average number of evaluations completed per shift by female and male faculty pre- and post-implementation of the incentive metric. **2b.** Average number of evaluations completed per shift by junior and senior faculty pre- and post-implementation of the financial-incentive metric.

departmental needs. One academic EM group concerned with the marginalization of educational pursuits developed a "mission-based budget" in which an EVU system assigns activities to faculty with aligned funding, which led to a significant improvement in the completion of obligations.[14] Ma et al has shown that academic productivity of a faculty could be measured and, thus, fiscally rewarded based on the accruing of "academic points" vis a vis aRVUs and using an associated bonus system.[15]

A Faculty Incentive Task Force within another group of emergency physicians created educational activity categories, assigned standardized time values correlating to EVUs for each activity, and then set a threshold of total EVUs to be met in order to receive compensation, which resulted in increased faculty completion of resident and fellow monthly evaluations as well as attendance at didactic conferences.[16] Similarly, Pugh et al demonstrated that the implementation of quarterly bonuses increased faculty participation in conferences and resident evaluations.[7]

Evaluation of residents must be well documented and trended to allow for proper summative assessment, teaching, and identification of possible interventions. Considering this, program leadership needs to curate frequent feedback to create a sufficient volume from diverse faculty across time. Thus, the focus of this investigation was intentionally limited to the quantitative analysis regarding numbers of evaluations. This was done from the perspective of program administration and the ACGME requirement for frequency/amount of feedback using the milestone scales.

LIMITATIONS

Limitations of this study include the fact that it was conducted at a single site and only for the duration of a single fiscal year. In this study we compared the number of evaluations, not their overall quality. It is important to note that the COVID-19 pandemic occurred during the study period, causing disruptions to physician staffing and salaries nationally. Within our institution, emergency physician work hours and salaries were not reduced due to the pandemic and did not affect the faculty's ability to submit evaluations.

CONCLUSION

Incentivizing faculty through use of a bonus compensation structure increased the number of evaluations of residents submitted at our institution. This information may be applied by other programs to increase the number and frequency of resident evaluations.

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Single-step Optimization in Triaging Large Vessel Occlusion Strokes: Identifying Factors to Improve Door-to-groin Time for Endovascular Therapy

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Introduction: Although acute stroke endovascular therapy (EVT) has dramatically improved outcomes in acute ischemic stroke (AIS) patients with large vessel occlusions (LVO), access to EVT-capable centers remains limited, particularly in rural areas. Therefore, it is essential to optimize triage systems for EVT-eligible patients. One strategy may be the use of a telestroke network that typically consists of multiple spoke sites that receive a consultation to determine appropriateness of patient transfer to an EVT-capable hub site. Standardization of AIS protocols may be necessary to achieve target door-to-groin (DTG) times of less than 60 minutes in EVT-eligible patients upon hub arrival. Specifically, the decision to obtain vascular imaging at the transferring hub site vs delaying until arrival at the hub is controversial. The purpose of this study was to identify factors associated with reduced DTG time in LVO-AIS patients.

Methods: We performed a retrospective chart review for all patients treated over a 3.5-year period at our home hub institution. Patients were classified as telestroke transfers, non-telestroke transfers, and direct-to-hub presentations. We recorded demographic information, DTG time, reperfusion status, length of stay (LOS), functional status at discharge, seven-day mortality, and the site where vascular imaging—computed tomography angiography (CTA)—was obtained. We performed binary logistic regression to identify factors associated with DTG <60 minutes.

Results: In the sample of EVT-eligible patients (n = 383), CTA was performed at the spoke site prior to transfer to the hub institution in 53% of cases. Further, 59% of telestroke transfer cases received a CTA prior to transfer compared to only 40% of non-telestroke transfers (59 vs 40%, $P = 0.01$). A Door-to-groin time <60 minutes was achieved in 67% of transfer patients who received pre-transfer CTA compared to only 22% of transfer patients who received CTA upon hub arrival and 17% of patients who presented directly to the hub. Ultimately, transfer patients who received CTA prior to transfer were 7.2 times more likely to have a DTG <60 minutes compared to those who did not (OR 7.2, 95% confidence interval 3.5–14.7; $P < 0.001$).

Conclusion: Pre-transfer computed tomography angiography was the only significant predictor of achieving target door-to-groin times of less than 60 minutes. Because DTG time has been well established as a predictor of clinical outcomes, including pre-transfer CTA in a standardized acute ischemic stroke protocol may prove beneficial. Our findings also illustrate the need to optimize direct-to-hub stroke alerts and telestroke relationships to minimize workflow disruptions, which became more apparent during the pandemic. [West J Emerg Med. 2023;24(4)737–742.]

INTRODUCTION

Endovascular therapy (EVT) for large vessel occlusion acute ischemic stroke (LVO-AIS) is now the standard of care for eligible patients.[1] However, roughly half of all Americans, predominantly those residing in rural areas, lack timely (<60 minutes [min]) access to centers capable of performing EVT.[2] Therefore, optimal triage systems for LVO-AIS patients are essential for emergency departments (ED) and health systems in rural regions that may be located hours from an EVT-capable center. Telestroke networks are a potent tool that improves clinical outcomes in resource-limited rural areas.[3,4]

Door-to-groin (DTG) time has been shown to be an independent predictor of favorable outcomes in AIS patients undergoing EVT.[5,6] However, it remains unclear whether spoke-site participation in a hub's telestroke network directly contributes to shorter DTG times. The timing of the vascular imaging required prior to a patient undergoing EVT must also be considered with respect to DTG time. The results of previous studies evaluating the effect of pre-transfer vascular imaging on DTG time have been inconsistent, with some studies indicating either prolonged or improved DTG.[7–9] Therefore, it remains controversial as to whether computed tomography angiography (CTA) should be performed prior to transfer in patients with suspected LVO-AIS.

The COVID-19 pandemic highlighted inefficiencies in the triaging of AIS patients, particularly due to resource limitations and staffing issues. Although a large, single-center study detailed a decline of nearly 32% in stroke code activations at the beginning of the pandemic in April 2020, the rate of EVT remained consistent compared to the last several years.[10] As COVID-19 continues to require the rapid reallocation of resources and staff, with further long-term effects on staffing, it is critical that EDs and stroke teams efficiently triage patients who may be candidates for EVT. Decreasing the number of futile transfers is also a key component of reducing the burden on hub centers. We previously reported an averted transfer rate of 65% using our telestroke network in West Virginia,[11] a state in which 34 of its 55 counties are designated as either rural or super-rural. Consideration of factors that impact the triage process, such as pre-transfer CTA or access to telestroke consultation, serves to maximize the efficiency with which hub EDs and comprehensive stroke centers can provide care.

In this study, we sought to determine the primary factors contributing to target hub-DTG times in LVO-AIS patients undergoing EVT. Our overarching goal was to identify factors that may impact the efficiency of the triage process for stroke patients with LVOs in EDs and stroke centers.

Population Health Research Capsule

What do we already know about this issue?
Endovascular therapy (EVT) is a time-sensitive treatment for acute ischemic stroke (AIS) that has dramatically improved patient outcomes. It can only be performed at EVT-capable institutions.

What was the research question?
We sought to *identify factors associated with reduced door-to-groin (DTG) times in AIS patients with large vessel occlusion.*

What was the major finding of the study?
Transfer patients who received computed tomography angiography prior to transfer were 7.2 times more likely to have a DTG <60 min compared to those who did not.

How does this improve population health?
Triage systems must be optimized to provide timely EVT. This is of particular importance to patients in resource-limited rural areas.

METHODS

We conducted this study at West Virginia University Hospital, a tertiary-care facility with a comprehensive stroke center that serves as the telestroke hub of 29 spoke hospitals. This organizational framework was previously described in more detail.[11] This study received institutional review board approval, and the requirement for patient-informed consent requirement was waived based on retrospective chart review. Between January 2016–September 2021, we performed a retrospective chart review of all LVO-AIS patients who received EVT at our hub institution. This included direct-to-hub ED presentations, as well as transfer patients from spoke sites.

The hub-and-spoke model arranges service-delivery assets into a network consisting of an anchor establishment (hub), which offers a full array of services, complemented by secondary establishments (spokes), which offer more limited-service arrays, routing patients needing more intensive services to the hub for treatment. Our network had 29 spokes ranging from critical access hospitals to large community-academic centers across four states (West Virginia, Maryland, Ohio, and Pennsylvania). Furthermore, transfers were categorized as telestroke vs non-telestroke transfers.

Variables collected from each patient's chart included the following: site of initial presentation (direct-to-hub vs transfer); telestroke spoke-site transfer; or non-telestroke site transfer. Other variables collected included National Institutes of Health Stroke Scale (NIHSS) scores upon arrival and at discharge, recanalization status (thrombolysis in cerebral infarction) after EVT, and hub length of stay.

Functional outcome was assessed using the modified Rankin scale (mRS) at or within 90 days of discharge; patients with mRS >2 were considered to have poor functional outcome. Mortality rate within 90 days of discharge was also determined. We calculated DTG time for all patients, defined as the elapsed time between hub arrival time to groin puncture at the start of EVT.

We performed statistical analysis using SPSS Statistics 27.0 (IBM Corporation, Armonk, NY). All study variables were assessed for normality using Shapiro-Wilk testing to determine appropriate parametric or non-parametric tests for unadjusted comparisons between independent variables. We compared frequencies and proportions of study variables using a chi-square (x2) test. We used binary logistic regression to determine whether there was an association between study variables, including NIHSS score, telestroke vs non-telestroke, or pre-transfer CTA with a DTG <60 min. We verified that the data did not violate the assumptions of logistic regression, including performing a Box-Tidwell test to check for linearity between the predictors and the logit. We performed a backward stepwise regression model whereby each variable was entered in the first step of the model, and variables that remained in the last step of the model were considered significant predictors of DTG <60 min.

RESULTS

A total of 383 patients met inclusion criteria for this study; 189 (49%) presented directly to our hub institution (direct-to-hub); and 194 (51%) arrived as a transfer. Median DTG time was significantly shorter in transfer patients compared to direct-to-hub patients (62 vs 83 min, $P < 0.001$). Similarly, DTG <60 min was achieved in a significantly higher proportion of transfer patients compared to direct-to-hub (47 vs 17%, $P < 0.001$).

Of the transfers, 71% received a telestroke consult prior to transfer. Median DTG time was significantly shorter in telestroke transfer to direct-to-hub patients (61 vs 83 min, $P < 0.0001$), and DTG <60 min was achieved in a significantly higher proportion of telestroke transfer patients compared to direct-to-hub (50 vs 17%, $P < 0.001$) (Table 1). There was no difference in median DTG time in telestroke compared to non-telestroke transfers (61 vs 78 min, $P = 0.30$), nor was there a difference in DTG <60 min in telestroke compared to non-telestroke transfers (50 vs 38%, $P = 0.13$). While there was no significant difference in median DTG time between direct-to-hub patients and non-telestroke transfers (83 vs78 min, $P = 0.75$), DTG <60 min was achieved in a significantly higher proportion of non-telestroke transfer patients compared to direct-to-hub (38 vs 17%, $P = 0.003$) (Table 1).

In 53% of cases, CTA was performed at the spoke site prior to transfer to the hub institution. Further, 59% of telestroke transfer cases received a CTA prior to transfer compared to only 40% of non-telestroke transfers (59 vs 40%, $P = 0.011$) (Table 2). In all of the transfer patients who did not receive a CTA at the spoke, CTA was obtained upon arrival to the hub. As expected, median DTG time was shorter in transfer patients who received pre-transfer CTA compared to transfer patients who received CTA upon hub arrival (45 vs 83 min, $P < 0.001$) (Table 2). Further, there was no difference in median DTG time between transfer patients who received CTA upon hub arrival and patients who presented directly to the hub institution (direct-to-hub) (83 vs 83 min, $P = 0.92$). Similarly, DTG <60 min was achieved in 67% of transfer patients who received pre-transfer CTA compared to only 22% of transfer patients who received CTA upon hub arrival and 17% of patients who presented direct-to-hub (Table 2).

A repeat CTA was obtained upon arrival in 67% of transfer patients despite also having received a CTA at the spoke. There was no significant difference in the frequency of repeat CTA in telestroke compared to non-telestroke transfers (63 vs 86%, $P = 0.09$). As expected, in transfer patients who received pre-transfer CTA, median DTG was significantly shorter in patients who did not receive repeat CTA upon arrival at the hub compared to those with repeat CTA (26 vs 59 min, $P < 0.001$). Similarly, DTG <60 min was achieved in 100% of transfer patients who received pre-transfer CTA but did not require repeat CTA upon arrival at

Table 1. Unadjusted comparison of direct-to-hub, telestroke transfer, and non-telestroke transfer patients.

Variable	Direct to hub (n = 189)	Telestroke Transfer (n = 134)	Non-telestroke Transfer (n = 60)	*P*-value
Baseline NIHSS (mean ± SD)	14 ± 6	14 ± 7	15 ± 8	0.478
Door-to-groin time (DTG) (median [IQR] minutes)	83 [37]	61 [47]	78 [50]	<**0.0001**
DTG time <60 min (%)	17	50	38	<**0.0001**
EVT recanalization (%)	37	42	30	0.329
Length of stay (median [IQR] days)	5 [4]	7 [7]	7 [10]	0.108
Discharge mortality (%)	17	19	19	0.832
90-day mRS 0-2 (%)	36	24	32	0.081

NIHSS, National Institutes of Health Stroke Scale*; EVT*, endovascular therapy; *IQR*, interquartile range; *mRS*, modified Rankin Scale.

Table 2. Unadjusted comparison of transfer patients by computed tomography angiography status.

Variable	CTA obtained prior to transfer (n = 102)	CTA upon hub arrival only (n = 92)	*P*-value
Received telestroke consultation (%)	59	40	**0.011**
Door-to-groin time (DTG) (median [IQR] minutes)	45 [46]	83 [47]	<**0.001**
DTG <60 min (%)	67	22	<**0.001**
Repeat CTA at hub (%)	67	-	**-**

CTA, computed tomography angiography; *IQR*, interquartile range.

the hub compared to 53% who received pre-transfer CTA plus repeat at the hub (100 vs 53%, $P < 0.001$).

Interestingly, median DTG was shorter in patients who received pre-transfer CTA and subsequently received a repeat CTA upon hub arrival compared to transfer patients who only received a CTA upon arrival to the hub (59 vs 83, $P = 0.02$). Similarly, DTG <60 min was achieved in 53% of patients who received pre-transfer CTA and subsequently received a repeat CTA upon hub arrival compared to only 22% of transfer patients who only received a CTA upon arrival to hub (53 vs 22%, $P < 0.001$).

We used binary logistic regression analysis to determine which study variables could predict a DTG <60 min in transfer patients, controlling for the following variables entered in the first step: baseline NIHSS score; telestroke vs non-telestroke; CTA prior to transfer; and repeat CTA at the hub. The only variable that remained in the model was CTA prior to transfer, as transfer patients who received CTA prior to transfer were 7.2 times more likely to have a DTG in < 60 min compared to those who did not (odds ratio [OR] 7.2, 95% confidence interval [CI] 3.5-14.7; $P < 0.001$).

Despite the reduced DTG times among those with pre-transfer CTA, we observed no difference in patient outcomes on the basis of successful recanalization rate, length of stay, functional status (mRS), or mortality.

DISCUSSION

Within our study population, pre-transfer CTA was the only significant predictor of achieving benchmark DTG metrics. Additionally, patients who received telestroke consultation were more likely to have received CTA prior to arrival. Given that a significant proportion of LVO-AIS patients will occur among patients far from EVT-capable centers, flexible solutions and innovation in practice are necessary to expedite treatment. One key component to the triage and transfer process is CTA acquisition.

Debate persists regarding whether pre-transfer CTA optimizes treatment or simply prolongs transfer to an EVT-capable center where image acquisition may be more operational. In their analysis of two telestroke networks, Al Kasab et al determined that AIS patients with LVO who received pre-transfer CTA had longer DTG times than those who received CTA at the hub hospital.[7] This was attributed to the interventional team being activated at the hub hospital only after CTA was repeated by the direct-to-hub team; however, frequency of repeat CTA was not reported. In contrast, our study demonstrated that patients were 7.2 times more likely to have a DTG time <60 min if they underwent pre-transfer CTA.

Repeat CT head is obtained in patients with prolonged transfer time (>2 hours), and repeat CTA is typically performed in cases with lower Alberta Stroke Program Early CT Scores (ASPECTS), implying larger infarction core. Among our population, interfacility transport is vulnerable to a variety of factors including rural geography, a statewide lack of emergency medical services resources via ground or air, as well as weather patterns impeding helicopter transfer approximately 50% of the time. Given these factors, most transferred patients have prolonged transfer times, as demonstrated with a 67% rate of repeat imaging. A DTG <60 min was achieved in 100% of transfer patients who received pre-transfer CTA but did not require repeat CTA upon arrival at the hub, compared to 53% of patients who received pre-transfer CTA plus repeat at the hub (100 vs. 53%, $P < 0.001$). However, DTG <60 min was achieved in 53% of patients who received pre-transfer CTA and subsequently received a repeat CTA upon hub arrival compared to only 22% of transfer patients who only received a CTA upon arrival to hub (53 vs 22%, $P < 0.001$). Therefore, even in cases where CTA must be repeated at the hub, there is still a reduction in DTG time, and even including patients with repeat CTA, patients who received CTA prior to transfer were 7.2 times more likely to have a DTG time <60 min compared to those who did not (OR 7.2, 95% CI 3.5-14.7; $P < 0.001$). Therefore, the observed improvement in DTG time in transfer patients cannot be solely attributed to simply time saved by obtaining CTA prior to transfer; rather, it is likely related to advanced pre-notification and activation of the neurointerventional team, leading to more efficient triage and expedited ED course.

These findings underscore the value of enhanced pre-notification of incoming LVO patients. Pre-notification systems are established as effective ways to expedite treatment in time-critical conditions such as stroke.[12–14] Telestroke facilitates streamlining of communication from spoke to hub, especially during the transfer process, and

involvement of all stakeholders (receiving emergency medicine, neurology, and neuro-interventional teams) prior to patient transfer maximizes efficiency. Although implementation and maintenance of telestroke systems require significant resources and commitment from all network partners,[15,16] the benefits from a patient and payor perspective are well-established.[17–21] We have shown here that transfer patients from telestroke spoke sites were more likely to receive pre-transfer CTA than transfer patients from non-telestroke sites, with pre-transfer leading to improved DTG times. Sun et al demonstrated that DTG time, along with unmodifiable factors such as patient age, NIHSS score, and reperfusion status, was most strongly associated with favorable patient outcomes following AIS.[5]

While establishing or participating in a telestroke network may not be feasible in some areas, standardizing imaging protocols for all potential AIS-LVO patients should be a priority. The importance of an efficient triage process has been further highlighted by the COVID-19 pandemic. Disruptions in EVT-workflow became more common during the pandemic due to reallocation of staff.[10] A more uniform triage process would limit delays in facilitating time-critical acute stroke therapy. Although telestroke consultation did not independently predict a shorter DTG time, pre-transfer CTA was obtained in a significantly higher proportion of telestroke compared to non-telestroke transfers, which may indirectly contribute to decreased DTG time.

Our findings demonstrate that patients who receive pre-transfer CTA are more likely to achieve DTG time ≤60 minutes. Including pre-transfer CTA as part of a standardized protocol for AIS patients could potentially decrease the time and resource burden on the over-populated and understaffed hub hospitals. Not only can CTA confirm that a patient has a target lesion amenable to EVT, but it equally serves to identify patients who are not candidates for intervention, thereby reducing futile transfers or avoiding resource-heavy helicopter flights. Although we did not observe improved outcomes among cases with shortened DTG times, it is well established that DTG time is a powerful predictor of clinical outcome.[5,6,22]

LIMITATIONS

Our study has several limitations. First, the elapsed time from arrival to spoke to transfer from spoke—door in/door out time—could not be reliably obtained for all transfer patients. Therefore, we were unable to determine the net effect of pre-transfer CTA on door in/door out and DTG time. Future studies are necessary to evaluate door in/door out times at the transfer site, with and without CTA, to confirm that pre-transfer CTA does not delay time of transfer that exceeds the improvement of DTG time at the hub. Furthermore, while this study only evaluated DTG time at a single hub site, the diversity of geography (spanning four states) and volume (ranging from critical access hospitals to primary stroke centers) among participating spoke sites is also a notable strength. This data demonstrates that pre-transfer CTA can be reasonably acquired across a variety of practice environments.

We believe the findings of this study are generalizable to both rural and non-rural areas. Our rural academic center, which serves much of the 1.8-million-person population of West Virginia, is the only center with EVT-capabilities in the region. While many of our patients may be affected by factors that are more unique to this area, such as prolonged transportation times due to geography, nearly 50% of US residents live in areas with similar healthcare densities,[2] indicating that this is a significant problem throughout the country. Thus, the association between obtaining pre-transfer vascular imaging and reduced DTG time is generalizable to both rural and non-rural areas.

Lastly, we observed no significant association between reduced DTG time and improved patient outcomes on the basis of successful recanalization rate, length of stay, functional status (mRS), or mortality. The absence of a clear outcome correlate in our data may be due to the relatively small sample size, as well as to our inability to control for all confounding factors, including individual site operating procedures, telestroke utilization rates, transfer modalities, and distance traveled to arrive at the hub.

CONCLUSION

Reduction in door-to-groin time remains an important benchmark to advance the treatment of acute ischemic stroke patients with large vessel occlusions. Although several multitier, lean quality improvement initiatives have been developed to optimize workflow,[23–27] our study provides evidence that focusing efforts on pre-transfer vascular imaging alone yields powerful results. Furthermore, our findings underscore an important implementation opportunity for emergency medicine leaders that also facilitates collaboration across disciplines and health systems.

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Violence and Abuse: A Pandemic Within a Pandemic

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Introduction: During the COVID-19 pandemic, as society struggled with increasing disease burden, economic hardships, and with disease morbidity and mortality, governments and institutions began implementing stay-at-home or shelter-in-place orders to help stop the spread of the virus. Although well-intentioned, one unintended adverse consequence was an increase in violence, abuse, and neglect.

Methods: We reviewed the literature on the effect the pandemic had on domestic violence, child and elder abuse and neglect, human trafficking, and gun violence. In this paper we explore common themes and causes of this violence and offer suggestions to help mitigate risk during ongoing and future pandemics. Just as these forms of violence primarily target at-risk, vulnerable populations, so did pandemic-related violence target marginalized populations including women, children, Blacks, and those with lower socioeconomic status. This became, and remains, a public health crisis within a crisis. In early 2021, the American College of Emergency Physicians (ACEP) Public Health and Injury Committee was tasked with reviewing the impact the pandemic had on violence and abuse as the result of a resolution passed at the 2020 ACEP Council meeting.

Conclusion: Measures meant to help control the spread of the COVID-19 pandemic had many unintended consequences and placed people at risk for violence. Emergency departments (ED), although stressed and strained during the pandemic, remain a safety net for survivors of violence. As we move out of this pandemic, hospitals and EDs need to focus on steps that can be taken to ensure they preserve and expand their ability to assist victims should another pandemic or global health crisis develop. [West J Emerg Med. 2023;24(4)743–750.]

Keywords: *pandemic; elder abuse; human trafficking; COVID-19; gun violence; intimate partner violence; child abuse; fear.*

INTRODUCTION

In early 2020, as the world was thrust into the COVID-19 pandemic, countries struggled with increasing disease burden, economic hardships, and disease morbidity and mortality, which led to the implementation of stay-at-home orders to help stop viral spread. This led to increased stress, anxiety, and work/school absence.[1] Unintended adverse consequences included increases in violence, domestic violence (DV), child and elder abuse and neglect, human trafficking, and gun violence. In this article we look at the impact of the COVID-19 pandemic on violence and its relationship to DV, child and elder abuse and neglect, human trafficking, and gun violence, and we offer suggestions to help mitigate violence and better manage our response in the face of this uncertainty.

METHODS

A group of experts in the topics of DV, child abuse and neglect, human trafficking, elder abuse and neglect, and gun violence came together to summarize the literature available regarding the COVID-19 pandemic and its impact on these topics.

DOMESTIC VIOLENCE

Soon after the implementation of pandemic mitigation measures, reports of DV surged globally. This led to United Nations Secretary Guterres' ominous warning: "We know lockdowns and quarantines are essential to suppressing COVID-19, but they can trap women with abusive partners . . . Over the past weeks, as the economic and social pressures have grown, we have seen a horrifying surge in domestic violence."[2] Media reports quickly called attention to links between pandemic lockdown orders and worldwide increases in intimate partner violence.[3] While anyone can be a victim of DV, women are disproportionately affected; thus, for this paper we refer to female victims.

Researchers in New Zealand previously showed that all forms of family violence (DV, child abuse, and elder abuse) increase during and after large-scale crises.[4] Examples of the widespread impact of pandemic lockdowns are abundant. In 2020 the *Guardian* reported a global surge in reports of DV.[5] Brazil experienced a 40–50% increase in DV, and Spain had a 20% increase in the number of helpline calls in the first few days of lockdown.[5] In Cyprus, the number of hotline calls rose 30% within one week of its first COVID-19 case.[6] In the United Kingdom (UK), Refuge—one of the leading domestic abuse organizations—reported a 25% increase in helpline calls in the seven days following UK lockdown measures.[6] During the same period, Refuge noted a 150% increase in website visits.[7] In China's Hubei province, DV tripled when comparing February 2020 to February 2019.[6] In France reports of DV increased 30% and in Argentina 25%.[6]

In March 2020 reports of DV within the United Sates followed a similar trajectory: the Portland [Oregon] Police Bureau recorded a 22% increase in family violence calls[8]; the San Antonio [Texas] Police Department saw an 18% increase[9]; in Alabama the Jefferson County Sheriff's Office reported a 27% increase in March 2020 compared to March 2019[11]; and the New York City Police Department responded to a 10% increase in DV calls in March 2020 compared to March 2019.[11] In February 2021, the National Commission on COVID-19 and Criminal Justice (NCCCJ) reported that DV incidents in the US increased by 8.1% after lockdown orders were issued.[12] The NCCCJ report included police call logs, DV crime reports, emergency line registries, and health records. Despite these increases in reports and hotline calls, US emergency departments (ED) saw a significant decrease in visits related to intimate partner violence (442 vs 484) and suspected child abuse and neglect (884 vs. 1,038) during March 15-October 10, 2020, compared to the same period in 2019.[13]

Hotline and helpline calls surged in the US, with the National DV Hotline reporting a contact volume increase of 9% and ≈10% of callers citing COVID-19 as a factor.[15] Between March-May 2020, 90% of callers reported experiencing emotional/verbal abuse, 61% physical abuse, 16% digital abuse (use of technology to bully, harass, stalk, or intimidate), and 11% sexual abuse.[15] Some hotlines noted decreased call volumes as survivors were unable to access hotlines due to isolation and abuser contact.

Homicides related to DV increased. In 2020 more than 2,000 people were killed in the US in DV-related shootings, an increase of 4% from 2019, with disproportionate increases in Texas (69%), Maryland (93%), Missouri (67%), and Utah (160%).[16] In a survey of law enforcement personnel focused on DV response, 33% reported an increase in DV homicides in their communities and half reported abusers threatening to shoot survivors.[17] Spain's first DV fatality occurred five days after lockdown. The UK as well saw an increase in DV-related homicides.[18]

Cases of DV rose during the pandemic as lockdown placed those vulnerable populations in close proximity to their abusers.[19–22] Social isolation of survivors made them more susceptible to abuse with few resources for help. Unemployment, economic/financial strain, disease fears, childcare stress and homeschooling, depression, and drug and alcohol use all increased DV risk in the home, resulting in an increase in all forms of violence. Those victims in pre-existing violent relationships as well as in previously non-violent relationships had difficulty reaching out to DV hotlines; while some hotlines had dramatic increases in call volume, others experienced fewer calls. Without in-person access to family, friends, and co-workers, visible injuries go unnoticed and subtle clues may have been missed with face masks hiding visible facial trauma. Video-conferencing

platforms allow cameras to be off or adjusted, blocking physical signs of the abuse or the abuser off-screen.

Aid from social service agencies, DV agencies, shelters, and rape crisis centers was limited with some organizations deemed non-essential. Infrastructure, technology, and financial limitations curtailed the transition to remote response. Remotely staffed hotlines and helplines stayed open. Shelters faced losses of volunteers and workers and difficulty implementing social distancing and personal protective equipment (PPE) protocols and cleaning/disinfecting measures in the face of supply shortages.

Many EDs and hospitals severely restricted visitors, including DV and sexual assault advocates, crisis workers, and shelter staff, leaving victims without adequate support while being evaluated for injuries or following sexual assault. When allowed into the ED or hospital, agencies were required to provide their own PPE, despite supply shortages. Going forward, hospitals should establish policies allowing social service agencies access to survivors and to provide those workers with appropriate PPE during a pandemic. Emergency departments need to ensure they screen ALL patients for violence at the time of the visit/hospitalization and provide appropriate agency referrals. Given the unprecedented access abusers have to victims, resources need to be compact, easily concealable, and non-discoverable. Hospitals should work with local agencies to ensure access to services, personnel, and resources. State governments need to re-classify social service agencies as essential, allowing them to continue their important work.

Agencies need to do the following: 1) develop protocols and policies that allow for easy transition to work from home; 2) enhance information technology infrastructure in anticipation of future pandemics or lockdowns with staff education; and 3) institute routine, camera-on employee checks to ensure their well-being.

CHILD ABUSE AND NEGLECT

The World Health Organization, United Nations Women, and UNICEF released a joint statement calling for the protection of children from violence including maltreatment, gender-based violence, and sexual exploitation.[23] A report from the US Centers for Disease Control and Prevention found that despite a dramatic decrease in total pediatric ED visits during lockdown, the number of hospitalizations from child abuse and neglect remained stable, representing a dramatic increase in the yearly percentage of ED visits related to child abuse and neglect among all age groups.[24] The National Child Abuse Hotline allows anyone, including children, to call in or report. In 2018 and 2019 the hotline received 93,000 and 90,000 calls, respectively.[25,26] By contrast, in fiscal year 2020 there were over 112,000 calls, representing a 23% increase.[27]

The same COVID-19 lockdown measures affecting DV survivors affected children as well. This includes social isolation, virtual education, and financial and housing insecurities. The presence of children at home continuously instead of away at school or daycare led to added stress, with parents and caregivers denied respite from direct childcare duties. Home life became private. Without visitors to the home and children barred from attending school and extracurricular activities, there was no direct interaction with potential, mandated reporters or concerned citizens. Children had less opportunity to privately confide in or ask for help from teachers, counselors, friends, and healthcare personnel who would otherwise recognize signs of abuse.

If an individual doesn't already live in a safe environment, then lockdown becomes more dangerous to them. Sheltering in place may lead to child neglect as supervising adults engage in other necessary tasks. Abusers having unlimited access to new household members, both related and non-related, in shared living space, potentially placed children at further risk.

Without the in-person supervision of teachers or other school-based mandated reporters, virtual learning limits assessment of children for abuse or neglect, especially as virtual learning via cameras only shows part of the child or their environment. The actual household environment was potentially obscured with preloaded backgrounds or children being outside the home to access better Wi-Fi.

Similarly, case workers conducting virtual visits were not able to fully assess home-life situations. Food insecurity may have been missed. Children who relied on school breakfast and lunch programs as their source of healthy nutritious meals lacked adequate nutritious food during lockdown, negatively affecting health and learning. Mandated reporters did not have the same level of pre-pandemic contact with children, given the implementation of virtual learning and telemedicine visits. Abusers had greater ability to cover up or limit visualization of telltale signs of abuse. Official reports to child protective services decreased significantly by about 20-70%, possibly attributable to fewer in-person contacts with mandated reporters.[27]

Child abuse and neglect is preventable. Pandemic and disasters require heightened methods of surveillance, reporting, and investigation of cases. Prevention strategies include the following: offering economic support; allowing parents flexible work schedules to balance childcare and work responsibilities; and implementing mechanisms to get children safely back in school for their mental health and physical well-being. Schools need flexibility for in-person services for children, including access to nutritious meals with community support to help with these efforts.

A visit to the ED may be a child's only access to help. Emergency physicians should conduct thorough history and physical exams of children, paying attention to emotional well-being, signs of physical injury, neglect, and other red flags of child abuse. Consults to social services and child protective services (CPS) should not be restricted due to a

pandemic or limited access to PPE. The CPS agencies must have mechanisms to continue to conduct in-person and in-hospital evaluations and have processes for virtual home visits with the ability to provide other needed services.

EXPLOITATION AND HUMAN TRAFFICKING

Societal safety measures meant to protect against COVID-19 transmission further isolated at-risk, exploited, and trafficked individuals, posing added barriers to potential victim identification and assistance. Vulnerability to exploitation and trafficking has been exacerbated by both the rise in family violence and household financial insecurity. Widespread school closures unique to the COVID-19 pandemic resulted in children spending more time online, possibly unsupervised, as parents or legal guardians who were essential workers had to juggle work and homelife.

The remote digital era ushered in by the COVID-19 pandemic led to exponential growth in predatory cyber activity including the targeted solicitation of minors through social media, chat rooms, and gaming platforms. As early as the first quarter of 2020, cybersecurity groups began to detect chatter within child sexual abuse material (CSAM) subscription forums and other parts of the darknet describing the pandemic as a unique opportunity to entice children online and including instructions on how to access children to produce and share CSAM.[28–30] The National Center for Missing and Exploited Children (NCMEC) experienced "an explosion in reporting" to their *CyberTipline* early on.[28,29] In May 2020, during the first wave of shutdowns, reports to the NCMEC tipline numbered almost 1.7 million, as compared to ≈745,000 reports in May 2019.[29]

According to NCMEC, reports involving at-risk children from across the country increased by 28% from an average of ≈326,680 per week in 2019 to a weekly average of ≈418,290 reports during 2020.[28] Reports of online enticements experienced an exponential growth of 97.5% from 19,174 total reports in 2019 to 37,872 in 2020.[28] The dramatic rise in criminal cyber activity and the concomitant risk to children are thought to be related to increased time online while socially distancing, adult boredom, and preoccupation with sexual thoughts, and a doubling in the number of chatters on CSAM forums since the start of the COVID-19 pandemic.[30]

Survivors of trafficking in recovery, already struggling to establish themselves socially and financially, have had to endure food and housing insecurity and lack of employment opportunities during the general economic downturn. While some benefited from eviction moratoriums, many others were left homeless due to job loss and inability to pay rent. Socioeconomic stressors associated with the pandemic increased the risk of survivors being re-trafficked and of at-risk individuals being newly trafficked. The pressures for money to pay for food, housing, and other necessities may lead individuals to accept exploitative work, engage in commercial sex work, and commercially sexually exploit children.

To compound the problem, frontline health and social service organizations—and the precarious local mechanisms for referral—experienced severe disruptions of their everyday outreach and service activities. Any legal or immigration proceedings in progress prior to the start of the pandemic likely were unexpectedly suspended resulting in prolonged states of abeyance, uncertainty, and non-closure for victims and survivors. Consequently, the COVID-19 pandemic may have exacted a heavier toll on the physical, mental, emotional, and financial health of victims and survivors than is currently understood.

ELDER ABUSE AND NEGLECT

Elder abuse and neglect is "an intentional act, or failure to act, by a caregiver or another person in a relationship involving an expectation of trust that causes or creates a risk of harm to an older adult."[31] Types of abuse include physical, sexual, emotional or psychological, as well as financial abuse, and neglect. Before COVID-19, an estimated one in six older persons were subject to abuse globally with one in 10 US residents ≥60 years subject to abuse. Post-COVID-19 increases in elder abuse were reported worldwide.[32] Previously mentioned risk factors may be exacerbated in elderly populations.

There are associated risk factors of elder abuse that can be assessed and managed by medical and public health professionals such as diagnoses of mental illness, alcohol use disorder, and greater degrees of financial and emotional dependence experienced by a vulnerable elder. Risk factors vary among individuals, relationships, communities, and cultures. Identified protective factors include high levels of community cohesion and coordination of resources and services for older people. With early recognition of risk factors and implementation of protective strategies, elder abuse can be prevented.

There was an increase in mental health issues for persons of all ages in part due to implementation of mandatory public health and social measures such as physical distancing, isolation, and restrictions on movement. One study reported that elder abuse increased to one in five older people in the US during the COVID-19 pandemic.[33] Reports include those living in long-term care facilities or other community settings, as well as those living with caregivers.

Those living away from caregivers were further isolated, with less direct access to services and a decrease in available communication methods. Older people often have less technologic access and literacy, making it difficult to navigate without in-person support. Given their social isolation, older adults have become more dependent on caregivers, risking abuser exploitation. Caregivers had their own health and safety to worry about, as well as concerns about financial and other resources needed to care for the

older persons in their life, leading to increased stress and burden on all involved, and further risk of exploitation of resources such as Social Security benefits designated for older people. Increased stigma was placed on older people, as those most severely affected by COVID-19 were sometimes given priority medical resources over younger people with a greater chance of survival.

Governments and public health professionals must acknowledge that elder abuse exists. Emergency clinicians should screen all older people for possible abuse and consider risk factors and protective factors during every encounter. Especially on the ED frontline and primary care offices, healthcare professionals must be aware of local/state reporting mandates. Any suspected mistreatment should be reported according to local/state mandates (usually via Adult Protective Services).

An impactful way to prevent mistreatment is to increase social connectedness with older people and their caregivers in our communities. With persistent physical distancing, we need to try harder to stay close socially—via phone and video calls, messaging, or outside meeting—to stay connected and check in with others to reduce isolation.

GUN VIOLENCE

The pandemic has been associated with increased firearms purchasing both by experienced owners and first-time buyers. With the start of the pandemic, a surge in US gun sales was tied to stay-at-home orders and the first wave of pandemic-related unemployment.[35,36] As the year progressed and political polarization increased, people continued to arm themselves; 40 million background checks for gun purchases were recorded in 2020.[35,36] Almost one-quarter of those seeking guns had not previously owned a firearm. Woman and Blacks showed the greatest increases in firearm purchasing. Historically, increases in firearm purchases have been linked with elections or restrictive policy worries. But the COVID-19 pandemic diverged from this trend and was linked to fear associated with the pandemic, lockdown, racism, elections, and the police.

Both firearm assault and DV incidents in the US increased by 8.1% in the first months following the imposition of stay-at-home orders.[18] People at risk of DV are at high risk of being killed by a firearm with over one half of all intimate partner homicides committed with guns.[37] In a study conducted at Level I trauma centers across Philadelphia, Abdallah et al found that intentional or violent trauma, such as firearm violence, stabbings, and assaults, significantly increased when comparing six weeks prior to and 10 weeks after implementation of stay-at-home orders; other studies reported greater increases in shootings after lockdown was lifted.[38] Recognizing the synergistic epidemic, or syndemic, of racism, COVID-19, and firearm injury is important. Preliminary data showed Blacks were twice as likely as Whites to die from COVID-19.[38] Blacks are also eight times more likely to be killed by a firearm than Whites.[34] Preliminary statistics from 2020 suggest that the COVID-19 pandemic compounded racial inequities in firearm violence. In a study conducted using the Philadelphia Police Department data registry of shooting victims, researchers noted that a spike in the number of people shot per week depended on a temporal relationship to Philadelphia's first COVID-19 lockdown.[40]

Finally, more than half of deaths from firearms occur from suicide. Although preliminary data suggests suicide deaths dropped in 2020 compared with 2019, it is anticipated that the mental health burden of the pandemic will peak later than the actual pandemic. The 1918 Spanish Flu pandemic, for example, was associated with an increase in death by suicide, suggesting the social isolation link.[41] Firearms were shown to reduce the time period of first suicidal thoughts and attempts, as well as to significantly increase the lethality of those attempts.[42] With increased access to firearms, numbers of first-time buyers, and feelings of social isolation, there is a high risk of future increases in suicides related to firearm injury.

While the summative effect of the COVID-10 pandemic and the gun violence pandemic, and their relationship to each other, has not yet been studied, there is cause for concern. Recognition of risk is the first step toward improved prevention of firearm injury. Emergency clinicians are uniquely positioned to intervene as we care for vulnerable patients who may be facing DV, racial violence, or depressive symptoms. Screening of *all* ED patients may make a difference.

COVID-19 FEAR AND NEGLECT

During the pandemic, there was a documented decrease in ED visits for medical and traumatic conditions, myocardial infarctions, stroke, and hyperglycemic crises.[43–46] Forty percent of adults deferred care for fear of catching COVID-19, leading to serious morbidity and mortality.[47] An ACEP study found that 80% of those surveyed were concerned about contracting COVID-19 from other ED patients or visitors, and 29% actively delayed or avoided seeking medical care due to these concerns.[48] Another survey regarding non-COVID-19-related complaints found 59% were unlikely to use the ED and another 20% "didn't know."[49]

Emergency physicians have countless stories of patients delaying medical care due to fear of contracting disease. Many of these patients presented very late into the course of their disease, suffering unnecessary complications and potentially permanent consequences. Such instances raise the question of when does fear of disease turn into actual neglect, and complicate the assessment of abuse and neglect, particularly of dependent populations.

Patients exercise their autonomy when deciding whether to seek care due to fear of COVID-19. What if that decision were made for the patient by someone else? Are parents neglectful when choosing not to take their child to the doctor or ED for care because of fears surrounding COVID-19? Is it

child neglect if parents delay seeking care for their 9-year-old with right lower quadrant abdominal pain for a week resulting in perforated appendicitis requiring percutaneous drainage, prolonged parenteral antibiotics, and delayed appendectomy? Is this reportable to CPS?

Conversely, there is the example of an elderly woman who falls with immediate hip pain and inability to walk and whose refusal of family members' offer to take her to the ED leaves her bedbound for a week. Family bought diapers for toileting and gave her meals in bed. Finally, when the pain escalated, she agreed to present to the ED where she was diagnosed with an intertrochanteric hip fracture with associated deep vein thrombosis. Is this self-neglect or elder neglect? Nursing home staff assume a resident with fever, body aches, abdominal pain, and nausea/vomiting/diarrhea has COVID-19 during an outbreak in their facility and don't send her to the ED for three days despite a negative COVID-19 test. She was found to have incarcerated bowel with sepsis. Was the nursing home neglectful for anchoring on COVID-19 because of their facility's concomitant outbreak? Are these events reportable to Adult Protective Services?

Child neglect is defined as the failure of a parent or other person with responsibility for the child to provide needed food, clothing, shelter, medical care, or supervision to the degree that the child's health, safety, and well-being are threatened with harm.[50] Similarly, elder neglect is defined as failure by a caregiver or other person in a trust relationship to protect an elder from harm or the failure to meet needs for essential medical care, nutrition, hydration, hygiene, clothing, and basic activities of daily needs or shelter, which results in a serious risk of compromised health and/or safety relative to age, health status, and cultural norms.[31] Self-neglect is the behavior of an elderly person that threatens his/her own health and safety.[31]

During non-pandemic times, most clinicians would believe that these questions posed above were proof of neglect. However, pandemic fears, especially during surges, made this judgment difficult. In assessing situations, several factors must be considered, including intent, expectation of trust, risk, and harm. The key question to consider is "what was the intent or intentionality of the decision?" Was delaying care malicious or honoring the patient's wishes? In cases of self-neglect, the competence and decision-making capacity of the patient must be considered. It is not self-neglect if the patient has competence and decision-making capacity.[31]

Classifying actions as neglect requires thought. One does not want to wrongfully accuse or, conversely, miss red flags and possibly subject the patient to more serious abuse. Emergency physicians should employ ED social workers to help with difficult cases. With regard to COVID-19 fear, local and national organizations needed to educate the public about seeking appropriate medical care and the true risk of disease transmission in healthcare settings. Patient education is key to ensure timely and appropriate medical care. With the advent of vaccination, hopefully these fears were lessened.

LIMITATIONS

The authors who performed the literature search and review were not blinded. The true extent of pandemic-related violence remains, and will likely remain, incompletely reported and understood. As a result, the available quantitative data is limited. Anecdotal evidence suggests that pandemics require increased vigilance for signs of interpersonal abuse and violence. Moreover, and perhaps more pressing, a thorough risk-benefit analysis of universal lockdowns as a mitigation strategy must be conducted to further our understanding and ensure adequate emergency preparedness during future respiratory pandemics, given a much earlier prediction that lockdowns would be of little help and would increase violence. Finally, we did not focus on specific prevention techniques related to COVID-19, as research on this subject was sparse.

CONCLUSION

It is evident that measures meant to help control the spread of the COVID-19 pandemic had many unintended consequences and placed people at risk for violence. The pandemic left abuse and violence victims feeling isolated with fewer options for help and decreased opportunities for recognition. Hospitals and violence prevention programs need to start planning for the next pandemic with a focus on preserving or expanding access to services, strengthening social service agency partnerships, and ensuring these agencies have access to the ED with proper PPE.

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Examining Predictors of Early Admission and Transfer to the Critical Care Resuscitation Unit

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Introduction: Previous studies have demonstrated that rapid transfer to definitive care improves the outcomes for many time-sensitive conditions. The critical care resuscitation unit (CCRU) improves the operations of the University of Maryland Medical Center (UMMC) by expediting the transfers and resuscitations for critically ill patients who exceed the resources at other facilities. In this study we investigated CCRU transfer patterns to determine patient characteristics and logistical factors that influence bed assignments and transfer to the CCRU. We hypothesized that CCRU physicians prioritize transfer for critically ill patients. Therefore, those patients would be transferred faster.

Methods: We performed a retrospective review of all non-traumatic adult patients transferred to the CCRU from other hospitals between January 1–December 31, 2018. The primary outcome was the interval from transfer request to CCRU bed assignment. The secondary outcome was the interval from transfer request to CCRU arrival. We used multivariate logistic regressions to determine associations with the outcomes of interest.

Results: A total of 1,741 patients were admitted to the CCRU during the 2018 calendar year. Of those patients, 1,422 were transferred from other facilities and were included in the final analysis. Patients' mean age was 57 ± 17 years with a median Sequential Organ Failure Assessment (SOFA) score of 3 [interquartile range 1-6]. Median time from transfer request to CCRU bed assignment was 8 (0-70) minutes. A total of 776 (55%) patients underwent surgical intervention after arrival. Using the median transfer request to bed assignment time, we found that patients requiring stroke neurology (odds ratio [OR] 5.49, 95% confidence interval [CI] 2.85-10.86), having higher SOFA score (OR 1.04, 95% CI 1.001-1.07), and needing an immediate operation (OR 2.85, 95% CI 1.98-4.13) were associated with immediate bed assignment time (≤8 minutes). Patients who were operated on (OR 0.74, 95% CI 0.55-0.99) were significantly less likely to have an immediate bed assignment time.

Conclusion: The CCRU expedited the transfer of critically ill patients who needed urgent interventions from outside facilities. Higher SOFA scores and the need for urgent neurological or surgical intervention were associated with near-immediate CCRU bed assignment. Other institutions with similar models to the CCRU should perform studies to confirm our observations. [West J Emerg Med. 2023;24(4)751–762.]

INTRODUCTION

When caring for a patient exceeds the initial hospital's resources, patients are usually transferred to tertiary or quaternary medical centers for higher levels of care. The transfer of patients from either the emergency department (ED) or intensive care unit (ICU) to regional referral centers, interhospital transfer (IHT), is becoming more common.[1,2] However, the system for medical IHT is not robust and most of the high-volume referral medical centers do not have immediate ICU bed availability.[3,4] As a result, the IHT of critically ill patients is often delayed, leading to worse patient outcomes.[5]

Furthermore, certain patients are found to have time-sensitive disease and will need transfer to tertiary or quaternary care centers for immediate diagnostic or therapeutic interventions. Early intervention or early arrival at referral centers have been associated with improved outcomes for patients who had Type A aortic dissection, ruptured abdominal aortic aneurysm, intracranial hypertension, or ischemic stroke from large vessel occlusion.[6-9]

To expedite IHT and optimize outcomes for patients with critical illness or time-sensitive conditions, the critical care resuscitation unit (CCRU) at the University of Maryland Medical Center (UMMC) was created in July 2013. The CCRU streamlines the IHT process by providing timely and effective resuscitation for patients who need further interventions from a quaternary care medical center. The CCRU has been found to outpace traditional ICUs by providing care for a higher number of patients with critical illnesses or time-sensitive diseases, while also leading to improved outcomes.[4,10] However, details about how the CCRU physicians triage and prioritize transfer requests while optimizing patient volume has not been described. In this study we aimed to investigate and describe factors that contribute to early bed assignment and early transfer to the CCRU. Determining these factors can provide further information for administrators at other facilities that might be interested in setting up a similar unit.

Population Health Research Capsule

What do we already know about this issue?
Interhospital transfers of critically ill patients are often delayed as there is no immediate ICU bed availability.

What was the research question?
What are the transfer patterns and patient characteristics that lead to immediate bed assignment at the critical care resuscitation unit (CCRU)?

What was the major finding of the study?
Patients admitted to stroke neurology, with higher SOFA score, and needing immediate surgery, were associated with immediate bed assignment time (≤8 minutes).

How does this improve population health?
A CCRU expedites the transfer of critically ill patients from outside facilities who are in need of urgent intervention.

METHODS

Study Design and Clinical Setting

We performed a retrospective analysis of data from all adult patients who were transferred from other hospitals to the CCRU between January 1-December 31, 2018 (the latest year that this data became available). All non-traumatic adult patients who were admitted from other hospitals to the CCRU during this period were eligible. We excluded patients who were admitted to the CCRU from within our medical center (intrahospital transfer), either from our institution's ED or another inpatient unit. This study was exempt from formal consent by our institutional review board (HP-00084554).

The CCRU is a six-bed, ICU-based resuscitation unit that is staffed around the clock by one attending physician, one advanced practice provider (APP), and three to four nurses who are required to have at least two years of prior ICU experience. The operational costs to staff the CCRU, represented in full-time equivalents (FTE), are 5.0 FTE for APPs, 5.0 FTE for attending physicians, and 32.0 FTE for nurses. When a referring clinician needs to transfer a patient with critical illness or time-sensitive disease to our quaternary medical center, the referring clinician first contacts the Maryland ExpressCare (MEC) Center, which handles all transfer logistics for our institution. The MEC personnel then contact the on-call specialty physician and the appropriate ICU physician for possible transfer. When no ICU bed is available, the CCRU attending physician is involved with the transfer request for an available CCRU bed.

Once the patient is considered appropriate for transfer by the specialist and the CCRU attending physician, the CCRU attending assigns an available bed to the patient, as appropriate. This assigned bed is now reserved until this patient arrives. Once a bed is assigned to the patient, the CCRU team and the accepting physicians at UMMC leave the decision of transport to the referring clinicians. The sending facility will arrange for the most appropriate mode of transport (eg, ground vs air transport, private vs academic-affiliated transport teams) for the patient, according to the transport team's availability and the patient's acuity.

The CCRU is a fluid and dynamic unit. Regarding the capacity of the CCRU, "empty" beds may already be promised to a patient in transit; thus, even though a patient is not physically occupying the bed, it is technically not empty. The CCRU attendings triage patients' acuity levels and the demands of the unit for appropriate bed assignment. There is an agreement within the medical center that when the CCRU is reaching its capacity that any available bed in the medical center will be given to a CCRU patient. Typically, when the CCRU is reaching its capacity, such as a situation where five of the six beds are occupied, the CCRU calls the appropriate inpatient unit(s) to alert them, so that the CCRU can get their first available bed when it becomes available.

Once a patient arrives at the CCRU, the patient will receive resuscitation from the CCRU team as indicated and timely diagnostics or therapeutic intervention(s) from specialists, such as a thrombectomy for ischemic stroke from large vessel occlusion, or cannulation for extracorporeal membrane oxygenation (ECMO), etc. In addition, patients may be taken to the operating room (OR) for emergent surgery, which was defined as within 12 hours of CCRU arrival.[4] Once a patient undergoes adequate resuscitation and treatment by the multidisciplinary clinical teams, the patient will be moved to another appropriate inpatient unit at our medical center for further longitudinal care.

Data Collection

We extracted the following data from the CCRU records and our institution's electronic health records: the date and time that the referring clinicians contacted MEC for a transfer request; the date and time that the CCRU attending physicians assigned a bed to each patient; and the date and time that patients arrived at the CCRU. We also extracted other clinical data, such as components of the Sequential Organ Failure Assessment (SOFA) score upon a patient's arrival at the CCRU. The SOFA score served as a surrogate for a patient's disease severity at the sending facility, prior to arrival at the CCRU. We also collected other laboratory values that were not part of the SOFA score, such as serum lactate concentrations, white blood cell count, and hemoglobin concentrations. We collected the types of continuous infusions prior to CCRU arrival, such as insulin and anti-hypertensive infusions, as a marker of care intensity at the referring facilities.

The UMMC is a quaternary medical center with a capacity of approximately 800 beds. There are five adult non-trauma ICUs: the cardiac surgical ICU; coronary care unit; neurocritical care unit; medical ICU (MICU); and surgical ICU. UMMC has a system in place to handle transfer requests from another hospital via MEC. MEC works to connect the transferring clinicians with the relevant ICU for possible admission. If patients are deemed appropriate for admission but the corresponding ICU does not have available beds, the CCRU will be included in the consultation. The transfer records of patients coming from another hospital to UMMC are maintained by MEC as part of their operations, which manages all incoming IHT.

We extracted the data used from non-CCRU units in this study from the MEC database. Prior to commencement of data extraction, investigators who were blinded to the study's hypothesis were trained by the principal investigator with sets of 10 patients until data accuracy reached at least 90% agreement. Data was extracted into a standardized Excel spreadsheet (Microsoft Corporation, Redmond, WA). Up to 5% of data was double-checked by an independent investigator to maintain inter-rater agreement of ≥90%. The data abstracters were blinded to the study hypothesis and objectives. Our study adhered to the reporting practices outlined by Worster et al.[11] Our study also met the minimum requirements outlined by Lowenstein's editorial regarding medical records review in emergency medicine.[12] If a component of the SOFA score was missing, we imputed a normal value.

Outcome Measures

The primary outcome was the percentage of patients who were immediately assigned a bed at the CCRU (≤8 minutes) from time of transfer request. Our secondary outcome was the percentage of patients who arrived early to the CCRU, which was defined by the median time interval from transfer request to CCRU arrival (<180 minutes). An additional outcome investigated was mortality of patients transferred to the CCRU.

Statistical Analysis

We did not perform a sample-size calculation for this descriptive study, presuming that we would obtain an adequate sample size for our analysis by using a full calendar year of CCRU admissions. Based on a previous study, it was estimated that we would have approximately 1,400 patients using a full calendar year of CCRU admissions.[10] By using the median time from transfer request to bed assignment or CCRU arrival as cut-off points to dichotomize our primary and secondary outcomes, we estimated that we would have approximately 700 patients for each of our outcomes. This would provide enough of a sample size to accommodate multivariable logistic regressions with at least 70 independent variables, according to the previous recommendation of 10 counts of outcome events per each independent variable.[13]

We used descriptive analyses to present patients' demographic and clinical information with mean (±SD or median (interquartile range [IQR]), or frequency (percentage) as appropriate. Continuous variables between groups were compared with the Student *t*-test or the Mann-Whitney U test, while categorical variables were compared with the Pearson chi-squared test or Fisher exact test, as indicated. We performed multivariate logistic regressions with dichotomous outcomes as immediate CCRU bed assignment

(vs normal CCRU bed assignment), early CCRU arrival (vs normal CCRU arrival), or deceased (vs living). All relevant independent variables were determined a priori and were used in the regression models.

Prior to data analysis, we performed preliminary analyses and defined immediate CCRU bed assignment as the median of the time interval from transfer request to CCRU bed assignment as the cut-off time for our dichotomous outcome (immediate vs normal CCRU bed assignment). Similarly, the median time interval from transfer request to CCRU arrival was the cut-off point for the dichotomous outcome of early CCRU arrival vs normal CCRU arrival. We assessed multicollinearity of the models using variance inflation factor (VIF). A threshold of VIF ≥5 was used to deem any factor as having multicollinearity. Any independent variable with VIF ≥5 would meet the threshold for having high collinearity and would be excluded from the multivariable logistic regression. No independent variable met this threshold in any of our models. All models were assessed for goodness of fit using the Hosmer–Lemeshow test. A $P > 0.05$ was the threshold indicating that the model was an appropriate fit.

We performed all statistical analyses with Minitab version 19.0 (Minitab, LLC, State College, PA) or using R version 4.1.0 (R Project for Statistical Computing, Vienna, Austria) and RStudio version 1.4.1717 software (RStudio PBC, Boston, MA). All two-sided *P*-values < 0.05 were considered statistically significant.

RESULTS

Patient Demographics of All UMMC Facilities and Patients Triaged to the CCRU

We identified 1,741 patients who were admitted to the CCRU during the study period, and 1,422 patients who were transferred from other hospitals with sufficient data included in our final analysis (Figure 1). There were 712 (50%) patients who had immediate bed assignment to the CCRU, defined as within eight minutes. There were 750 (53%) patients who arrived at the CCRU within 180 minutes from the time of transfer request, while the majority of patients (1,168, 82%) arrived at the CCRU within 360 minutes from the time of transfer request.

Demographic data are reported in Table 1A for the 5,717 patients from all UMMC units comprised of the following: CCRU; any adult, non-trauma ICU; ED; and other inpatient units (intermediate care unit or surgical or medical wards). Patients who were transferred to the CCRU had the shortest time interval from transfer request to bed assignment, with a median (IQR) of 8 [0-70] minutes ($P < 0.001$), when compared to patients who were transferred to other inpatient units at our medical center. When stratifying patients by admission location (CCRU vs ICU vs ED vs other inpatient units), the CCRU had statistically significant higher rates of air transport compared to other units (17% CCRU vs 10% ICU vs 1% ED, vs 4% other inpatient units, $P < 0.001$).

The CCRU patients' demographic data are reported in Table 1B stratified by bed assignment time (immediate vs normal). Patients who were immediately assigned a CCRU bed also arrived at the CCRU faster than those who received a normal bed assignment time (Table 1C). Patients with normal bed assignment time had a statistically lower rate of initiation of mechanical ventilation (37% immediate vs 29% normal, $P = 0.002$) and lower proportion receiving anti-hypertensive infusion, when compared with patients who had immediate bed assignment time (15% immediate vs 10% normal, $P = 0.005$). Among all patients who underwent surgical interventions, a greater number of patients with normal bed assignment time underwent surgery during hospitalization at UMMC (58% normal vs 51% immediate, $P = 0.009$), but a significantly higher proportion of patients with immediate bed assignment were taken to the OR within 12 hours compared to those patients who had normal bed assignment (27% immediate vs 20% normal, $P = 0.002$). More patients with normal bed assignment were discharged home and survived

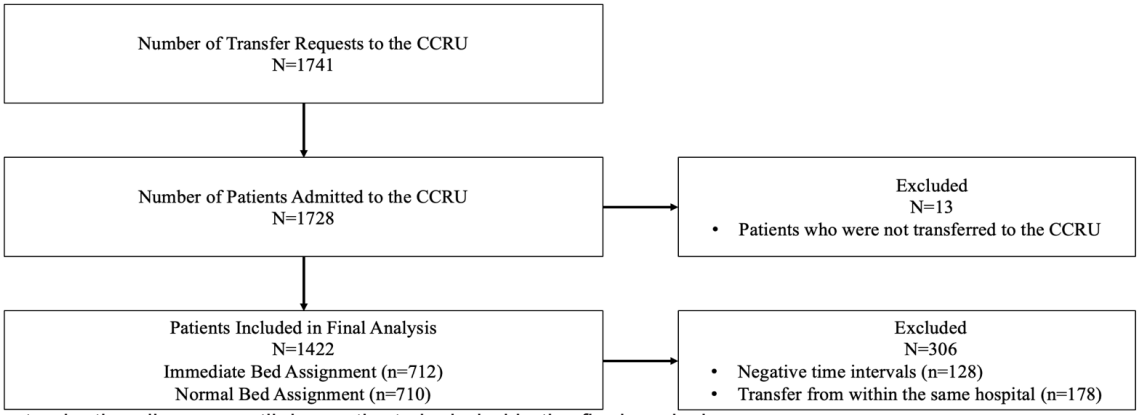

Figure 1. Patient selection diagram outlining patients included in the final analysis.
CCRU, critical care resuscitation unit.

Table 1A. Demographics and clinical features of patients from all University of Maryland Medical Center units in 2018.

Variables	All UMMC*	UMMC CCRU	UMMC ICU**	UMMC ED	UMMC other inpatient units	P†
Total patients, N	5,717	1,422	1,046	817	2,432	NA
Age (years), mean (SD)	56 (18)	57 (17)	59 (16)	48 (18)	54 (17)	**< 0.001, < 0.001, < 0.001**
Type of transport, N (%)^						
Air	443 (8)	240 (17)	103 (10)	10 (1)	90 (4)	**< 0.001, < 0.001, < 0.001**
Ground	5134 (90)	1182 (83)	941 (90)	716 (88)	2295 (94)	**< 0.001, < 0.001, < 0.001**
Unknown	140 (2)	0 (0)	2 (0)	91 (11)	47 (2)	
Ground distance (km), median [IQR]	44 [11-75]	44 [13-75]	44 [13-74]	21 [8-64]	44 [13-92]	**0.035, < 0.001,** 0.68
Type of referring hospital, N (%)^						
Teaching	1,837 (32)	460 (32)	379 (36)	233 (28)	765 (31)	**0.037, 0.041,** 0.72
Community	3,663 (64)	962 (68)	663 (63.5)	397 (49)	1641 (68)	
Other/unknown	217 (4)	0 (0)	4 (0.5)	187 (23)	26 (1)	**0.005, < 0.001, < 0.001**
Transfer request to placement (min), median [IQR]	88 [15-410]	8 [0-70]	243 [77-660]	20 [10-53]	221 [50-1055]	**< 0.001, < 0.001, < 0.001**
Admission day of the week, N (%)						
Weekday (Monday-Friday)	4,323 (76)	1,046 (74)	806 (77)	538 (66)	1933 (79)	**0.047, < 0.001, < 0.001**
Weekend (Saturday-Sunday)	1394 (24)	376 (26)	240 (23)	279 (34)	499 (21)	
Admission time of the day, N (%)						
Day time (7:00 AM-7:00 PM)	3,881 (68)	679 (48)	801 (77)	496 (61)	1905 (78)	**< 0.001, < 0.001, < 0.001**
Evening time (7:01 PM-06:59 AM)	1,836 (32)	743 (52)	245 (23)	321 (39)	527 (22)	
Accepting service, N (%)^						
Emergency general surgery	223 (4)	147 (10)	1 (0)	0 (0)	75 (3)	
Cardiac surgery	732 (13)	297 (21)	106 (10)	0 (0)	329 (14)	
Cardiology	906 (16)	12 (1)	373 (36)	0 (0)	521 (21)	
Neurology	317 (6)	114 (8)	145 (14)	0 (0)	58 (2)	
Neurosurgery	392 (7)	191 (13)	164 (16)	0 (0)	37 (2)	**< 0.001,** NA**, < 0.001**
Oncology	208 (4)	2 (1)	0 (0)	0 (0)	206 (8)	
Pulmonary and critical care	311 (5)	57 (4)	252 (14)	0 (0)	2 (0)	**< 0.001, < 0.001, < 0.001**
Thoracic surgery	99 (2)	25 (2)	0 (0)	0 (0)	74 (3)	
Transplant	334 (6)	38 (3)	3 (0)	0 (0)	293 (12)	
Vascular surgery	224 (4)	134 (9)	1 (0)	0 (0)	89 (4)	
Other accepting services	1,971 (34)	405 (28)	1 (0)	817 (100)	748 (31)	

*All UMMC does not include pediatric or trauma patients.
**ICU patients are separate from CCRU.
^Indicates that the top group of P-values was calculated excluding the unknown or other/unknown group and that the bottom group of P-values was calculated with the unknown or other/unknown groups with either Pearson chi-square test or Fisher exact test as appropriate.
†Bold cells indicate statistically significant findings (P < 0.05).
P-values written as P_1, P_2, P_3 where: P_1 = CCRU vs. ICU; P_2 = CCRU vs. ED; P_3 = CCRU vs. Other Inpatient Units
CCRU, critical care resuscitation unit; *ED,* emergency department; *ICU,* intensive care unit; *IQR,* interquartile range; *min,* minutes; *km,* kilometers; *NA,* not applicable; *UMMC,* University of Maryland Medical Center.

compared to patients with immediate bed assignment time (44% normal vs 38% immediate, $P = 0.014$).

Primary Outcome: Transfer Request to Bed Assignment

The Kaplan–Meier curves presented in Figure 2A and Figure 2B depict each time interval from transfer request to CCRU bed assignment. The top five accepting services based on volume for the CCRU during the 2018 calendar year were as follows: 1) cardiac surgery (297, 21%); 2) soft tissue surgery (240, 16%); 3) neurosurgery (191, 13%); 4) acute care emergency services (147, 10%); and 5) vascular surgery (134, 9%). **Appendix 1** provides a complete list of accepting

Table 1B. Demographics of accepted patients triaged to the critical care resuscitation unit.

Variables	All patients	Immediate bed assignment (≤ 8Minutes)	Normal bed assignment (>8 Minutes)	P†
Total patients, N	1,422	712	710	NA
Age (years), mean (SD)	57 (17)	58 (17)	57 (16)	0.72
Gender, N (%)				
Male	783 (55)	378 (53)	405 (57)	0.13
Female	639 (46)	334 (47)	305 (43)	
Past medical history, N (%)				
HTN	644 (45)	326 (46)	318 (45)	0.71
DM	347 (24)	165 (23)	182 (26)	0.28
Any liver disease	99 (7)	45 (6)	54 (8)	0.34
Any kidney disease	238 (17)	114 (16)	124 (17)	0.46
Any heart disease	315 (22)	157 (22)	158 (22)	0.93
Type of referring hospital, N (%)				
Teaching hospital	460 (32)	237 (33)	223 (31)	0.45
Non-teaching hospital	962 (68)	475 (67)	487 (69)	
Ground distance (km), mean (SD)	55 (56)	56 (58)	54 (54)	0.45
Transport by air, N (%)	240 (17)	157 (22)	83 (12)	**< 0.001**
Transfer request details, N (%)				
Transfer request weekdays (Mon-Fri)	1046 (74)	517 (73)	529 (75)	0.42
Transfer request weekend (Sat-Sun)	376 (26)	195 (27)	181 (25)	
Transfer request at night	743 (52)	313 (44)	430 (61)	**< 0.001**
Transfer request weekend night	208 (15)	103 (14)	105 (15)	0.86
Laboratory values				
WBC count (counts/μL), mean (SD)	14.28 (15.51)	14.60 (19.70)	13.96 (9.78)	0.44
Hemoglobin (g/dL), mean (SD)	11.5 (4.3)	11.7 (3.5)	11.4 (5.0)	0.13
Serum lactate (mmol/dL), mean (SD)	2.30 (2.32)	2.49 (2.59)	2.11 (2.00)	**0.002**
First troponin level (ng/L), median [IQR]	0.020 [0.010-0.110]	0.020 [0.010-0.120]	0.020 [0.010-0.100]	0.47
SOFA score, median [IQR]	3 [1-6]	3 [1-7]	2 [1-6]	**0.001**

†Bold cells indicate statistically significant findings (P < 0.05).
CCRU, critical care resuscitation unit; *dL,* deciliter; *DM,* diabetes mellitus; *Fri,* Friday; *g,* gram; *HTN,* hypertension; *IQR,* interquartile range; *km,* kilometer; *μL,* microliter; *mmol,* millimole; *Mon,* Monday; *ng,* nanogram; *NA,* not applicable; *Sat,* Saturday; *SOFA*, Sequential Organ Failure Assessment; *SD,* standard deviation; *Sun,* Sunday; *WBC,* white blood cell.

services for patients being transferred to the CCRU. Figure 2B illustrates the CCRU bed assignment at each time interval from transfer requests for respective accepting services. Figure 3A demonstrates the time from transfer request and that ~50% of patients arrive at the CCRU within three hours. The time interval that patients arrive at the CCRU stratified by accepting service is represented in Figure 3B.

The covariates that were significantly associated with our primary outcome of interest—transfer request to bed assignment ≤8 minutes—are reported in Table 2. The full multivariate model is reported in **Appendix 2**. Patients requiring stroke neurology (odds ratio [OR] 5.49, 95% confidence interval [CI] 2.85-10.86, $P < 0.001$), with an increased SOFA score (OR 1.04, 95% CI 1.00-1.07, $P = 0.047$), and receiving surgical operation within 12 hours (OR 2.85, 95% CI 1.98-4.13, $P < 0.001$) were associated with immediate bed assignment time. However, patients who would receive any surgical intervention during hospitalization (OR 0.74, 95% CI 0.55-0.99, $P = 0.044$) were significantly less likely to have an immediate bed assignment time.

Secondary Outcome: Transfer Request to Arrival at the Critical Care Resuscitation Unit

We reported the statistically significant findings from our multivariate analysis of our secondary outcomes in Table 2 and the full multivariate models are available in **Appendix 3**. Factors significantly associated with increased likelihood of transfer request to CCRU arrival time <180 minutes were

Table 1C. Clinical characteristics of accepted patients triaged to the critical care resuscitation unit.

Variables	All patients	Immediate bed assignment (≤ 8Minutes)	Normal bed assignment (>8 Minutes)	P†
Total patients, N	1,422	712	710	NA
Transfer request to bed assignment (min), median [IQR]	8 [0-70]	0 [0-3]	70 [22-254]	**< 0.001**
Transfer request to arrival (min), median [IQR]	174 [115-290]	131 [93-183]	253 [163-447]	**< 0.001**
CCRU LOS (hours), median [IQR]	7 [4-18]	6 [3-15]	8 [4-19]	**< 0.001**
Continuous infusion, N (%)				
Any anti-hypertensive	184 (13)	110 (15)	74 (10)	**0.005**
Insulin	189 (13)	92 (13)	97 (14)	0.68
Invasive mechanical ventilation on arrival	471 (33)	264 (37)	207 (29)	**0.002**
Any blood transfusion on arrival	146 (10)	80 (11)	66 (9)	0.23
Type of procedure, N (%)				
Cannulation for ECMO	25 (2)	15 (2)	10 (1)	0.32
Intra-aortic balloon pump	15 (1)	4 (1)	11 (2)	0.07
IR	29 (2)	18 (3)	11 (2)	0.19
Other procedure	30 (2)	20 (3)	10 (1)	0.07
Any surgical intervention	776 (55)	364 (51)	412 (58)	**0.009**
To OR within 12 hours	324 (23)	192 (27)	142 (20)	**0.002**
Patients' dispositions, N (%)				
Discharge home	580 (41)	269 (38)	311 (44)	
Acute rehab	327 (23)	182 (26)	145 (20)	
Skilled nursing home	253 (18)	116 (16)	137 (19)	**0.014**
Dead or hospice	218 (15)	123 (17)	95 (13)	
Other	44 (3)	22 (3)	22 (3)	

†Bold cells indicate statistically significant findings (P < 0.05).
CCRU, critical care resuscitation unit; *ECMO,* extracorporeal membrane oxygenation; *IQR,* interquartile range; *IR,* interventional radiology; *LOS,* length of stay; *min,* minutes; *NA,* not applicable; *OR,* operating room.

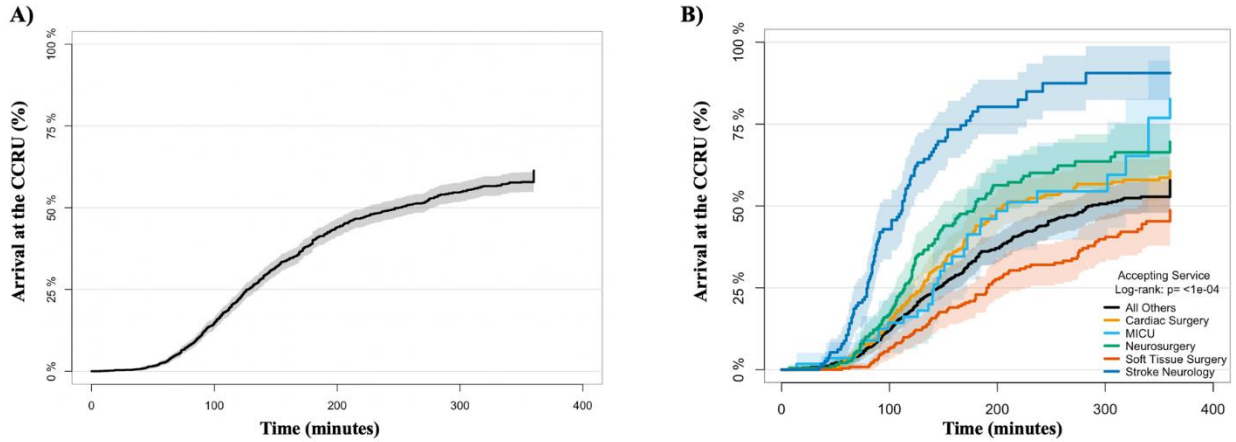

Figure 2. Kaplan-Meier curve for bed assignment to the CCRU (A) Time intervals for bed assignment to the CCRU for all patients. (B) Comparison of time intervals for bed assignment to the CCRU based on accepting service.
* The 50% mark indicates the censored time.
CCRU, critical care resuscitation unit; *MICU,* medical intensive care unit.

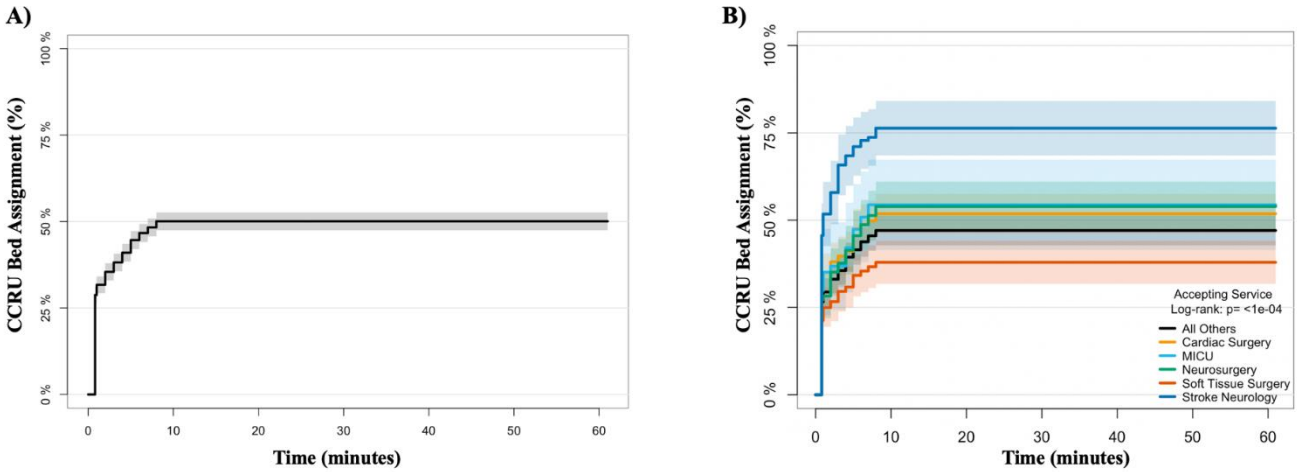

Figure 3. Kaplan-Meier curve for arrival at the CCRU: (A) Time intervals for all patients arriving to the CCRU. (B) Comparison of time intervals from arrival to the CCRU based on accepting service.
CCRU, critical care resuscitation unit; *MICU,* medical intensive care unit.

patients being accepted by stroke neurology (OR 12.81, 95% CI 6.09-28.51, $P < 0.001$) and being taken to the OR for emergent surgical intervention (OR 3.15, 95% CI 2.12-4.71, $P < 0.001$). Higher SOFA score (OR 0.96, 95% CI 0.92-0.99, $P = 0.033$) was associated with decreased likelihood of arrival within 180 minutes.

Other Outcome: Predictors for Mortality Among Patients Transferred to the CCRU

The statistically significant covariates are presented in Table 2 for the outcome of mortality and the result of the complete multivariate logistic regression is available in **Appendix 3**. Accepting services associated with a significant likelihood of mortality were neurosurgery (OR 4.14, 95% CI 1.87-9.37, $P < 0.001$) and stroke neurology (OR 3.00, 95% CI 1.20-7.52, $P = 0.019$). Each gram per deciliter increase in hemoglobin was protective and associated with 12% decreased risk of death (OR 0.88, 95% CI 0.80-0.95, $P = 0.002$).

All of the model's Hosmer–Lemeshow goodness of fit tests returned $P > 0.05$, indicating the data fit the models well, and all VIF values for each covariate were <5 indicating that multicollinearity was not present.

DISCUSSION

When originally conceptualized, the purpose of the CCRU—similar to the model of trauma transfer—was to provide "immediate ICU access to accommodate IHT with time-sensitive surgical critical illness," while "decreasing lost admissions, minimizing transfer times, and improving outcomes of known trauma critical care transfers."[4] Having demonstrated a significant increase in the volume of transfers, decreased transfer times, and decreased time to operative intervention, the CCRU expanded its patient population, including other critical care emergencies requiring intervention, such as acute ischemic stroke caused by large vessel occlusion and coronary interventions.[4,9,10] While formalized systems exist for patients transferred between hospitals with traumatic etiologies, ST-segment elevation myocardial infarction and stroke, there are no formal systems to ensure timely transfer for other highly morbid, highly fatal, and time-sensitive conditions, including acute aortic diseases, toxicologic, obstetric, septic, respiratory, and other vascular emergencies. The CCRU demonstrates that such a regionalized ICU is feasible, although further studies are necessary to elucidate how units like the CCRU could affect the operations of referring hospitals.

In general, the literature supports the conclusion that patients with critical illness or time-sensitive diseases should be referred to large-volume centers with multiple advanced modalities and therapeutic options that are not available at most acute care hospitals.[14] However, bed availability is usually a prime factor in the delay of care for these patients as ICU bed utilization in most hospitals is not oriented toward the acceptance of outside transfers. Furthermore, there is no formal system to triage and prioritize the transfer of these patients. Therefore, immediate acceptance to an ICU bed is difficult for most units, and a significant amount of time and uncertainty is lost in the interim between initial consult and eventual bed assignment. A traditional ICU may need to decide whether to leave a bed open, while other critically ill patients wait in the ED or other part of the hospital. On the other hand, a traditional ICU may fill all the available beds and then waitlist patients from other hospitals.

The CCRU offers solutions to avoid many problems that traditional ICUs face when they are confronted with an emergent bed request. One of our guiding principles is to maintain bed availability continuously for emergent transfer requests for patients with all disease states. The CCRU has been largely successful in being able to accommodate appropriate requests for emergent transfer by maintaining

Table 2. Multivariate logistic regression measuring association of demographic and clinical factors with the primary outcome of transfer request to bed assignment ≤8 minutes and the secondary outcomes of transfer request to CCRU* arrival < 180 minutes and mortality.

	Multivariate regression results			
Variables	OR	95% CI LL	95% CI UL	P
Primary Outcome: Transfer Request to Bed Assignment ≤ 8minutes				
Accepting service – Stroke neurology	5.487	2.852	10.858	< 0.001
Need for OR within 12 hours	2.847	1.977	4.125	< 0.001
CCRU transfer request – Day	2.351	1.759	3.153	< 0.001
CCRU transfer request – Weekend night	2.248	1.279	3.958	0.005
Arrival SOFA score – each increment	1.036	1.001	1.073	0.047
Any OR	0.738	0.549	0.991	0.044
Accepting service – Soft tissue surgery	0.593	0.352	0.997	0.049
Secondary Outcome: Transfer Request to CCRU Arrival < 180 minutes				
Accepting service – Stroke neurology	12.814	6.092	28.510	< 0.001
Need for OR within 12 hours	3.146	2.120	4.711	< 0.001
Accepting service – Neurosurgery	2.813	1.575	5.075	< 0.001
Accepting service – Pulmonary critical care	2.415	1.098	5.411	0.029
Accepting service – Vascular surgery	1.897	1.053	3.442	0.033
Accepting service – Cardiac surgery	1.865	1.126	3.115	0.016
Any infusion on arrival	1.712	1.292	2.274	< 0.001
CCRU transfer request – Day	1.428	1.048	1.949	0.024
Serum lactate – each mmol/dL	1.080	1.011	1.156	0.025
Distance from UMMC – each kilometer	0.991	0.988	0.995	< 0.001
Arrival SOFA score – each increment	0.960	0.924	0.996	0.033
Transport type – ground	0.195	0.126	0.296	< 0.001
Any OR	0.712	0.520	0.974	0.033
Secondary Outcome: Mortality				
Accepting service – Neurosurgery	4.137	1.870	9.365	< 0.001
Accepting service – Stroke neurology	3.002	1.196	7.523	0.019
Arrival SOFA score – each increment	1.265	1.202	1.333	< 0.001
Serum lactate – each mmol/dL	1.153	1.068	1.251	< 0.001
Age – each year	1.037	1.023	1.052	< 0.001
Arrival troponin – each ng/L	1.010	1.003	1.020	0.016
Hemoglobin – each g/dL	0.875	0.804	0.950	0.002

*Only variables with significant association with the outcome of interest are reported (P < 0.05).
CI, confidence interval; *CCRU,* critical care resuscitation unit; *g/dL,* grams per deciliter; *LL,* lower limit 95% CI; *mmol/dL,* millimole per deciliter; *ng,* nanogram; *OR,* odds ratio; *OR,* operating room; *SOFA,* Sequential Organ Failure Assessment; *UMMC,* University of Maryland Medical Center; *UL,* upper limit 95% CI.

effective flow management through the entire system with institutional support.

In this study we investigated the triage process and the prioritization of patients who needed to be transferred for higher levels of care. We evaluated patient characteristics and logistical factors associated with rapid acceptance and transfer to the CCRU by comparing those patients with immediate assignment vs those who waited a more standard time for bed assignment after initial consult. Not surprisingly, those patients with immediate bed assignment were more likely to have a more rapid arrival, arrive by air, and undergo surgical interventions within 12 hours of arrival. These patients also had higher SOFA scores and were more likely to be mechanically ventilated or receiving continuous infusions. All these characteristics are arguably markers found in those illnesses requiring more time-sensitive intervention,

resuscitation, or higher care intensity and, therefore, highest priority for immediate bed assignment. Furthermore, the time-sensitive nature for those patients who require timely intervention and resuscitation is likely the main driver of early transfer and would seemingly affect their outcomes.

The triage and prioritization process for early CCRU bed assignment and transfer may have explained previous observations regarding critically ill patients' outcomes. Previously, we have shown that patients requiring higher critical care intensity who were transferred from other hospitals' EDs to the CCRU were associated with lower likelihood of mortality when compared with those admitted to other traditional adult non-trauma ICUs in our own medical center.[10] Similarly, patients who received early intervention at an ED-based resuscitation unit were also associated with lower 30-day mortality.[15] Thus, our triage process eliminated lost time and uncertainty for the referring clinicians, while potentially optimizing patients' outcomes.

In this study, the severity and characteristics of patients requiring immediate bed assignment were largely supported by the primary and secondary outcome analyses. Criteria such as the severity of illness, as indicated by high SOFA scores, needing operative intervention within 12 hours, and admission of these patients to the stroke neurology service at a comprehensive stroke center, are plausible factors to necessitate immediate bed assignment. Similarly, when predicting which patients would be associated with a higher burden of morbidity and mortality, those with emergent need for neurosurgical and stroke intervention seem natural candidates and an intuitive choice. Patients with strokes have a time-sensitive disease if the patient is a candidate for mechanical thrombectomy (eg, occlusion in a large vessel such as the middle cerebral artery or internal carotid artery); thus, they would be prioritized by the CCRU team during triage.

Minimizing the time from symptom onset to reperfusion for candidates of mechanical thrombectomy is known to impact patient outcomes; thus, the CCRU is designed to expedite transfer for these patients in conjunction with our comprehensive stroke center.[16] Hemorrhagic stroke would also be another reason patients are prioritized if they require interventions to prevent increased intracranial pressure. Furthermore, severity of illness is directly linked to mortality; therefore, it is not surprising that arrival SOFA score, high serum lactate, age, and troponin would be the multivariate factors predictive for mortality, as each can reasonably be associated with mortality itself in undifferentiated critical illness.

The time intervals from transfer request to CCRU arrival for the early arrival group is multifactorial. As our institution is a comprehensive stroke center, it is not surprising that the strongest factor for a patient arriving rapidly to our medical center is for emergent intervention by the stroke neurology team. Similarly, those patients needing emergent evaluations and interventions by neurosurgery, vascular surgery, and cardiac surgery, as well as other patients requiring any medication infusion and those resulting in operative intervention within 12 hours would be priorities for transfer in most situations. On the other hand, those patients who were requested for transfer during daylight hours would theoretically undergo early surgical interventions upon arrival, and these patients would also benefit from the higher nursing staffing and resources available when compared to nighttime levels at most institutions.[17]

Given the complexity and myriad of factors that play a role in the transport of patients to our center, distance and ground transport negatively affecting the intervals between transfer request and arrival time are appropriate. Similarly, patients who would need to be transferred for non-urgent but complex surgical interventions that are only available at a quaternary medical center may not need to be transferred immediately, thereby explaining how those patients undergoing any operative intervention during their hospitalization at our medical center did not arrive at the CCRU within 180 minutes. However, patients having higher arrival SOFA score, but not an elevated serum lactate, did not arrive to the CCRU early. This was a curious and counterintuitive finding that warrants further study. It is probable that patients who were critically ill with high SOFA scores were associated with prolonged stabilization before patients could be stable for transfer; thus, it could have taken them longer to be transferred, although a bed was already ready for them.[18,19]

Single elevation of lactate could be multifactorial from several conditions, including but not limited to status epilepticus or hypovolemia. Therefore, those patients can be evaluated along the way with resuscitation at the referring center. Typically, lactate can be cleared with prompt and effective treatment. Upon evaluation of a patient for transfer to the CCRU, a CCRU attending asks about factors such as ventilator mode, arterial blood gas(es), resulted laboratory values, and vasopressor requirements, among other factors, so that a mental picture can be created of the patient's SOFA score prior to arrival. The SOFA score is a composite metric that involves a patient's neurologic, cardiac, renal, hematologic, and hepatic status. All components of the SOFA score will be asked at the time of transfer request and then an idea will be formed of how critically ill the patient is. This will then become more objective when a SOFA score is calculated when the patient arrives. Based on the clinical picture of the patient, the CCRU attendings will prioritize how soon a patient will come to the CCRU and their bed assignment time. Lactate does play a role in prioritization but only if lactate is elevated and caused by a condition that requires intervention at a quaternary care center such as elevation caused by an ischemic limb, ischemic bowel, or severe acute respiratory distress syndrome requiring ECMO, among other conditions.

One peculiarity throughout the modeling is the negative association with any operative intervention or acceptance by our soft tissue surgery service. This potential inconsistency is likely a result of our policy for the admission and management of patients with soft tissue infection. The R Adams Cowley

Shock Trauma Center at the University of Maryland is a regional referral center for soft tissue infections and surgery. During the day between 7 AM and 5 PM, all surgical operations and transfer requests are handled by the regular soft tissue surgery team, which is staffed by our trauma surgeons who specialize in soft tissue infection. The service is covered during overnight hours by the on-call trauma service.

To avoid taking the attention of trauma surgeons away from the critically ill trauma patients, our clinical practice is to admit all patients with soft tissue infections to the CCRU first, thus allowing our critical care staff to evaluate and manage these complex patients. Unless these patients need urgent surgical intervention, which the trauma surgeons will carry out, these patients will otherwise undergo scheduled operations, as clinically indicated, at a later day with the regular soft tissue surgeons. Therefore, while the acuity of those patients who have necrotizing fasciitis would be high and would require urgent interventions and immediate bed assignment, most patients with soft tissue infections do not require immediate surgical intervention at arrival, either because they have received an initial debridement at the referring hospital or they have an intermediate acuity disease state (eg, cellulitis, abscess, etc) that warrants longer wait times for transport and subsequent surgical interventions at a later time. Nevertheless, the patients with soft tissue infections, which represent approximately 13% of our population, could partly explain these observations. Future studies specifically involving patients with soft tissue infection are needed to further investigate this phenomenon.

LIMITATIONS

Our study has several strengths, as well as some limitations that should be highlighted. We only focused on the patients who were accepted to the CCRU; we did not have data regarding patients who were not accepted to the CCRU. When the CCRU reaches its capacity and immediate bed assignment is not possible, referring clinicians may opt to contact other tertiary facilities to transfer their patients. Our study involved a large and heterogenous patient population; therefore, we had to categorize patients according to the accepting services and could not identify the individual disease states that would necessitate immediate bed assignment. For example, all patients who were admitted to our medical intensive care unit were categorized as being accepted by the pulmonary and critical care service. These patients could span a variety of conditions, such as respiratory failure, gastrointestinal bleeding, septic shock, etc. Finally, we used the SOFA score as a surrogate marker for disease severity, but it does not apply to all disease states, such as patients with stroke or spontaneous intracerebral hemorrhage.

CONCLUSION

Our study showed that patients who had high acuity or required urgent surgical intervention, such as patients with ischemic stroke, were given highest priority to have immediate bed assignments at the CCRU. However, patients who had high SOFA scores or were referred during overnight hours were associated with longer intervals between transfer request to arrival at the CCRU. Further studies are necessary to confirm our observations and to investigate the relationship between this group of patients and their outcomes.

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Arterial Monitoring in Hypertensive Emergencies: Significance for the Critical Care Resuscitation Unit

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Introduction: Blood pressure measurement is important for treating patients. It is known that there is a discrepancy between cuff blood pressure vs arterial blood pressure measurement. However few studies have explored the clinical significance of discrepancies between cuff (CPB) vs arterial blood pressure (ABP). Our study investigated whether differences in CBP and ABP led to change in management for patients with hypertensive emergencies and factors associated with this change.

Methods: This prospective observational study included adult patients admitted between January 2019–May 2021 to a resuscitation unit with hypertensive emergencies. We defined clinical significance of discrepancies as a discrepancy between CBP and ABP that resulted in change of clinical management. We used stepwise multivariable logistic regression to measure associations between clinical factors and outcomes.

Results: Of 212 patients we analyzed, 88 (42%) had change in management. Mean difference between CBP and ABP was 17 milligrams of mercury (SD 14). Increasing the existing rate of antihypertensive infusion occurred in 38 (44%) patients. Higher body mass index (odds ratio [OR] 1.04, 95% confidence Interval [CI] 1.0001–1.08, *P*-value <0.05) and history of peripheral arterial disease (OR 0.16, 95% CI 0.03–0.97, *P*-value <0.05) were factors associated with clinical significance of discrepancies.

Conclusion: Approximately 40% of hypertensive emergencies had a clinical significance of discrepancy warranting management change when arterial blood pressure was initiated. Further studies are necessary to confirm our observations and to investigate the benefit-risk ratio of ABP monitoring. [West J Emerg Med. 2023;24(4)763–773.]

INTRODUCTION

Blood pressure (BP) monitoring is an essential component of managing hypertensive disease processes, many of which require maintenance of specific BP windows. Intra-arterial blood pressure (ABP) monitoring is widely considered the gold standard of BP measurement in critical care settings; however, its invasive nature also presents some rare but serious risks including bleeding, thrombosis, infection, embolism, and nerve damage.[1,2] Additionally, little research has been done to demonstrate whether its use is associated

with changes in clinical management when compared to noninvasive cuff blood pressure (CBP) monitoring, such as oscillometric CBP measurement. Therefore, the necessity of ABP monitoring has been questioned.[3,4]

Previous studies have shown, however, that discrepancies exist between noninvasive CBP and invasive ABP measurement.[5–12] Accuracy of CBP measurement may be affected by obesity, cuff location, age, and arterial stiffness.[13–16] Accurate measurement of BP is important, as brief episodes of either hypotension or hypertension are associated with higher rates of mortality and other unfavorable outcomes in various critical illnesses.[17–22] Use of CBP generally underestimates intra-arterial systolic (SBP) in hypertensive diseases, which may lead to mismanagement of patients with conditions requiring adherence to specific BP guidelines.[6,10,23–25] Additionally, ABP monitoring offers the benefit of real-time continuous monitoring, while cuff measurements are typically performed intermittently.

Guidelines established by several professional societies recommend specific BP goals for various hypertensive disease states. For example, current guidelines for management of acute aortic diseases suggest a SBP goal of <120 millimeters of mercury (mm Hg) in Type A dissection and SBP goal of <140 mm Hg in Type B dissection.[26] Additional guidelines exist for ischemic stroke,[27] spontaneous intracerebral hemorrhage,[28] and preeclampsia,[29] among others. As previously discussed, operating within a safe BP margin has important clinical implications. For example, in patients with acute aortic pathology, both hypotension and hypertension are associated with increased mortality risk.[18,21,22] This highlights the importance of accurate continuous BP measurement to maintain pressures within specific parameters.

A few previous studies provide evidence for the utility of ABP monitoring in hypertensive critically ill patients. Manios et al found that CBP measurements underestimate ABP in patients with ischemic stroke, most markedly in those with critically high SBP.[11] A retrospective study by Raffman et al demonstrated that nearly one in three patients with hypertensive disease admitted to a resuscitation unit had a difference between ABP and CBP that would result in a change in clinical management.[6] However, these studies were limited by small sample size or the use of hypothetical definitions of change in management, respectively.

Our prospective study sought to investigate the clinical significance of the difference between ABP monitoring vs CBP monitoring, in real time, among patients with hypertensive critical illnesses. We specifically aimed to determine whether the difference in monitoring between CBP and ABP would result in change in clinical management for patients with hypertensive emergencies and to identify clinical factors predicting change in management between the two measurement modalities. We hypothesized that the difference between monitoring of ABP and CBP values would lead to a change in BP management in at least 30% of our patients with hypertensive emergencies.

Population Health Research Capsule

What do we already know about this issue?
Discrepancy between arterial (ABP) vs cuff blood pressure (CBP) monitoring exists. CBP is commonly used although ABP monitoring is considered the gold standard.

What was the research question?
Does a discrepancy between the two blood pressure monitoring modalities result in change of clinical management?

What was the major finding of the study?
88 patients (42%) had a change of management in real time resulting in increasing doses of antihypertensive medication.

How does this improve population health?
In a patient with hypertensive emergency whose blood pressure is at borderline of recommended guidelines, ABP should be considered.

METHODS

Study Setting

This prospective observational study took place in the critical care resuscitation unit (CCRU), an intensive care unit (ICU)-based resuscitation unit that was created at our quaternary-care institution with the goal of expediting transfer of patients with time-sensitive critical illnesses from other hospitals when there are no available beds at one of our traditional ICUs.[30,31] These patients' critical illnesses usually exceed the capability of the sending hospitals; so, upon their arrival at the CRRU, they receive immediate resuscitation and timely ICU-level care. Once patients are stabilized, they are moved to appropriate inpatient beds. Per CCRU clinical policy, all patients receiving antihypertensive medication infusion or requiring hemodynamic monitoring will need ABP monitoring, and an arterial catheter is placed upon arrival to the unit. The CCRU clinicians would place a majority of arterial cannulations, in compliance with our institutional protocols for maximum sterility. The study was approved by our institutional review board (HP-00079864) and was exempted from formal consent.

Patient Selection

We included consecutive adult patients with any hypertensive emergency diagnosis (ischemic stroke, spontaneous intracerebral hemorrhage, acute aortic diseases) who required ABP monitoring upon admission to the CCRU between January 2019–May 2021. Patients who had CBP and ABP measurements within 60 minutes of each other were eligible. Exclusion criteria included the following: arterial catheter in place prior to arrival; arterial catheter and BP cuff placement on opposite side of body (ie, cuff pressure on left arm while arterial catheter in right radial artery); unreliable arterial measurements according to the clinicians; use of vasopressors prior to or starting at the time of arterial catheter placement. We additionally excluded patients with non-hypertensive diagnoses (eg, sepsis, organ ischemia, pancreatitis, any bleeding, respiratory failure). We excluded these patients because their BPs are managed differently. Patients who require vasopressors or have non-hypertensive diagnoses are managed in accordance with their mean arterial pressure, instead of SBP, as recommended by previous management guidelines for hypertensive emergencies.

Prospective Data Collection

Prior to the study recruitment period, we created a standardized form and educated the CCRU clinicians (nursing staff, advanced practice practitioners, residents, fellow physicians) on the use of the form for all patients requiring arterial catheter placement. Most of the CCRU nursing staff were blinded to the study hypothesis and were not involved in preparation of the manuscript. The form contained sections for clinicians to record patient demographic information (age, gender, medical record number, diagnosis, goal of BP), CBP values, ABP values, arterial catheter site (right/left radial or femoral), cuff site (right/left arm or leg), and management decisions as guided by each BP value.

Before placing the arterial catheter, the CCRU nurse or the clinician prospectively filled out the form in real time to indicate CBP values immediately and the associated management according to the CBP monitoring values (eg, decrease nicardipine infusion from 7.5 milligrams per hour [mg/hr] to 5 mg/hr). After arterial catheter placement, the clinicians additionally recorded the ABP monitoring values and the management decision guided b those values (eg, increase nicardipine infusion from 7.5 mg/hour to 10 mg/hour, etc). An APP and the principal investigator adjudicated the missing data on the prospective data collection form, using patients' electronic health records (EHR). We identified approximately 23 patients (11%) who did not have a diagnosis that required ABP monitoring in the CCRU. These included 14 patients with aortic aneurysms and nine other diagnoses.

Retrospective Data Collection

Members of the research team retrospectively collected additional patient data from our institution's EHR. Extracted demographic information included age, gender, body mass index (BMI), and past medical history. They also collected clinical data during hospitalization, including lab values (serum creatinine and lactate), echocardiography results (ejection fraction, presence of left ventricular hypertrophy), medications used at the time of arterial cannulation, and patient outcomes (deceased, discharged to home, discharged to acute rehabilitation facility, etc). Additionally, they collected information regarding complications associated with arterial catheter cannulations and total duration of arterial catheter insertion. We defined arterial catheter complications as bleeding, aneurysm, extremity necrosis, local nerve damage, or definitive source of local or systemic infection or embolism.[32] We had planned to impute any missing retrospective data with the population's mean; however, no data was missing as all the recorded data was part of the clinical standard of care.

We obtained all retrospective data in compliance with methodologic standards for medical record review.[33] Members of the research team were not blinded to the study hypothesis. Each investigator received training in data extraction from patient records and input data into a standardized Excel spreadsheet (Microsoft Corporation, Redmond, WA). To reduce bias, investigators collected specific subsets of data only; for example, those who recorded hospital outcomes did not collect BP measurements or lab values and vice versa. The senior investigator reviewed the accuracy of data during the training phase to ensure greater than 90% agreement before team members started data collection. Additionally, the senior investigator randomly rechecked up to 20% of the collected data to ensure accuracy throughout the process.

Outcome Measures

Our primary outcome was the prevalence of clinically significant difference between measurements of ABP and CBP monitoring. We defined this as a difference in clinical management based on the values obtained from ABP vs CBP monitoring, as determined in real time by the clinicians upon placement of the arterial catheters. For example, the American Heart Association Task Force on Practice Guidelines recommends a SBP of ≤120 mm Hg for type A aortic dissection.[26] We identified clinically significant difference as a difference between ABP and CBP that resulted in a change in BP management to adhere to these guidelines.

If a patient with Type A aortic dissection had CBP of 115 mm Hg and ABP of 125 mm Hg, the difference in BP measurements necessitated a change in management between the two modalities. In this case, the CBP value indicated the SBP was at goal and no further action was needed. In

contrast, the ABP suggested that increasing the dose of the current antihypertensive infusion was warranted. Alternatively, if the patient had CBP of 135 mm Hg and ABP of 145 mm Hg, the clinician indicated that both values required increasing the dose of current antihypertensive infusion, in accordance with the guidelines to lower SBP to ≤120 mm Hg. Thus, this action indicated that no clinically significant difference existed.

Our secondary outcomes included mean difference between CBP monitoring and ABP monitoring and the percentage of patients with difference of ≥20 mm Hg between the two modalities. Given that previous guidelines suggested that patients with a difference of ≥20 mm Hg may be at risk for worse outcomes than those with a difference ≤20 mm Hg,[34] we determined this cutoff to be a significant difference in this study. We additionally reported factors associated with either the primary or secondary outcomes.

Sample Size Calculation

We calculated our sample size according to a prior study from Ruszala.[10] Based on this study, which reported that ABP monitoring was associated with approximately 20% higher prevalence of patients who received more frequent interventions during transport, we calculated that we would need 97 patients in each group (total 194 patients) to detect a difference of 20% of prevalence of clinical management between CBP and ABP monitoring, with a = 0.05 and power of 80%.

Data Analysis

We used descriptive analysis to present patient data. Categorical variables are presented as percentages, and continuous variables are reported as mean (+/-SD) or median (interquartile range), as applicable. We analyzed differences between groups of continuous variables using the Student *t*-test or Mann Whitney U test, while the chi-square test was used for categorical variables.

To graphically represent the distributions of ABP and CBP monitoring differences, we used the Bland-Altman analysis. The Y-axis of the Bland-Altman graphs depicted the values of [ABP-CBP] differences. If ABP values are >CBP values, there would be more dots in the positive region of the Y-axis. The X-axis represented the ranges of patients' CBP monitoring values. A dispersed distribution along the X-axis would suggest that the differences between [ABP-CBP] occurred at all ranges of CBP monitoring values.

We used forward stepwise multivariable binary logistic regressions to identify associations between independent variables and the outcomes (clinically significant difference, ABP-CBP difference >20 mm Hg). We a priori determined the independent variables included in regression analysis, which are listed in Appendix 1. Goodness-of-fit, multicollinearity, and discriminatory capability of the multivariable logistic regression models were also assessed. A Hosmer-Lemeshow test with *P*-value > 0.05 indicates a model with a good fit of independent variables. We reported the variance inflation factors (VIF) for assessment of the multicollinearity of independent variables, and factors with VIF ≥5 were considered to have high multicollinearity and thus were removed from the logistic regression. The discriminatory capability of the regressions was assessed via the area under the receiver operating curve (AUROC). Models with AUROC approaching −1 or +1 were considered having perfect discriminatory capability between dichotomous outcomes.

We performed all statistical tests using Minitab version 19.0 (Minitab Corp, State College, PA). A *P*-value of less than 0.05 was considered statistically significant.

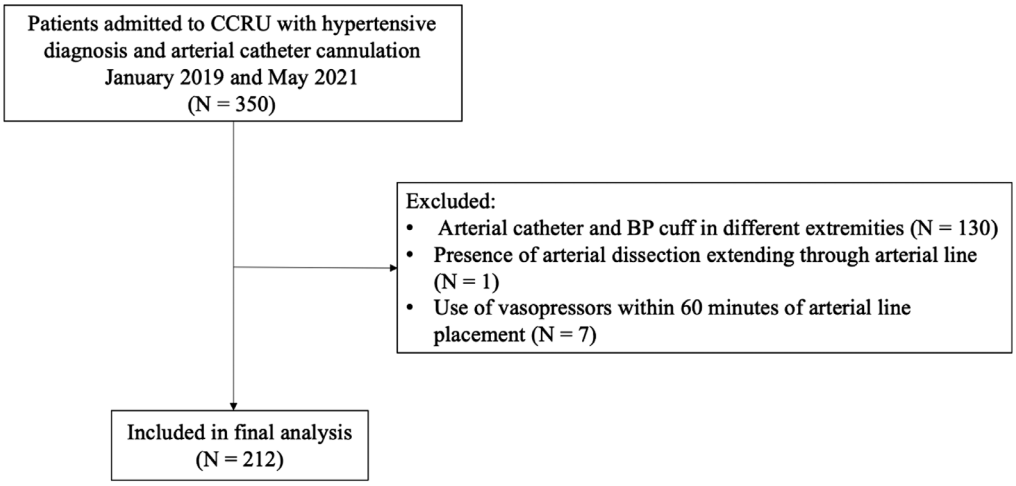

Figure 1. Patient selection diagram. A total of 212 patients with hypertensive disease and arterial catheter cannulation were included in analysis.
CCRU, critical care resuscitation unit; *BP*, blood pressure.

RESULTS

Patient Characteristics

We identified a total of 350 patients with hypertensive diagnoses and arterial catheter cannulation for ABP monitoring between January 2019–May 2021 (Figure 1). Among these patients, 212 met our inclusion criteria and were included in analysis. A total of 88 patients (42%) had a change of management in real time (Table 1). There was only

Table 1. Characteristics of hypertensive patients with change in management vs patients without change in management between intra-arterial and noninvasive blood pressure monitoring.

Demographic	All patients N = 212	No change in management N = 124 (58.5%)	Change in management N = 88 (41.5%)	*P*-value
Age, mean (SD)	63 (14)	62 (13)	62 (15)	0.9
Gender, N (%)				
Male	130 (61)	77 (62)	53 (60)	0.8
Female	82 (39)	47 (38)	35 (40)	0.8
BMI, mean (SD)	29.0 (6.7)	28.2 (6.0)	30.1 (7.4)	0.4
Clinical data				
Serum lactate, mean (SD)	2.1 (1.6)	2.1 (1.7)	2.1 (1.3)	0.8
Left ventricular EF, mean (SD)[1]	0.60 (0.12)	0.60 (0.12)	0.60 (0.12)	0.9
Left ventricular hypertrophy, N (%)	128 (60)	74 (60)	54 (62)	0.7
Arterial catheter location, N (%)				
Right	126 (59)	75 (60)	51 (58)	0.7
Left	86 (41)	49 (40)	37 (42)	0.7
Radial	209 (99)	121 (98)	88 (100)	N/A[2]
Other (brachial, femoral)	3 (1)	3 (2)	0 (0)	N/A[2]
Time between IABP and NIBP measurement in minutes, mean (SD)	1.2 (2.3)	1.0 (2.0)	1.4 (2.7)	0.7
Pre-existing conditions, N (%)				
Diabetes mellitus	51 (24)	28 (23)	23 (26)	0.6
Hypertension	177 (84)	101 (82)	76 (86)	0.3
Coronary artery disease	25 (12)	16 (13)	9 (10)	0.6
Peripheral arterial disease	6 (3)	2 (2)	4 (5)	0.2
Kidney disease	37 (18)	23 (19)	14 (16)	0.6
Obesity	83 (39)	44 (36)	39 (44)	0.2
Diagnosis, N (%)				
Aortic aneurysm	14 (7)	11 (9)	3 (3)	0.09
Stroke without TPA	19 (9)	10 (8)	9 (10)	0.6
Stroke with TPA	18 (9)	10 (8)	8 (9)	0.8
Subarachnoid hemorrhage	30 (14)	18 (15)	12 (14)	0.9
Intracerebral hemorrhage with IVH	28 (13)	14 (11)	14 (16)	0.3
Intracerebral hemorrhage without IVH	19 (9)	8 (7)	11 (13)	0.1
Type A aortic dissection	42 (20)	27 (22)	15 (17)	0.4
Type B aortic dissection	33 (16)	21 (17)	12 (14)	0.5
Other[3]	9 (4)	5 (4)	4 (5)	0.9

[1]Transthoracic echocardiogram was available for all patients in the analysis.
[2]We did not perform a statistical analysis due to the presence of zero counts in this subgroup.
[3]Other diagnoses included patients with three iliac aneurysms, two renal artery aneurysms, two nonspecific hypertensive emergencies, pre-eclampsia, and one non-ST-elevation myocardial infarction.
BMI, body mass index; *EF*, ejection fraction; *IABP*, intra-arterial blood pressure; *IVH*, intraventricular hemorrhage; *LVEF*, left ventricular ejection fraction; *LVH*, left ventricular hypertrophy; *NIBP*, noninvasive blood pressure; *TPA*, tissue plasminogen activator.

one (0.5%) complication from arterial catheter use among the entire group of patients (Table 2). Other hospital outcomes were similar between the groups.

Of the included patients, the most frequent hypertensive diagnoses included spontaneous intraparenchymal hemorrhage (22%), type A dissection (20%), type B dissection (16%), and subarachnoid hemorrhage (14%) (Table 1). Baseline clinical characteristics (age, BMI, serum lactate, left ventricular ejection fraction, presence of ventricular hypertrophy) were similar between patients with change in management and those without. Additionally, there were no statistically significant differences between the two groups with respect to pre-existing medical conditions, arterial catheter location, or time in minutes between ABP and CBP measurement.

Difference Between Arterial Blood Pressure-Cuff Blood Pressure

The mean difference between ABP and CBP in the overall study population was 17 mm Hg (SD 14), with a mean difference of 11 mm Hg (SD 10) in the group without clinically significant BP difference and 26 mm Hg (SD 14) in

Table 2. Blood pressure values, interventions, and clinical outcomes among patients admitted to the critical care resuscitation unit with hypertensive disease. Higher arterial blood pressure (ABP) values were associated with change in management between ABP and cuff blood pressure monitoring.

	All patients N = 212	No change in management N = 124 (58.5%)	Change in management N = 88 (41.5%)	*P*-value
Blood pressure values				
ABP SBP (mm Hg), *mean (SD)*	145 (23)	145 (27)	162 (34)	<**0.001**
CBP SBP (mm Hg), *mean (SD)*	138 (24)	139 (28)	145 (28)	0.2
ABP-CBP dfference (mm Hg), *mean (SD)*	17 (14)	11 (10)	26 (14)	<**0.001**
Patients with ABP-CBP difference ≥20 mm Hg, *N (%)*	78 (37)	24 (19)	54 (61)	<**0.001**
Clinical interventions				
Mechanical ventilation, *N (%)*	57 (27)	32 (26)	25 (28)	0.7
Medication, *N (%)*				
Beta blocker	62 (29)	37 (29)	25 (28)	0.8
Calcium channel blocker	134 (63)	75 (60)	59 (67)	0.3
Both beta and calcium channel blocker	49 (23)	29 (23)	20 (23)	0.9
>1 Beta blocker	2 (1)	1 (1)	1 (1)	0.8
>1 Calcium channel blocker	8 (4)	5 (4)	3 (3)	0.8
Propofol	38 (18)	25 (20)	13 (15)	0.3
Fentanyl	60 (28)	38 (31)	22 (25)	0.4
Patients with arterial line complication, N (%)	1 (0.5)	0 (1.1)	1 (0)	N/A[1]
Hospital course (days), *median [IQR]*				
Length of arterial catheter placement	2 [1–4]	2 [1–3]	2 [1–4]	0.1
Hospital length of stay	10 [5–18.25]	10 [5–19.25]	9.5 [5–17]	0.96
ICU length of stay	6 [3–12.25]	6 [3–13]	6 [3–11]	0.9
Discharge destination, *N (%)*				
Home, self-care	38 (18)	20 (16)	18 (20)	0.4
Home health care, acute care, or rehabilitation center	133 (63)	82 (66)	51 (58)	0.2
Skilled nursing facility	11 (5)	6 (5)	5 (6)	0.98
Deceased/Hospice	31 (15)	16 (13)	15 (17)	0.4

[1]We did not perform a statistical analysis due to the presence of zero counts in this subgroup.
ABP, arterial blood pressure; *ABPM*, arterial blood pressure monitoring; *CBP*, cuff blood pressure; *CBPM*, cuff blood pressure monitoring; *ICU*, intensive care unit; *mm Hg*, millimeters of mercury; *SBP*, systolic blood pressure; IQR, interquarttile range.

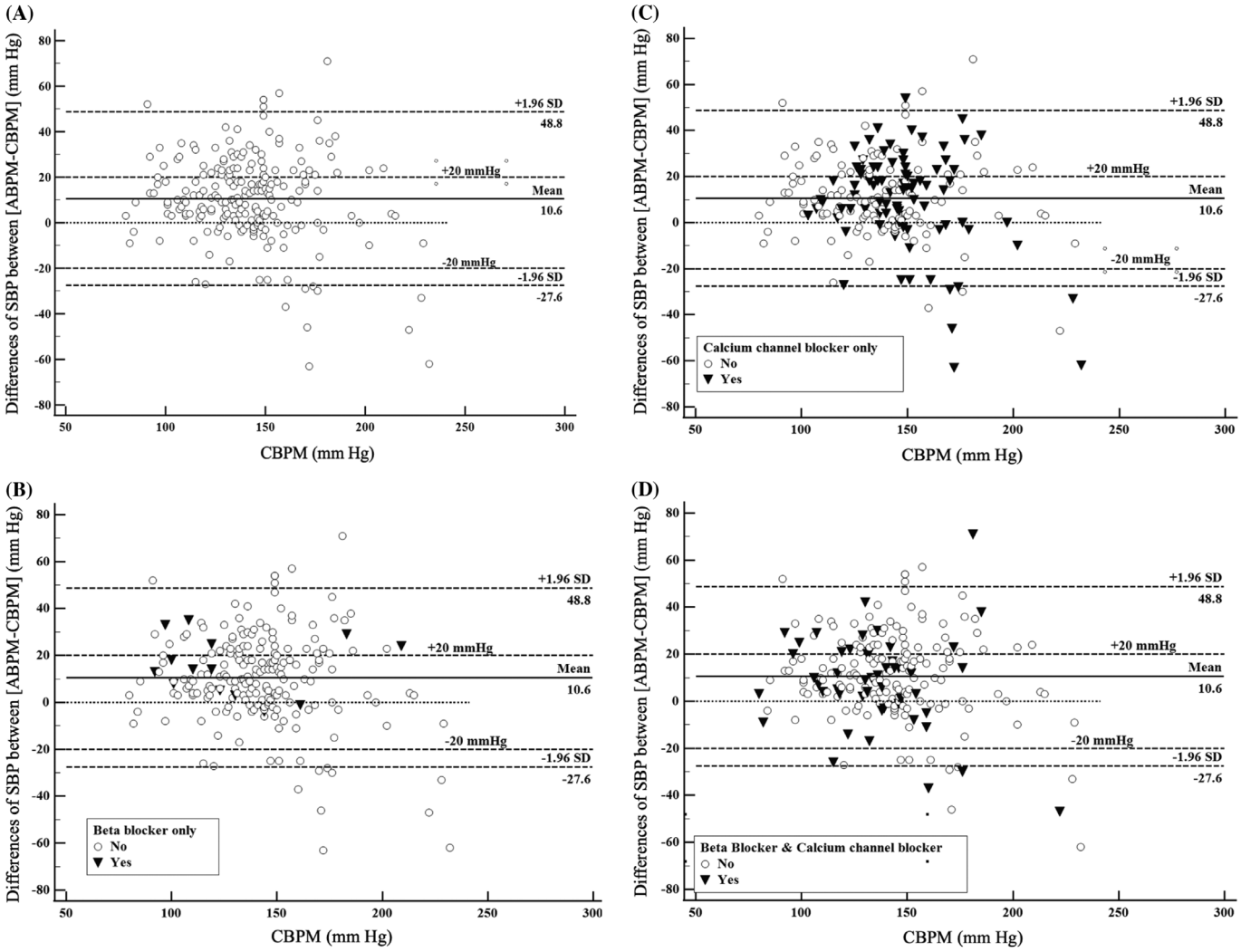

Figure 2. (A) Bland-Altman graph depicting the difference between initial arterial blood pressure and cuff blood pressure monitoring values for all hypertensive patients. (B–D) Bland-Altman graph comparing initial values of arterial blood pressure and cuff blood pressure monitoring values for hypertensive patients who received or did not receive (B) beta blocker antihypertensive medication alone for antihypertensive therapy; (C) calcium channel blocker antihypertensive medication alone for antihypertensive therapy; and (D) both beta blocker and calcium channel blocker antihypertensive medication. ABPM, arterial blood pressure monitoring; CBPM, cuff blood pressure monitoring; mm Hg, millimeters of mercury.

ABPM, arterial blood pressure monitoring; *CBPM*, cuff blood pressure monitoring; *mm Hg*, millimeters of mercury.

the group with clinically significant difference (Table 2). Seventy-eight patients (37%) had a difference in BP of ≥20 mm Hg between the two modalities.

The Bland-Altman graph illustrating [ABP-CBP] differences among the included patients demonstrated that the mean difference between the two BP measurements was 10.6 mm Hg (Figure 2A). The graph also showed that a large percentage of patients had ABP monitoring values >CBP monitoring values. These trends were observed among patients who received beta-blocker infusions (Figure 2B), calcium channel blocker infusions (Figure 2C), or both beta-blocker and calcium channel blocker infusions (Figure 2D). Similarly, among these patients with hypertensive emergencies, a large percentage had [ABP-CBP] differences ≥20 mm Hg, compared to the number of patients who had [ABP-CBP] differences ≥ −20 mm Hg.

Clinically Significant Difference

Within our study population, 88 of 212 patients (42%) had a clinically significant difference between CBP and ABP monitoring as demonstrated by a change in management between the two measurement modalities (Table 2). Of patients with a change in management as guided by ABP vs CBP monitoring, 44% required an increase in antihypertensive medication dose per ABP but not per CBP values, and 40% warranted a new antihypertensive

Table 3. Management decisions for hypertensive critically ill patients with and without clinically significant difference between arterial blood pressure and cuff blood pressure measurement.

Type of BP management intervention	Number of patients (%)
Patients with change in clinical management according to ABP vs CBP measurement, N = 88	
Increase existing medication dose	38 (44)
Decrease existing medication dose	7 (6)
Add new antihypertensive medication	35 (40)
Maintain infusion versus discontinuing	8 (9)
Patients without change in clinical management between ABP vs CBP measurement, N = 124	
Continue existing regimen (no changes)	79 (64)
Both ABP and CBP warranted an increased antihypertensive dose	29 (23)
Both ABP and CBP warranted a decreased antihypertensive dose	3 (2)
Both ABP and CBP warranted initiation of new antihypertensive medication	13 (11)

ABP, arterial blood pressure; *BP*, blood pressure; *CBP*, cuff blood pressure.

Table 4. Stepwise multivariable logistic regression for identification of clinical factors associated with clinically significant difference between arterial blood pressure and cuff blood pressure measurements. Predetermined factors were entered into models and only factors with a significant association were reported. Models for each outcome measure showed both food fit of independent variables and good discriminatory capability (higher AUROC).

	OR	95% CI	*P*-value
Primary outcome: clinically significant difference between ABP and CBP[1]			
Body mass index	1.04	(1.001, 1.084)	0.045
Peripheral arterial Disease	0.16	(0.03–0.97)	0.046
Secondary outcome: difference between ABP and CBP ≥20 mmHg[2]			
Right-sided arterial catheter location	0.46	(0.25, 0.85)	0.013

[1]Hosmer-Lemeshow DF = 8; chi-square = 14.12, *P*-value = 0.079. AUROC = 0.64.
[2]Hosmer-Lemeshow DF = 8; chi-square = 7.04, *P*-value = 0.532. AUROC = 0.67.
ABP, arterial blood pressure; *AUROC*, area under the receiver operating characteristic curve; *CBP*, cuff blood pressure; *CI*, Confidence Interval; *mmHg*, millimeter mercury; *OR*, odds ratio.

medication according to ABP but not CBP monitoring. Another 6% required a decreased dose of antihypertensive infusion per ABP but not per CBP monitoring, and 9% required maintenance of an antihypertensive infusion per ABP monitoring when CBP monitoring indicated discontinuation of the infusion (Table 3).

Of patients who did not have a change in management between ABP and CBP monitoring, 64% required continuation of the current regimen, 23% required an increased dose of current antihypertensive infusion or an addition of a new medication per both values, and 2% warranted a decreased dose per both CBP and ABP monitoring (Table 3). In 11% of patients, both CBP- and ABP-monitored measurements warranted initiation of a new antihypertensive medication.

Predictors of Change in Management

Our multivariable regressions identified that each unit increase of BMI was associated with 4% higher likelihood of having a change in management among patients with hypertensive emergencies (odds ratio [OR 1.04, 95% confidence interval [CI] 1.00–1.08, *P*-value <0.05). Patients who had history of peripheral arterial disease (OR 0.16, 95% CI 0.03–0.97, *P*-value <0.05) were also associated with having lower likelihood of a clinically significant difference between ABP and CBP monitoring (Table 4). This model had an acceptable discriminatory capability with AUROC of 0.64.

Additionally, a multivariable logistic regression identified that right-sided arterial catheters were associated with significantly lower odds for [ABP-CBP monitoring] difference ≥20 mm Hg (OR 0.46, 95% CI 0.25–0.85, *P*-value <0.05) (Table 4). The model also had acceptable AUROC of 0.67.

DISCUSSION

While two retrospective studies have demonstrated clinically relevant differences in CBP and ABP measurements,[6,12] to our knowledge this is the first prospective study investigating the clinical relevance of differences between CBP and ABP monitoring among patients with different diagnoses of hypertensive emergencies. The results of this observational study support our hypothesis that the discrepancy between ABP and CBP measurements leads to a change in BP management in a large percentage of patients with hypertensive emergencies.

In this study, CBP monitoring underestimated ABP monitoring (by 17 mm Hg on average), and measurement of the latter warranted increases in antihypertensive medication. This suggests that the use of CBP monitoring alone to guide management of patients with hypertensive emergencies may result in unrecognized and untreated levels of hypertension. Barton et al suggested that patients with spontaneous intracerebral hemorrhage who sustained hypertension during the acute phase in the emergency department (ED) were associated with poor neurological

outcome at one-month and 12-month follow-ups.[35] Similarly, patients with acute uncomplicated type B aortic dissection but who continue to have hypertension were associated with higher in-hospital mortality, compared to those who have controlled BP.[36]

Although patient outcomes (which were not the outcomes in this observational and exploratory study) in univariate analyses were not different between groups with or without clinically relevant differences, clinicians should thus consider the use of ABP monitoring in hypertensive patients for whom adherence to specific BP goals is important. Additionally, when a patient is having BP at the borderline recommended by current guidelines, coupled with prolonged boarding time in the ED, the addition of ABP monitoring would provide helpful information for further medical decision-making, as it has been shown that CBP monitoring is not as reliable.[37] Future studies should further investigate our observation to better characterize the association between CBP and ABP monitoring differences and patient outcomes.

The use of invasive ABP monitoring is not entirely without risk and expense. Risks of ABP monitoring include bleeding, thrombosis, infection, embolism, and nerve damage; however, the incidence of complications is low with major complications occurring in less than 1% of cases.[3,4,33] We found one reported complication of soft hematoma within our study sample of 212 patients, producing an overall complication rate of 0.5%. On the other hand, we found a change in management rate of 42% in patients with the use of ABP monitoring. Thus, the potential benefit of ABP monitoring in guiding clinical management appeared to outweigh the risks of harm in our patients.

The use of ABP monitoring does incur additional cost of care. At our institution, the one-time, per-patient supply cost for initiation of ABP monitoring is approximately $55 US dollars (USD). With a change in management rate of 42% among our patients upon insertion of an arterial catheter, ABP monitoring was able to detect one change in management for approximately every three patients. The total cost to detect one clinically significant BP difference for every three patients with hypertensive critical illness is, therefore, $165 USD. This observational and exploratory study was not designed to detect differences in patient outcomes such as mortality, ICU or hospital length of stay, and did not demonstrate a direct benefit for ABP monitoring in the study patient population. Further studies should investigate the benefits-risk ratio between potential benefits vs financial cost and complications between ABP and CBP monitoring.

Within our patient population, patients with clinically significant difference between CBP and ABP monitoring had higher BMI than those without a clinically significant difference (30.1 vs 28.2, respectively), although the difference was not statistically significant. Previous studies have identified an association between obesity and greater differences between ABP and CBP monitoring, with CBP measurements typically underestimating direct intra-arterial SBP.[13,14] This is thought to be due to the arm circumference of obese patients preventing proper fit of BP cuffs, although a definitive cause has not been identified.[13,14]

Our finding that patients with peripheral artery disease were associated with lower odds of change in clinical management appeared counterintuitive at first. However, a study by Iida et al suggested that patients with arterial stiffness would have higher BP than those who did not.[16] Therefore, it would be probable that *both* ABP and CBP monitoring values from patients with peripheral artery disease, and their resulting arterial stiffness, would be higher than the recommended goal of SBP by guidelines. Thus, both ABP and CBP monitoring values would recommend an increase of current antihypertensive infusion, which is not considered a change in clinical management by our definition. However, our patient population included only six (3%) patients with peripheral artery disease; further studies with higher percentages of patients with peripheral artery disease are necessary to confirm our observations. The result from our multivariable logistic regression also showed that ABP monitoring on the right side was associated with lower likelihood of greater differences between CBP and ABP. While our study could not explain these findings, it could be a confounding finding or it could be due to the number of patients with acute aortic dissection within our patient population. Patients with acute aortic dissection have been shown to have greater differences between both arms, with BP on the left arm being affected more.[38] This phenomenon would have caused bigger differences between CBP and ABP on the left side. However, further studies including only patients with acute aortic diseases are needed to confirm or refute our observation.

Although identification of specific subsets of patients who would most benefit from ABP monitoring may be helpful in directing the placement of arterial catheters in the acute stages of illness, our study revealed very few predictors of such. The high incidence of clinically relevant ABP-CBP discrepancy and lack of clear distinction as to which patients are more likely to require different BP management after placement of an arterial catheter suggest that clinicians should consider invasive ABP monitoring more often in patients with hypertensive emergencies requiring a continuous antihypertensive infusions, at least during the acute resuscitation phase.

LIMITATIONS

Our study has several limitations, the first having to do with the clinical setting and the patient population. Although most of these disease states are encountered in the ED setting, the results in our setting may not be applicable to many EDs. Thus, our study may lack external validity. Additionally, we did not address any downstream consequences, such as

clinical outcomes and throughputs that could have been derived from the change of clinical management of these patients, as this topic was beyond the scope of this study. The heterogeneity of our patient population with respect to hypertensive emergency diagnosis limits our ability to draw conclusions about specific subsets of hypertensive disease. Because intra-arterial BP monitoring is considered the gold standard, we did not randomize patients to management guided by ABP vs CBP monitoring to determine associations between each measurement modality and patient outcomes. Finally, our limited sample size may have prevented accurate depiction of the incidence of arterial catheter complications or patient-related outcomes. Despite these limitations, our study does provide further evidence to support the use of invasive arterial catheters for BP monitoring in patients with hypertensive emergencies and requiring continuous antihypertensive infusions.

CONCLUSION

Approximately 4 in 10 patients with hypertensive emergencies had a change in management between monitoring of cuff blood pressure vs arterial blood pressure monitoring, indicating clinical relevance of the discrepancy in BP values obtained by these two measurement modalities. Patients with high BMI were associated with higher likelihood of requiring change of management due to the discrepancies between ABP and CBP monitoring. Additional studies and less heterogenous patient pathologies are recommended to further explore patient outcomes associated with these findings. Further studies are necessary to confirm our observations and to investigate the benefit-risk ratio of arterial blood pressure monitoring.

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Block Time: A Multispecialty Systematic Review of Efficacy and Safety of Ultrasound-guided Upper Extremity Nerve Blocks

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Introduction: Ultrasound-guided peripheral nerve blockade is a common pain management strategy to decrease perioperative pain and opioid/general anesthetic use. In this article our goal was to systematically review publications supporting upper extremity nerve blocks distal to the brachial plexus. We assessed the efficacy and safety of median, ulnar, radial, suprascapular, and axillary nerve blocks by reviewing previous studies.

Methods: We searched MEDLINE and Embase databases to capture studies investigating these nerve blocks across all specialties. We screened titles and abstracts according to agreed-upon inclusion/exclusion criteria. We then conducted a hand search of references to identify studies not found in the initial search strategy.

Results: We included 20 studies with1,273 enrolled patients in qualitative analysis. Both anesthesiology (12, 60%) and emergency medicine (5, 25%) specialties have evidence of safe and effective use of radial, ulnar, median, suprascapular, and axillary blocks for numerous clinical applications. Recently, multiple randomized controlled trials show suprascapular nerve blocks may result in lower pain scores in patients with shoulder dislocations and rotator cuff injuries, as well as in patients undergoing anesthesia for shoulder surgery.

Conclusion: Distal upper extremity nerve blocks under ultrasound guidance may be safe, practical strategies for both acute and chronic pain in perioperative, emergent, and outpatient settings. These blocks provide accessible, opioid-sparing pain management, and their use across multiple specialties may be expanded with increased procedural education of trainees. [West J Emerg Med. 2023;24(4)774–785.]

INTRODUCTION

Over three million upper extremity traumas, 38.4% of which are digital injuries, present to emergency departments (ED) in the United States annually.[1] Many of these injuries are treated with oral or intravenous analgesia, while more complicated cases often result in consultation with acute pain service. However, there is evidence that emergency physicians (EP) can provide safe and efficacious pain relief using ultrasound (US)-guided (upper extremity nerve blocks.[2,3] Upper extremity nerve blocks are also used in outpatient settings by sports medicine, physical medicine and rehabilitation, and neurology.[4-6] Despite this, most upper extremity nerve blocks are performed by anesthesiology perioperatively. It is less common for EPs to be trained in distal upper extremity blocks such as suprascapular, median, ulnar, and radial nerve blocks.[7,8] Our goal in this review was to assess the current state of evidence behind US-guided upper extremity nerve blocks across all specialties.

Despite their widespread use in different specialties, there are no prior multidisciplinary systematic reviews of these blocks.[7,9-11] In contrast, there are many published systematic reviews of brachial plexus blocks, which are standard of care for most upper extremity surgeries.[12,13] Proximal brachial plexus blocks are rarely performed by EPs due to the perceived risk of pneumothorax and diaphragmatic paralysis, while distal blocks require skills already familiar to EPs, such as US-guided vascular access, fascia iliacus nerve block, and musculoskeletal ultrasound.[14-17] These ultrasound applications are currently standard of practice for EPs.[18] Nerve blockade has the potential to provide safe, opioid-sparing analgesia in the ED in vulnerable populations such as elderly patients, those suffering from substance use disorders, and children. Additionally, a recent survey of experts in emergency medicine (EM) supported the notion that US-guided regional anesthesia should be a developed curriculum in all EM residencies.[19]

Our objective in this review was to systematically evaluate the evidence supporting US-guided distal upper extremity nerve blocks across all specialties and determine their efficacy and safety. We hope to inform future educational initiatives in EM and encourage EPs to gain competence in US-guided nerve blocks to treat pain optimally.[20]

METHODS

We searched MEDLINE and Embase databases to capture studies from the inception of each database to March 7, 2021. We developed a search strategy with guidance from sentinel articles using keywords from these articles as MeSH terms and consulted a medical librarian for a review of our search strategy (Appendix 1). Duplicate references were removed using EndNote. Titles and abstracts were screened by two independent investigators using the Rayyan screening app (Rayyan Systems Inc, Cambridge, MA) according to specific inclusions and exclusion criteria (Appendix 2).[21] We included randomized controlled trials, case-controlled studies, cross-sectional studies, and cohort studies assessing the efficacy of US-guided upper extremity nerve blocks compared to other forms of analgesia or techniques of nerve block (Appendix 1).

Outcomes included those studies related to pain and safety. Studies taking place perioperatively, emergent settings, and outpatient clinical environments were all considered. Two authors (CBH and AB) were responsible for screening articles based on inclusion criteria, using the title, abstract and, if needed, the full-text article. Disagreements in article inclusion (6/85 studies) were reconciled through consensus development by further discussion of methods and outcomes using the defined inclusion/exclusion criteria. A hand search was also conducted by using the references of all full-text screened studies to identify studies that may have been missed from the search strategy. Our study was reviewed by local institutional review board (IRB), which determined this does not constitute human subject research and was, therefore, exempt from IRB review.

We created standardized forms to extract individual study data regarding study details and design, population characteristics, and results for outcomes of interest. We also completed risk of bias on all included studies using the revised Cochrane risk-of-bias tool (RoB 2).[22]

RESULTS

Our literature search and study selection process identified 936 abstracts by search of MEDLINE and Embase databases (Figure 1). Abstract screening identified a total of 85 references for full-text screening. Hand search of references in all full-text screened articles identified two additional studies for inclusion. A total of 20 studies were deemed eligible for inclusion (Appendix 2). These included studies from the specialties of anesthesia (60%), EM (25%), orthopedics (measured with multiple outcomes including reduction in scores on the visual analog scale(VAS), comparison to landmark-guided blocks, and comparison to pharmacologic pain control (Table 1). Studies that had overall positive outcomes by these measures were considered "effective" blocks for the purposes of this systematic review. Of the 20 total included studies, four studied block effectiveness for chronic pain.

Mixed Forearm Blocks

Five publications studied the efficacy of combined forearm nerve blocks (median, ulnar, and radial nerves) (Table 1A). One randomized controlled trial (RCT) indicated median/radial/ulnar combined block was successful as primary anesthesia for hand surgery 97% of the time, while two single-arm, interventional studies in the ED indicated the effectiveness of combined blocks for hand injuries requiring procedural interventions.[7,9,10] A retrospective cohort study analyzing all forearm blocks completed by the anesthesiology department at an academic center (536) showed no neurologic complications.[23] One RCT of combined medial/ulnar blocks in patients undergoing carpal tunnel release surgery showed 93% effectiveness (Table 1B).[2]

Individual Forearm Blocks

Two studies assessed the effectiveness of US-guided ulnar nerve block and showed a 100% success rate in blocking pinprick sensation (Table 1C).[24,25] Three studies assessed median nerve block (Table 1D).[26–28] One determined there was no difference in success when using hydrodissection with a median nerve block and reported 100% success of US-guided block of index finger/thenar eminence sensation.[26] Another stated circumferential spread of the nerve block visualized on US increased success from 81–100% ($P < 0.05$).[28] Finally, a study of pediatric patients undergoing trigger thumb surgery found 50 (100%) successful median

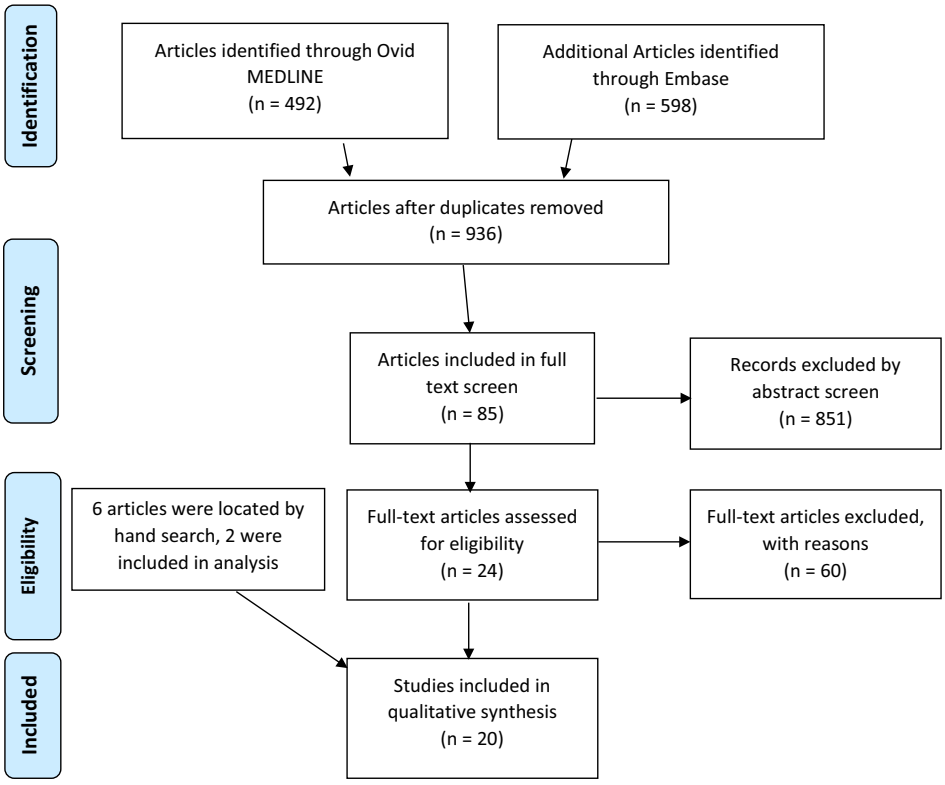

Figure 1. Flow diagram of search strategy for US-guided upper extremity blocks using PRISMA protocol.
US, ultrasound; *PRISMA*, Preferred Reporting Items for Systematic Reviews and Meta-Analysis.

nerve blocks in the US-guided group vs 50 (64%) using landmarks alone.[27] Two prospective studies of radial nerve blocks demonstrated improvements in pain scores. In one, patients with Colles fracture undergoing reduction had VAS decrease from 8.2 (7.6–8.8) to 3.53 (2.7–4.3) with US-guided radial nerve block.[29] The second study demonstrated improvement in hand osteoarthritis pain over 2–4 weeks.[30]

Axillary and Suprascapular Shoulder Blocks

There were two RCTs of combined suprascapular and axillary blocks in the perioperative setting. One showed that in rotator cuff surgery the combination block was superior to suprascapular block alone, and the other found these blocks provided significantly less analgesia than the interscalene brachial plexus block for arthroscopic shoulder surgery (Table 2A).[31,32]

Five RCTs assessed the US-guided suprascapular nerve block (Table 2B). One ED study found this block decreased pain of shoulder dislocation reduction from mean VAS 85 (70–98) to 45 (33–45) and decreased time to discharge compared to sedation analgesia.[33] Two studies in orthopedics studied the US-guided suprascapular block. One demonstrated improvement in Constant-Murley scores 12 weeks post-block for patients with rotator cuff tears compared to patients receiving subacromial injection; another found a nonsignificant change in VAS for patients with adhesive capsulitis.[34,35] In one anesthesia study 18 of 83 patients (21.7%) experienced hemidiaphragmatic paralysis with US-guided suprascapular nerve block, while another found suprascapular blocks have less respiratory effect than brachial plexus blocks.[36,37]

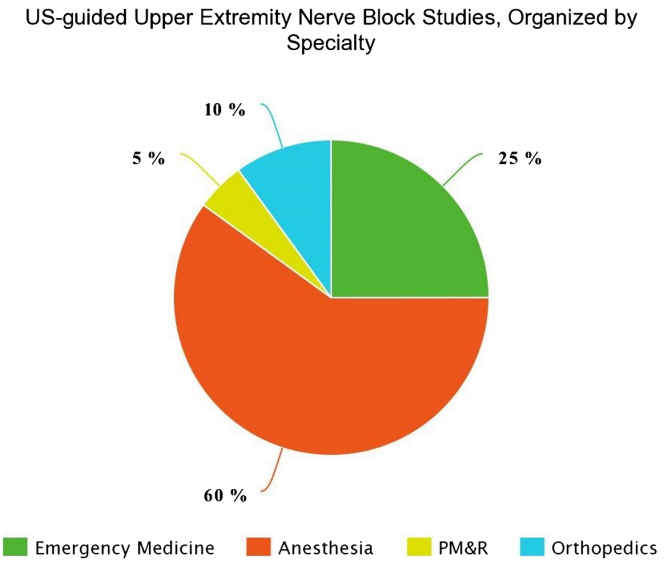

Figure 2. Total proportion of studies included in qualitative analysis by specialty.
US, ultrasound; *PM&R*, physical medicine and rehabilitation.

Table 1. Summary of published studies investigating the efficacy and safety of ultrasound-guided peripheral forearm nerve blocks.

Authors (Year)	Study Design: N enrolled	No. of Blocks Performed	Mean Age in Years (SD) [Range]	Health Status	Setting (Specialty)	Acute or Chronic Pain	Intervention or Exposure	Control	Outcome	Key Findings	Complications (n); type
A. Mixed forearm block performed (i.e., median, ulnar, and/or radial)											
Liebmann et al. (2006)	Single-arm interventional; N = 11	22	39* [21–60]	Patients with hand pathology requiring procedural intervention	ED (EM)	Acute	Ultrasound-guided block of the radial, median, and/or ulnar nerves	NA	VAS	Ten of 11 patients had a clinically meaningful reduction in VAS pain score (>13 mm reduction); median reduction in VAS score was 5.0 cm (IQR 3.0, 8.0; $P = .003$)	0
Frenkel et al. (2015)	Single-arm interventional; N = 10	30	11* [9–17]	Pediatric patients with hand injuries requiring procedural intervention	ED (EM)	Acute	Ultrasound-guided blocks of ulnar, median, and radial nerves combined	NA	VAS	Mean VAS decreased from 5.8 to 0.8 ($P = .04$); seven of 10 with complete resolution of pain	0
Soberon et al. (2015)	RCT; N = 60	30	49* [36–58]	Patients undergoing hand surgery	Perioperative (Anesthesia)	Acute	Ultrasound-guided median, ulnar, or radial nerve blocks	Ultrasound-guided brachial plexus block	Block as primary anesthetic	No difference in the number of blocks able to be used as a primary anesthetic between the two groups (97% vs 93% for forearm and brachial groups, respectively)	0
Sohoni et al. (2016)	RCT; N = 12	18	>18	Healthy volunteers	ED (EM)	Acute	Ultrasound-guided forearm block with a saline placebo wrist block	Landmark-based wrist block with an ultrasound-guided saline forearm block	Pinprick sensation	Ultrasound-guided forearm blocks were significantly more likely to	0

(*Continued on next page*)

Table 1. Continued.

Authors (Year)	Study Design: N enrolled	No. of Blocks Performed	Mean Age in Years (SD) [Range]	Health Status	Setting (Specialty)	Acute or Chronic Pain	Intervention or Exposure	Control	Outcome	Key Findings	Complications (n); type
										block sensation to pinprick compared to anatomic wrist blocks (78% vs 56%, respectively; $P = 0.032$)	
Sites et al. (2012)	Cohort	536	55	Patients receiving US-guided nerve block 2003-2011	Regional anesthesia (Anesthesia)	Acute	Ultrasound-guided wrist blocks	NA	Postoperative neurologic complications	Only complications reported	0
B. Median, Ulnar Combined studies											
Macaire et al. (2008)	RCT; N = 60	30	48 (12)	Patients undergoing carpal tunnel release	Perioperative (Anesthesia)	Acute	Ultrasound-guided median and ulnar nerve blocks at the wrist	Nerve stimulation guided nerve block of median and ulnar nerve	VAS; success rate of block	No difference in VAS scores during post-block venipuncture (30 vs 30, $P = 0.26$). Success rate was 93% in both groups.	1; Transient mechanical paresthesia
C. Ulnar											
Marhofer et al. (2013)	RCT; N = 24	12	NR	Healthy volunteers	Research ward (anesthesia)	Acute	Ultrasound-guided ulnar nerve block	Ultrasound-guided ulnar nerve block with added dexmedetomidine	Success rate of block	Complete sensory block in all patients was achieved in both groups.	0
Marhofer et al. (2019)	Crossover study; N = 24	72	30* [22–55]	Healthy volunteers	Research ward (anesthesia)	Acute	Ultrasound-guided ulnar nerve block	Ultrasound-guided ulnar nerve block with added dexamethasone	VAS to pinprick	6.87 (5.78–7.93) hour duration, 6.0 (4.5–10.0) minute onset of ropivacaine block, no relevant effect of dexamethasone on sensory block	0

(*Continued on next page*)

Table 1. Continued.

Authors (Year)	Study Design: N enrolled	No. of Blocks Performed	Mean Age in Years (SD) [Range]	Health Status	Setting (Specialty)	Acute or Chronic Pain	Intervention or Exposure	Control	Outcome	Key Findings	Complications (n); type
D. Median											
Dufour et al. (2012)	RCT; N = 100	NR	I:40.5 (15.6); C: 41.0 (18.2)	Healthy volunteers	Perioperative (Anesthesia)	Acute	Ultrasound-guided median nerve block	Ultrasound-guided median nerve block with prior dextrose 5% hydrodissection	Cold and light touch block to index finger and thenar eminence	No difference in the percentage of patients with complete cold and light touch blocks at index finger (100% vs 98.1% and 95.2% vs 96.2%) and thenar eminence (100 v 98.1 and 97.5 vs 88.2) between groups	2 in group without D5 hydrodissection; Intraneural injections
Marhofer et al. (2014)	Crossover study; N = 21	42	NR [18–45]	Healthy volunteers	Research ward (anesthesia)	Acute	Ultrasound-guided median nerve block with circumferential spread	Ultrasound-guided median nerve block with non-circumferential spread	Success rate of sensory block	The intended circumferential spread group had a higher success rate compared to non-circumferential spread group (100% v 81%, $P < 0.05$).	0
Liu et al. (2018)	RCT	50	26 months [NR]	Pediatric patients undergoing trigger thumb surgery	Perioperative (Anesthesia)	Acute	Ultrasound-guided median nerve block	Landmark-guided median nerve block	m-CHEOPS*	50/50 successful median nerve blocks in US group, 37/50 of landmark group	0
E. Radial											
Unluer et al. (2008)	Single arm interventional	15	NR	Patients with Colles fracture	ED (EM)	Acute	Ultrasound-guided radial nerve block	NR	VAS for fracture reduction	VAS decreased from 8.2 (7.6–8.8) preprocedure to 3.53 (2.73–4.34) postprocedure	0

(*Continued on next page*)

Table 1. Continued.

Authors (Year)	Study Design: N enrolled	No. of Blocks Performed	Mean Age in Years (SD) [Range]	Health Status	Setting (Specialty)	Acute or Chronic Pain	Intervention or Exposure	Control	Outcome	Key Findings	Complications (n); type
Okmen et al. (2018)	RCT	25	50 [46–64]	Patients with osteoarthritis	Research ward (PM&R)	Chronic	Ultrasound-guided block superficial branch of radial nerve + exercise	Exercise alone	VAS after 2, 4 weeks	VAS decreased from 8 (6–9) to 1 (0–6) after four weeks for nerve block group, significant difference from exercise group	NR

NA, not available; *PM&R*, physical medicine and rehabilitation; *VAS*, visual analog score; *EM*, emergency medicine; *ED*, emergency department; *m-CHEOPS*, modified Children's Hospital of Eastern Ontario Pain Scale; *NR*, not reported; *RCT*, randomized controlled trial.
*Indicates median age.

Table 2. Summary of published studies investigating the efficacy of ultrasound-guided shoulder nerve blocks.

Authors (Year)	Study Design: N enrolled	No. of Blocks Performed	Mean Age in Years (SD) [Range]	Health Status	Setting (Specialty)	Acute or Chronic Pain	Intervention or Exposure	Control	Outcome	Key Findings	Complications (n); type
A. Suprascapular and Axillary											
Lee et al. (2014)	RCT; N = 42	21	55.8 (39–72)	Patients with torn rotator cuffs	Perioperative (Anesthesia)	Chronic	Ultrasound-guided suprascapular + axillary nerve block with ropivacaine	Ultrasound-guided suprascapular nerve block alone	VAS	Significant reduction in VAS with suprascapular block + axillary block compared to suprascapular alone	13/21; Rebound pain. No paresthesia or long-term complications
Dhir et al. (2016)	RCT; N = 60	30	46.5 (SD 14.5)	Patients undergoing arthroscopic shoulder surgery	Perioperative (Anesthesia)	Acute	Ultrasound-guided suprascapular + axillary nerve block prior to general anesthesia	Ultrasound-guided interscalene block of brachial plexus	NRS score	Static NRS score of 5.45 in PACU, 4.00 6 hours post-operatively for suprascapular + axillary. Significantly less analgesia than interscalene brachial plexus block 6 hr	0
B. Suprascapular											
Tezel et al. (2014)	RCT; N = 41	21	24 (21–73)	Patients with shoulder dislocation	ED (EM)	Acute	Ultrasound-guided suprascapular nerve block	Sedation analgesia with 1–2 mg/kg of ketamine	VAS	VAS decreased from mean 85 (70–98) to mean 45 (33–55). Mean time to discharge significantly lower in nerve block group compared to sedation group	0
Coory et al. (2019)	RCT; N = 42	21	70 (43–85)	Patients with rotator cuff tears	Outpatient (orthopedics)	Chronic	Ultrasound-guided suprascapular nerve block	Subacromial injection	Constant-Murley Score at 12 weeks post-injection	Suprascapular nerve block outperformed Subacromial injection, improved CM score from 35.3 (SD 12.8) to 57.6 (SD 10) in 12 weeks	NR
Ferre et al. (2020)	RCT; N = 83	83	56.6 (11.6)	Patients undergoing shoulder surgery	Perioperative (Anesthesia)	Acute	Ultrasound-guided anterior suprascapular block	Ultrasound-guided posterior suprascapular block	Diaphragmatic excursion on US	41% of anterior (17/42) and 2% of posterior (1/41) had some hemidiaphragmatic paralysis	18/83; Hemidiaphragmatic paralysis of any kind
Bae et al. (2020)	RCT; N = 47	47	55.3 [39–76]	Patients with adhesive capsulitis	Outpatient (orthopedics)	Chronic	Proximal approach to ultrasound-	Distal approach to ultrasound-	VAS at week 12	Stratified by proximal vs. distal approach: proximal had VAS	0

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Table 2. Continued.

Authors (Year)	Study Design: N enrolled	No. of Blocks Performed	Mean Age in Years (SD) [Range]	Health Status	Setting (Specialty)	Acute or Chronic Pain	Intervention or Exposure	Control	Outcome	Key Findings	Complications (n); type
							guided suprascapular nerve block	guided suprascapular nerve block		decrease from 6.8 +/– 1.5 baseline to 3.7 +/– 1.3 at 12 weeks. Distal VAS pain score improved from 6.2 +/– 1.6 to 3.6 +/– 2.0 at 12 weeks.	
Lim et al. (2020)	RCT; N = 40	40	41.8	Patients undergoing arthroscopic shoulder surgery	Perioperative (Anesthesia)	Acute	Ultrasound-guided anterior and posterior suprascapular nerve block	Ultrasound-guided interscalene block of brachial plexus	Pain Score, FVC reduction	Both anterior suprascapular (19/20) and posterior suprascapular (19/20) had highly effective blockade at 30 minutes, less reduction of FVC compared to interscalene block	Compared SSB to brachial plexus block, less respiratory effect with SSB

NRS scale: 0 = no pain to 10 = worst pain imaginable. Constant Murley Score: combined functional and pain score for shoulder injury (0–100)
US, ultrasound; *mg/kg*, milligram/kilogram; *PACU*, post-anesthesia care unit; *FVC*, forced expiratory volume; *SSB*, suprascapular-axillary nerve block, VAS, visual analog score; *EM*, emergency medicine; *ED*, emergency department; *NR*, not reported; *RCT*, randomized controlled trial.

Median, Ulnar, Radial - Hand injuries* - Pediatric hand injuries* - Hand surgery	**Median** - Trigger thumb surgery
Median, Ulnar - Carpal tunnel surgery	**Radial** - Colles' fracture reduction* - Osteoarthritis
Suprascapular and Axillary - Torn rotator cuff - Arthroscopic shoulder surgery	**Suprascapular** - Shoulder dislocation reduction* - Torn rotator cuff - Shoulder surgery - Adhesive capsulitis

Figure 3. Clinical applications of ultrasound-guided distal upper extremities found on systematic review.
*Study performed in the emergency department.

Risk-of-bias Assessment

We assessed RoB for 17 outcomes in 16 studies, including two cross-over studies (Appendix 4). Briefly, 14 outcomes (82%) had low RoB due to the randomization process, and 12 outcomes (71%) had low RoB due to deviations from the intended interventions. Additionally, all assessed outcomes (100%) had low RoB due to missing outcome data, and 13 (76%) had low RoB due to measurement of the outcome. Notably, 12 outcomes (71%) had some RoB due to the selection of the reported results, with the other studies having low RoB.

DISCUSSION

We evaluated the multispecialty evidence behind US-guided upper extremity nerve blocks to support future educational interventions in EM. Our review supports using upper extremity blocks for multiple indications in the ED (Figure 3).[7,23,32,36] More broadly, this suggests high efficacy and few complications when performing upper extremity peripheral nerve blocks perioperatively and in the ED. Despite this evidence, there are no specific recommendations from the Accreditation Council for Graduate Medical Education or the American College of Emergency Physicians about which nerve blocks would be beneficial to patients presenting to EDs.[18,20] However, a recent survey found significant support for an US-guided regional anesthesia curriculum for EM residents.[19]

Our findings also predict a benefit from more standardized EP education in US-guided regional anesthesia, which has the potential to decrease the need for procedural sedation and opioid use in the ED while providing safe, adequate analgesia for hand and forearm injuries.[36] Populations such as patients with substance use disorder and older patients may benefit from regional pain management rather than central nervous system-active pharmaceuticals.

LIMITATIONS

This study has several limitations, including our inability to make inferences between the specialties of anesthesia and EM. Regional anesthesia is a year-long fellowship in anesthesia, and anesthesia residents have formal training in regional nerve blocks throughout their residency. In many EDs, US-guided regional anesthesia has become standard, but this remains institution-dependent. Since we are comparing heterogeneous data (in terms of training and procedural skill), our study is limited to a systematic review rather than a meta-analysis.

To make truly quantitative statements, we would need the statistical analysis that only a meta-analysis would provide. This factor also limited our ability to fully follow PRISMA checklist guidelines. We also defined effectiveness broadly as a positive study result, but this specific was quite varied between the studies. Despite this, the finding that these procedures are low risk was consistent throughout our review of studies. Further research should be multifaceted and interventional. The most effective approach may be a multicenter RCT that includes both an educational initiative on US-guided nerve blocks for EM residents and a study determining effectiveness of these blocks compared to pharmacologic pain control.

CONCLUSION

There is evidence that ultrasound-guided upper extremity nerve blocks are safe and effective based on multiple positive outcomes from different specialties. Improved training in US-guided nerve blocks in emergency medicine has the potential to provide a safe alternative to pharmacologic pain management or procedural sedation. In addition, given the significant intersection between the fields of anesthesia and EM in US-guided procedures, more formal educational collaboration may improve the technique and training of trainees by combining the considerable talents of both fields in performing these procedures.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources

and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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Community Paramedicine Intervention Reduces Hospital Readmission and Emergency Department Utilization for Patients with Cardiopulmonary Conditions

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Objective: Patients discharged from the hospital with diagnoses of myocardial infarction, congestive heart failure or acute exacerbation of chronic obstructive pulmonary disease (COPD) have high rates of readmission. We sought to quantify the impact of a community paramedicine (CP) intervention on hospital readmission and emergency department (ED) and clinic utilization for patients discharged with these conditions and to calculate the difference in healthcare costs.

Methods: This was a prospective, observational cohort study with a matched historical control. The groups were matched for qualifying diagnosis, age, gender, and ZIP code. The intervention group received 1–2 home visits per week by a community paramedic for 30 days. We calculated the number of all-cause hospital readmissions and ED and clinic visits, and used descriptive statistics to compare cohorts.

Results: Included in the study were 78 intervention patients and 78 controls. Compared to controls, fewer subjects in the CP cohort had experienced a readmission at 120 days (34.6% vs 64.1%, $P < 0.001$) and 210 days (43.6% vs 75.6%, $P < 0.001$) after discharge. At 210 days the CP cohort had 40.9% fewer total hospital admissions, saving 218 bed days and $410,428 in healthcare costs. The CP cohort had 40.7% fewer total ED visits.

Conclusion: Patients who received a post-hospital community paramedic intervention had fewer hospital readmissions and ED visits, which resulted in saving 218 bed days and decreasing healthcare costs by $410,428. Incorporation of a home CP intervention of 30 days in this patient population has the potential to benefit payors, hospitals, and patients. [West J Emerg Med. 2023;24(4)786–792.]

INTRODUCTION

Problem

We designed this investigation to quantify the impact of a one-month community paramedic (CP) intervention on all-cause hospital readmissions and visits to emergency departments (ED) and clinics at 30, 120 and 210 days post-hospital discharge for patients with congestive heart failure (CHF), acute myocardial infarction (AMI) and chronic obstructive pulmonary disease (COPD) as compared to a matched control group. We also quantified the difference in total cost of care between cohorts over the data collection period. Our hypothesis was that a CP intervention would

decrease the number of all-cause readmissions, ED visits, and total cost of care, and increase clinic utilization.

Population Health Research Capsule

What do we already know about this issue?
Patients discharged from the hospital with diagnoses of myocardial infarction, congestive heart failure, or chronic obstructive pulmonary disease have high rates of readmission.

What was the research question?
Can a community paramedic intervention reduce hospital and emergency department (ED) readmission in this patient population?

What was the major finding of the study?
Community paramedic (CP) intervention reduced readmissions at 120 (34.6% vs 64.1%, $P < 0.001$) and 210 days (43.6% vs 75.6%, $P < 0.001$)

How does this improve population health?
Implementation of a CP program decreases the need for re-hospitalization and decreases healthcare costs in this patient population.

Background

Patients readmitted to the hospital often have poor outcomes and incur high healthcare costs.[1] In addition, patient satisfaction scores are significantly and negatively correlated with the hospital's 30-day readmission rates for AMI, CHF, and pneumonia (PNA).[2] Patients with CHF have up to a 25% chance of being readmitted to the hospital within 30 days,[3,4] while those odds are nearly 20% in patients with AMI[5] and 15% in patients with exacerbations of COPD.[6] Moreover, the majority of readmissions for patients with AMI, CHF, or PNA occur within the first two weeks of hospital discharge.[7] Reducing hospital readmissions and repeat ED visits for patients with common chronic conditions is a key feature of healthcare reform efforts for both clinicians and payors.

As part of the Hospital Readmissions Reduction Program, Medicare payments have been reduced up to 3% to hospitals with excess readmissions for six conditions, including CHF, AMI, and COPD, since 2012.[8] Predictive modeling has been used to identify factors (eg, age, socioeconomic status, primary language, multiple medications, and place of residence) that put patients with CHF, AMI and COPD at highest risk for readmission.[9] Studies that have looked at the ability of predictive modeling to identify patients with acute cardiopulmonary diagnoses who are at highest risk of 30-day readmission vary greatly in their conclusions. No consensus has been reached on interventions to target the highest risk group.[10]

With varying rates of success, hospitals have implemented numerous approaches to reduce readmissions including single and bundled strategies, improved care coordination, better hospital discharge education, medication reconciliation, scheduling of follow-up visits before discharge, and standardization of communication tools at discharge.[11–19] Identification of a minimum threshold bundle of interventions proven to reduce readmissions remains elusive. Patients report feeling unprepared for discharge; the primary reasons for readmission include having difficulty performing activities of daily living, having problems adhering to or accessing medications, and lack of social support.[20]

One intervention that has been proposed to decrease hospital readmissions is the inclusion of a community paramedic in the outpatient care plan. Community paramedics are advanced, subspecialized paramedics who have undergone additional training designed to transition the application of their Advanced Life Support skillset from the emergency setting to the primary care setting. Community paramedicine takes advantage of the knowledge base and mobile capabilities of paramedics and leveragess their ability to conduct in-home assessments. Prior work with CPs has been reported, however, published research on the impact of CPs on ED utilization and hospital readmissions for patients with AMI, COPD or CHF is scarce. Prior published studies on community paramedicine have demonstrated generally positive results but have mainly focused on reducing 911 calls and ED usage.

Purpose

The main limitation to the integration of CPs into the current healthcare model as a recognized discipline is the paucity of safety, efficacy, and long-term outcomes data to demonstrate their impact on patient care. Our goal in this study was to contribute to this dialogue by describing the impact of a CP intervention on 210-day hospital readmission and ED and clinic utilization in patients discharged from an acute hospitalization with AMI, CHF, or an acute exacerbation of COPD as compared to a matched control group. Our project is the first to examine the impact of a CP intervention by using a prospective, observational cohort with a matched historical control. We followed patients for 210 days after discharge (180 days after completion of the CP intervention) in an attempt to better explore the impact of the intervention on the patient's longer term health.

METHODS

Design and Setting

This project was reviewed by our organization's Research Subjects Protection Program office and was granted a waiver from ongoing oversight from the institutional review board. The local urban fire/emergency medical services (EMS) agency, in collaboration with the local Level I trauma center, created a CP program in 2014 staffed by certified community paramedics. The fire department employed the community paramedics, and medical direction was provided by an EMS board-certified physician from the trauma center.

Selection of Participants

In January 2015, we began to prospectively identify patients admitted to the hospital for AMI, COPD or CHF. Participants met the following inclusion criteria: 1) ≥18 years old; 2) lived in the same city where the hospital is located; 3) discharged from an acute admission with a diagnosis of CHF, AMI, or COPD; 4) was not eligible for traditional home healthcare; and 5) was referred by an in-patient treatment team. Exclusion criteria were as follows: 1) non–English-speaking; 2) planning a move outside city limits in the 60 days after enrollment; and 3) being a prisoner. Participants were approached by the research team and offered participation after it was determined they met the inclusion criteria and their treating clinician had placed a referral for the intervention.

A historical control cohort was matched on age, gender, qualifying diagnosis, and ZIP code of residence. We retrospectively obtained data regarding control patients from a group of patients admitted to the hospital during the same data collection period who met eligibility criteria but did not participate in the intervention. Control group patients were not offered the intervention nor were they referred for the intervention; however, they met all other enrollment criteria. If a control patient had multiple hospital visits during the search period, one of the visits was chosen at random.

Interventions

Patients were enrolled in the CP intervention prior to hospital discharge. When possible, and with few exceptions, the patient and the CP met during enrollment while the patient was still hospitalized. Upon discharge the CP visited the patient in their home within 48 hours and subsequently 1–2 times per week for 30 days. While the home visit contained standardized elements (Figure 1), the CPs were allowed to individualize how they prioritized the specific required elements based on their needs assessment for each patient.

The CPs were granted access to the hospital electronic health record (EHR) for review of patient medical history, but they completed documentation of each visit in the ambulance service electronic patient care report (HealthEMS, Stryker Corp, Redmond, WA). Physician supervision of the CP intervention was provided by the ambulance service's EMS medical director in partnership with the patient's primary care team. Communication with the primary care physician typically occurred via a telephone call to the registered nurse at the clinic who would relay information to the physician. Patient satisfaction surveys were administered by a research staff member at the final home visit.

INTERVENTIONS
Physical Exam Perform auscultation of lung sounds, heart sounds, assessment of wounds, Assess for edema, skin condition, level of consciousness/memory, general vision, hearing and mobility.
Measurement of Vital Signs Measure blood pressure, pulse, respiratory rate, pulse oximetry, blood glucose, temperature, weight.
Medication Reconciliation Reconcile medications from all sources. Identify missing or duplicate medications, pillbox set-up. Confirm adequate supply of current medications, refills as needed. Assist with transfer to a more convenient pharmacy.
Medication Education Confirm timing of doses, why medications are needed, potential side effects or adverse reactions.
Disease Specific Education CHF: Reinforce importance of low-sodium diet and daily weights, including instruction on how to measure weight; provide scales when needed. AMI: Teach appropriate use of nitroglycerin, reinforcing cardiac rehabilitation principles. COPD: Educate the patient on proper use of steroid vs bronchodilator inhalers for rescue care; proper use and home maintenance of home oxygen equipment .
Nutrition Education Explain elements of a low-sodium diet, diabetes-specific diet education as needed.
Evaluation of Social Needs Determine transportation, housing, food access, health insurance, social support system. Refer to community resources such as social work or community health worker as appropriate.
Communication with Primary/Specialty Physician Provide assistance with making and keeping all medical appointments; titration of medications. Identify additional durable medical equipment or in-home medication needs.
Safety Evaluation Conduct home safety assessments, including fall and fire hazards. Evaluate for evidence of acute illness or injury requiring prompt physician intervention.

Figure 1. Standardized elements of community paramedic visits. *AMI*, acute myocardial infarction; *COPD*, chronic obstructive pulmonary disease; CHF, congestive heart failure.

Measurements

We used manual review of the EHR to quantify healthcare utilization for this project. Using the Care Everywhere function of the EHR, staff were able to identify healthcare visits within our integrated care delivery system and within most of the other local healthcare systems.

Patient demographics are summarized using descriptive statistics in Table 1. We calculated healthcare utilization (admissions, ED visits, and clinic visits) by cohort at 30 days (at the conclusion of the CP intervention), 120 days, and 210 days post-hospital discharge for both groups (Figure 2). We compared the percentage of subjects by type and time point of utilization using chi-square tests (Table 2).

Table 1. Subject characteristics at baseline.

	CP cohort (N = 78)	Control cohort (N = 78)	*P*-value
Age - Median (IQR)	63.5 (17.0)	64 (17.0)	0.81
Gender - N (%)			0.87
Male	44 (56.41%)	43 (55.13%)	
Female	34 (43.59%)	35 (44.87%)	
Race - N (%)			0.80
American Indian or Alaska Native	0 (0%)	1 (1.28%)	
Asian	1 (1.28%)	1 (1.28%)	
Black or African-American	23 (29.49%)	24 (30.77%)	
Hispanic or Latino	1 (1.28%)	1 (1.28%)	
Native Hawaiian or other	0 (0%)	1 (1.28%)	
White	52 (66.67%)	50 (64.10%)	
Other	1 (1.28%)	0 (0%)	
Qualifying diagnosis			
Congestive heart failure			
Chronic obstructive pulmonary disease			
Acute myocardial infarction			

IQR, interquartile range.

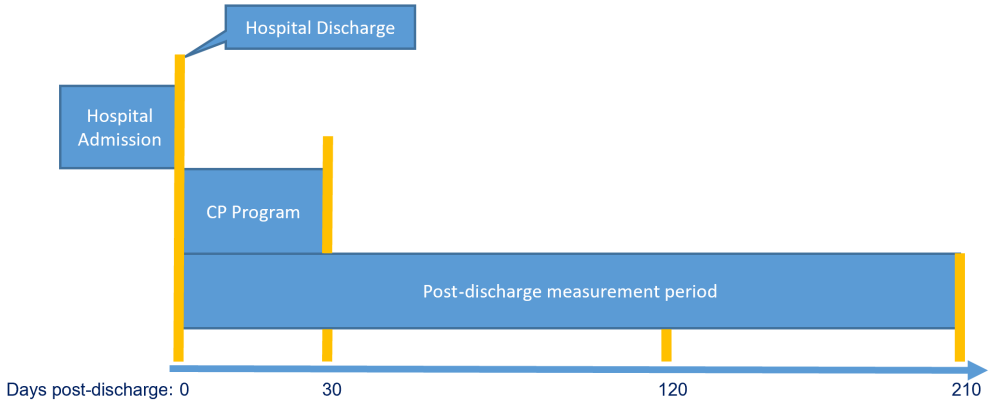

Figure 2. Program timeline.
CP, community paramedicine.

We computed the median utilization count per subject and generated an incidence rate ratio (IRR) using Poisson regression (Table 3). Total utilization count by type and time point for each cohort was also computed (Table 4). We calculated healthcare savings by comparing actual costs to the healthcare system for the CP group and the control group. Average cost to the program per CP home visit was $100 inclusive of CP salary, vehicle use, fuel and supply expenses, and physician medical direction. Patients received an average of five CP visits. Average cost per hospital admission was $6,413.00 for an average length of stay of four days based on the hospital's average for the diagnoses included in the intervention.

RESULTS

Findings

The intervention and control cohorts each consisted of 78 patients. There were no significant demographic differences between the CP and control groups (Table 1). Compared to controls, fewer subjects in the CP cohort had experienced a readmission at 120 days and 210 days after discharge (Table 2). A significantly higher percentage of CP subjects had at least one clinic visit in the first 30 days, although this difference was not observed at 120 or 210 days. Regression results for hospital readmissions indicated a lower likelihood of readmissions for CP subjects throughout the follow-up period compared to controls (30 days IRR 0.53; 120 days

Table 2. Cumulative percentage of patients in each cohort who had at least one hospital readmission, emergency department visit, or clinic visit at each study time point.

Days post discharge	CP cohort (N = 78)	Control cohort (N = 78)	*P*-value*
Hospital readmissions			
30	20.5%	32.1%	0.10
120	34.6%	64.1%	**<0.001***
210	43.6%	75.6%	**<0.001***
ED visits			
30	24.4%	37.2%	0.08
120	42.3%	65.4%	**<0.01***
210	52.6%	79.5%	**<0.001***
Clinic visits			
30	92.3%	70.5%	**<0.001***
120	93.6%	85.9%	0.11
210	94.9%	88.5%	0.15

*Bold indicates statistical significance at $\alpha = 0.05$.
CP, community paramedicine; *ED*, emergency department.

Table 3. Median healthcare utilization count per patient by cohort and time from discharge.

Days post discharge	CP cohort (N = 78)	Control cohort (N = 78)	Incidence rate ratio	95% confidence interval
Hospital readmissions Median (IQR)				
30	0 (0)	0 (1)	0.53	**0.30–0.94**
120	0 (1)	1 (2)	0.52	**0.37–0.74**
210	0 (1)	1 (1)	0.59	**0.45–0.78**
ED visits Median (IQR)				
30	0 (0)	0 (1)	0.50	**0.30–0.82**
120	0 (1)	1 (2)	0.54	**0.40–0.73**
210	1 (2)	1 (2)	0.59	**0.46–0.76**
Clinic visits Median (IQR)				
30	2 (2)	1 (3)	1.21	0.97–1.50
120	4 (5)	3 (7)	1.07	0.93–1.24
210	6 (7)	4.5 (7)	1.09	0.96–1.23

*Bold indicates statistical significance at $\alpha = 0.05$.
CP, community paramedicine; *ED*, emergency department; *IQR*, interquartile range.

IRR 0.52; and 210 days IRR 0.59). Similarly, regression results for ED visits also indicated lower likelihood of ED utilization for CP subjects compared to controls (30 days IRR 0.50; 120 days IRR 0.54; and 210 days IRR 0.59) (Table 3). At 210 days after discharge there were 56 (40.9%) fewer hospital admissions in the CP cohort (81 vs 137), which resulted in saving 218 bed days and $410,428 in healthcare costs (Table 4). Patients in the CP cohort had 70 (40.7%) fewer ED visits (102 vs 172). Of the 78 patients in the CP cohort, 78 (100%) recommended this program to others on the exit survey.

Table 4. Healthcare utilization event total count by cohort and time from discharge.

Days post discharge	CP cohort (N = 78)	Control cohort (N = 78)
Hospital readmissions		
30	18	34
120	49	94
210	81	137
ED visits		
30	23	46
120	62	115
210	102	172
Clinic visits		
30	175	145
120	389	363
210	536	492

DISCUSSION

As healthcare systems evolve, new care delivery models are needed to control costs, improve outcomes, and increase patient satisfaction. Our data suggest that CPs can be part of the solution by decreasing hospital readmissions and ED visits for a population that has been shown to have high rates of readmission. Traditionally, post-discharge readmission studies have targeted a period of 30 days. Our project quantified differences in healthcare utilization between cohorts at 30, 120, and 210 days after hospital discharge in an attempt to better explore the impact of the one-month CP intervention on the patient's longer term health. During this period the benefits of the CP intervention were maintained, the patients remained out of both the hospital and the ED, and the total cost of care was decreased. There were no identified increased adverse events in the intervention group. Patient surveys administered at the final paramedic visit indicated that patients overwhelmingly recommended this intervention, demonstrating that it improved the patient experience.

Establishing a permanent role for CPs in a hospital system's readmission-avoidance processes requires that the CP program develops mechanisms to ensure financial

sustainability. Our data demonstrate the cost savings that were possible with a CP intervention. In our case, the savings were not related directly to the hospital but instead were reflected in the decreased total cost of care for the insurers covering the patient's medical costs. To obtain access to these cost savings to fund a CP program, insurers must be persuaded to cover CP visits. Our data should make these conversations more empirical and evidenced based.

While the primary cost savings demonstrated by our intervention was to the benefit of the payors, the increased availability of hospital bed days was a direct benefit to our hospital. Like many tertiary care centers, our hospital is routinely operating at 95% capacity with multiple episodes of >100% capacity per month. This in turn results in ED boarding and the potential for ambulance diversions, which have been shown to have a negative financial impact on a hospital.[21] In this way our CP intervention offered a direct benefit to the receiving hospital; however, the financial impact to the hospital was difficult to quantify, which could lead to challenges in advocating for a hospital-financed CP program.

Our project is the first to examine the impact of a CP intervention by using a prospective, observational cohort with a matched historical control study design. By focusing on acute cardiopulmonary processes we were able to narrow our CPs' medical assessment on the most common components of this population's outpatient management including medications, comorbidities, and signs/symptoms of decompensation. Conducting the assessment in the patients' homes, as opposed to the clinic, allowed our CPs an opportunity to visualize the patients' living conditions and food resources and to have conversations about transportation, addiction, and mental health to better evaluate the social determinants of treatment failure. Many of these contributing factors were incompletely understood when the patient visited the primary care clinic, as key data that could be found only in the home were unavailable.

LIMITATIONS

There were limitations to the study. Community paramedics have varied education and clinical experience in providing post-acute care. We were unable to identify what specific CP intervention(s) led to the decreases in observed healthcare utilization. While our project followed patients for 210 days after hospitalization and 180 days after completion of the CP intervention, we were not able to extrapolate our data past this point. Additionally, although our EHR captures healthcare utilization at many local healthcare systems, it is possible that patients included in the CP or control groups had additional visits or hospitalizations that were not included in this analysis. However, because it was unlikely that it differed between the CP and control groups, it is unlikely that it introduced bias into the primary analysis. While we were able to describe cost savings to the healthcare system for this intervention, we were not able to describe the costs associated with program start-up or ongoing programming.

CONCLUSION

Our project demonstrated that an in-home community paramedic intervention conducted for 30 days with patients discharged from the hospital for CHF, AMI or COPD resulted in decreased hospital readmissions and decreased ED visits at 30, 120 and 210 days after hospital discharge. In addition, a savings of $410,428 for payors and an increase of 218 available hospital bed days was realized in the intervention cohort. Incorporation of a home CP intervention of 30 days in this patient population has the potential to benefit payors, hospitals and, most importantly, patients. The implications of our findings are important. As healthcare systems seek innovative approaches to reduce cost, improve quality of care, and enhance patient experience, new care models must be implemented. This project demonstrates that a 30-day, community paramedic intervention in the home for patients discharged from an acute hospitalization for CHF, AMI or COPD results in decreased hospital and ED readmissions while decreasing the total cost of care and improving hospital bed availability.

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Utility of Supraclavicular Brachial Plexus Block for Anterior Shoulder Dislocation: Could It Be Useful?

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Anterior shoulder dislocations (ASD) represent a common and painful orthopedic injury in the emergency department (ED). The management of ASD varies broadly from manual reductions via scapular manipulation with or without pain medication to procedural sedation and anesthesia (PSA), and various regional anesthesia (RA) techniques. The reduction approach often depends on the patient's subjective pain response, the expected difficulty of reduction, and the physician's experience with each method. Of the anesthetic options for difficult shoulder reductions, we generally favor RA techniques over PSA. While several RA techniques have been discussed in the literature, one technique that has yet to be analyzed is the supraclavicular brachial plexus nerve block (SBP). We believe there is evidence to suggest that the SBP would serve as an excellent anesthetic option for patients with ASD and significant pain or an expected difficult reduction.

ANTERIOR SHOULDER DISLOCATION–DIAGNOSIS AND MANAGEMENT

Anterior shoulder dislocations (ASD) are fairly common in the emergency department (ED); they account for 45% of all joint dislocations and carry a 2% prevalence in the general population.[1] Because of the significant pain patients often endure, timely management is imperative. Diagnosing ASD is traditionally via radiograph (Figure 1), but emergency physicians are adept at identifying it with point-of-care ultrasound (POCUS) alone with nearly 100% sensitivity and specificity[2] (Figure 2). Unfortunately, 95% of patients with ASD experience recurrence of this agonizing condition.[3]

Adequate analgesia can be critical to the management of ASD, and failure to obtain first-pass success portends lower rates of closed reduction.[4] Approaches to reduction include analgesia with intravenous and per os medications, procedural sedation and anesthesia (PSA), and regional anesthesia (RA). The first option, though, generally only blunts pain and thus portends a 16% failure in reduction;[5] so, we seldom employ it except for patients who are in only mild distress, such as those with recurrent ASD. For the management of most ASD in the ED, the fundamental choice lies between PSA and RA.

To its merit, PSA is analgesic, anxiolytic, anesthetic, and importantly, amnestic; with appropriate dosages patients achieve adequate (although temporary) pain control and do not recall the reduction. Furthermore, PSA allows physicians with little or no experience in RA or other anesthetic procedures (such as intra-articular injection) to reduce ASD successfully. However, PSA is time- and labor-intensive, mandating the presence of a nurse in the room during the entire procedure. Use of PSA also necessitates close patient airway and cardiac monitoring due to the risks of respiratory depression, hypotension, and vomiting.[6] It generally lengthens ED visits, as patients must reach clinical sobriety before being discharged. Depending on the doses of anesthetics used, patients may take hours to metabolize the induction agents sufficiently.[6] Emergency physicians also should not overlook the social aspect of PSA, as intoxicated patients often become disinhibited and may feel embarrassed afterward. Lastly, PSA exposes patients to opioids, and 80% of heroin addiction begins with medically dispensed opioids.[7]

REGIONAL ANESTHESIA—CURRENT USES AND NEW TECHNOLOGIES

Regional anesthesia, on the other hand, circumvents most of the drawbacks of PSA. Regional anesthesia requires only that the performing physician be present in the room with the patient on the cardiac and airway monitor. Patients can remain awake, alert, and oriented, and if performed properly RA can completely anesthetize the affected area, as is the case in brachial plexus (BP) blockade for upper extremity injuries.[8] Furthermore, depending on the anesthetic used, patients can be discharged home within hours to days of anesthesia post-reduction, an especially desirable outcome for patients with fracture-dislocations. Use of RA can also decrease the length of stay[9] and increase patient satisfaction.[10]

Should an attempted nerve block either provide subpar anesthesia or fail completely, the administration of local

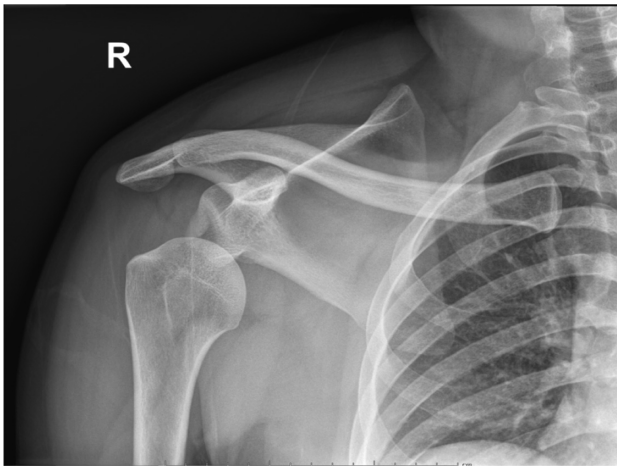

Figure 1. Radiograph of anterior shoulder dislocation, courtesy of Nirav Joshi, MD, Mount Sinai Medical Center, Miami Beach.

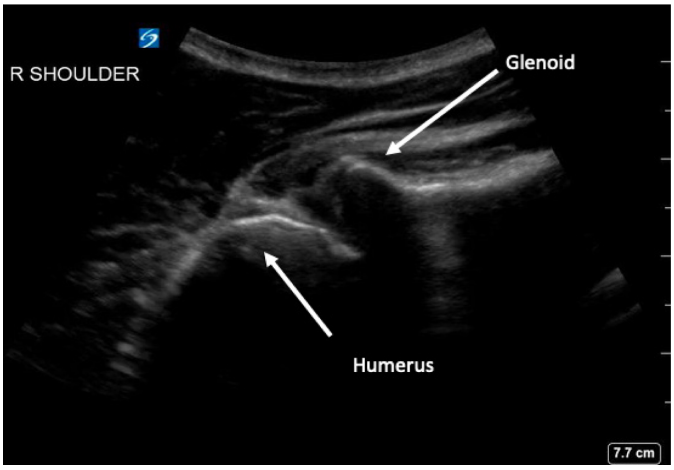

Figure 2. Posterior shoulder ultrasound demonstrating anteriorly dislocated humeral head, courtesy of Michael Rosselli, DO, Mount Sinai Medical Center, Miami Beach.

anesthetics does not preclude the subsequent use of PSA. However, like most invasive interventions RA poses its own perils, including risk of nerve damage, vascular puncture, pneumothorax (depending on anatomic location) and, most importantly, local anesthetic systemic toxicity, thus necessitating cardiac and airway monitoring.[11] Yet unlike with PSA, steps can be taken to avert such complications, which are most often minimized with increasing physician skill and are not the result of patient physiology alone. There are many RA options for emergency physicians to reduce ASD: interscalene and infraclavicular BP blockade, suprascapular nerve block, and intra-articular injection of local anesthetic into the glenohumeral joint.[6] Most recently, Yu et al published a case series on the successful use of the retroclavicular approach to the infraclavicular region (RAPTIR), an infraclavicular BP block, for anterior shoulder reduction.[6]

The use of RA in the ED is endorsed by the American College of Emergency Physicians (ACEP), which in a 2021 policy statement emphasized that ultrasound-guided nerve blocks are "not only within the scope of the practice of emergency physicians, but represent a core component of a multimodal pathway to control pain for patients in the emergency department."[12] Academic emergency medicine leaders are on board with ACEP's statement: In a survey study of program directors and ultrasound department directors, nearly all agreed that RA is an integral part of resident education.[13] Curricula for teaching RA are being actively developed across residency programs,[14] and residents continue to show an eagerness to learn and the capacity to perform RA techniques.[15] When it is clinically appropriate, we favor RA in the ED for the reduction of fractures and dislocations.

Supraclavicular Brachial Plexus Block—Why It Will Work for Anterior Shoulder Dislocation

The SBP block anesthetizes the upper limb and shoulder by targeting all trunks and divisions of the BP[16] (Figure 3). The SBP block can be performed in any position in which the patient is comfortable, as long as the patient's head is turned to the contralateral side. After placing a high-frequency (10–5 megahertz) linear probe immediately superior to the clavicle, the SBP is visualized with the subclavian artery medial, the first rib caudal, and the pleura deep to the rib[16] (Figure 4). Many features of the SBP block make its application in the ED favorable for both physician and patient. First, the SBP is very shallow (usually 1–2 centimeters deep to the skin) and easily identified when all other necessary structures (subclavian artery, first rib, pleura)

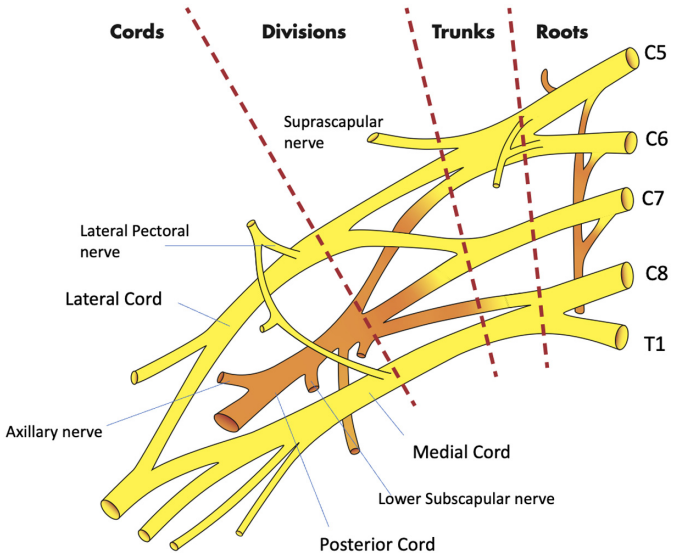

Figure 3. The brachial plexus. Image courtesy of Anthony Casazza.

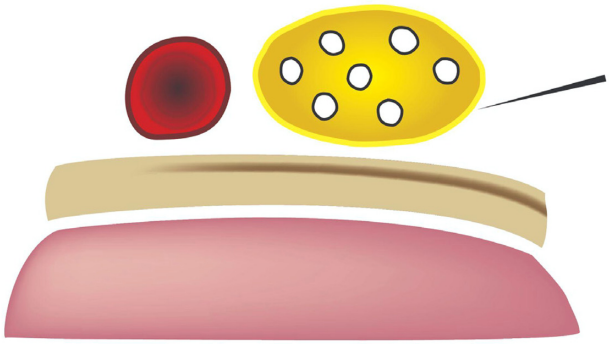

Figure 4. Supraclavicular brachial plexus (SBP) (yellow), subclavian artery (red), first rib (beige), and pleura (pink). The needle (upper right corner of the image) approaches the SBP from lateral to medial. Image courtesy of Anthony Casazza.

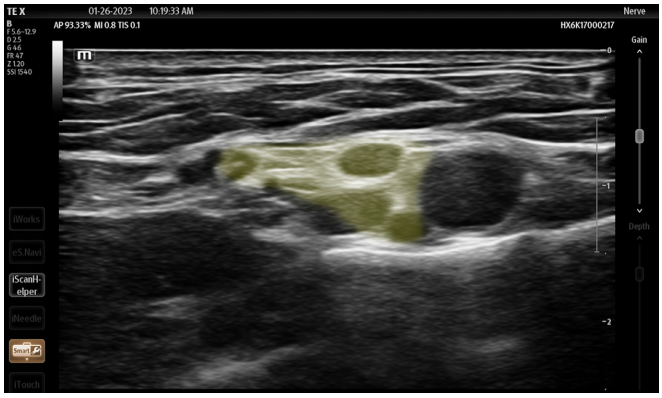

Figure 5. Ultrasound image of supraclavicular brachial plexus highlighted in yellow (Smart Nerve), Mindray TE X, Mindray North America, Image courtesy of Andrew Parrish.

are also visible within the field of view on POCUS. Moreover, the first rib acts as a backstop, so that should the physician overshoot the SBP with the block needle, a resulting pneumothorax may be avoided.

Additionally, the setup is simple: depending on the patient's body habitus the SBP block only requires a 22 gauge needle and usually not a spinal needle, as well as a short linear probe easily held and manipulated in one hand. If the physician is skilled enough, she or he can directly aspirate and inject with a syringe instead of having an assistant control aspiration and injection with a syringe connected to the needle via tubing. We prefer the Miller weight-based dosing for local anesthetic, based on the patient's calculated ideal body weight.[17] However, in our experience, usually 15 milliliters of local anesthetic injected directly into the plexus sheath is adequate for anesthesia of the upper limb, which frequently entails less than the maximum amount of local anesthetic for an adult patient.

Although the SBP block has classically been used for more distal procedures,[16] the spread of anesthetic within the BP sheath after an SBP block supports its use for the reduction of ASD. The glenohumeral joint and intrinsic shoulder muscles derive their sensory innervation from the suprascapular, lateral pectoral, axillary, and lower subscapular nerves.[18] By anesthetizing these sensory nerves, the SBP block anesthetizes the glenohumeral joint capsule and alleviates pain induced by an ASD. Additionally, disruption of the other cords of the BP weakens or paralyzes muscles of the upper extremity that actively resist reduction, even in patients who are under the influence of PSA.[6] For patients who suffer from associated Hill-Sachs deformity, which induces lingering discomfort post-reduction, longer acting anesthetics such as bupivacaine or ropivacaine provide hours or days of relief.[19] And while the SBP is already easy to perform, newer cart-based POCUS systems are equipped with settings that highlight the BP and provide needle trajectory guidance (TE X, Mindray North America,

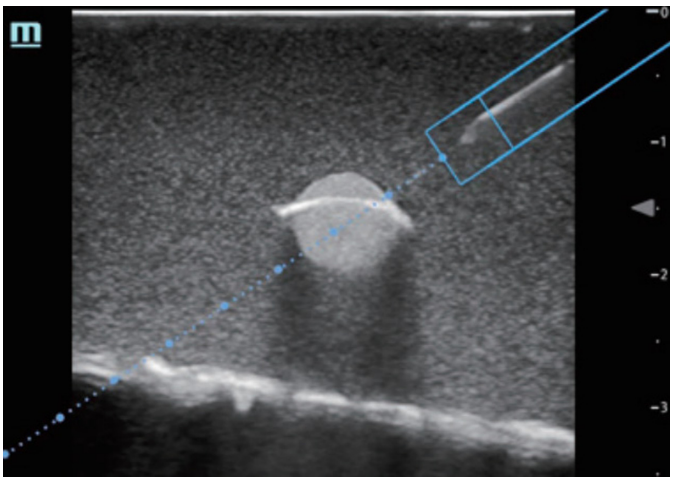

Figure 6. Magnetized needle trajectory guidance (ESpacial Navi), Mindray TE7, Mindray North America.

Mahwah, NJ) (Figures 5, 6). The SBP block is comfortable for patient; block performance allows patients to remain in their preferred position on the stretcher.

Of note, although the SBP block carries a low complication rate, some experts are wary of intracluster injection. Gadsen et al argue that based on cadaveric studies, the inadvertent, sub-perineural spread of anesthetic may result in axonal damage.[20] Other complications include pneumothorax, hemidiaphragmatic paralysis, and subclavian artery puncture, due to the proximity of both these structures to the SBP. Clinically, however, the SBP is safe. Ultrasound use for the SBP block has been demonstrated to nearly eliminate the risk of pneumothorax and neuronal injury.[21–24] Furthermore, in our opinion if the treating physician maintains appropriate needle visualization throughout the procedure—which should be feasible given the shallow nature of the SBP block—both the lungs and the subclavian artery will remain well out of the needle trajectory. And while most often the performance of

an SBP block will require two operators (one to inject and one to guide the needle), possibly limiting its use in settings with limited staffing, a skilled physician can perform the entire procedure with a single needle and syringe. Overall, the SBP block is safe, convenient, comfortable, and suitable for ASD.

The interscalene block, commonly used for shoulder pathology in the ED, also provides excellent anesthesia for the shoulder by targeting the C5 to C7 nerve roots.[25] However, in our opinion, it is more difficult to perform: The target nerves are smaller, harder to visualize on POCUS, and probe manipulation is more technically challenging because the BP at the level of the anterior and middle scalene muscles is farther up the neck and requires a steadier grip on the probe, as opposed to the more favorable position of the probe resting on the clavicle in the SBP block. In a patient in severe distress who has trouble lying still, the performance of this block may represent a difficult task. Lastly, the interscalene block is known to carry a slightly higher risk of permanent nerve damage.[26] Intra-articular injection, on the other hand, anesthetizes the glenohumeral joint capsule but does not paralyze spastic muscles and, therefore, it does not make ASD reduction easier for the patient or the physician.

DISCUSSION

Anterior shoulder dislocation is prevalent, painful, and tends to recur in patients with previous episodes. Reduction without sufficient analgesia may be intolerable for patients,[5] and failed initial attempts lead to more open reductions.[4] Thus, all efforts should be made to make patients comfortable prior to reduction. Although most physicians are familiar with PSA, it is time-consuming, labor-intensive, increases the length of stay for patients in the ED, risks airway compromise, exposes patients to opioids, and does not impart lasting analgesia. On the other hand, RA is learnable, involves fewer personnel, and generally does not pose airway risk or oversedation. From our experience, patients leave the ED satisfied, in a timely manner, and with potentially lasting pain relief.

It should also be noted that we practice in a community-academic setting and often work shifts without resident physicians to assist with performing RA. Newer ultrasound systems make RA more user-friendly and less intimidating for physicians. The SBP block provides reliable anesthesia, is easy to perform, safe, and allows patients to remain in a comfortable position. Moreover, the use of the SBP block is already commonplace prior to shoulder surgery.[27] While the interscalene block is also effective, in the setting of an ASD it may be much more technically difficult for the operator. Intra-articular injection is also helpful for pain but does not paralyze muscles. Therefore, we propose that a non-inferiority trial be undertaken to investigate the feasibility and effectiveness of the SBP block compared to the interscalene block or intra-articular injection for the reduction of ASD in the ED.

CONCLUSION

The supraclavicular brachial plexus nerve block should provide anesthesia for patients with an anterior shoulder dislocation by targeting all sensory nerves responsible for nociception associated with an ASD, as well as weakening/paralyzing muscles that actively resist reduction due to spasms. If an infraclavicular BP block provides anesthesia for ASD,[6] why should a SBP block not as well?

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Haboob Dust Storms and Motor Vehicle Collision-related Trauma in Phoenix, Arizona

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Background: The Sonoran Desert region, encompassing most of southern Arizona, has an extreme climate that is famous for dust storms known as haboobs. These storms lead to decreased visibility and potentially hazardous driving conditions. In this study we evaluate the relationship between haboob events and emergency department (ED) visits due to motor vehicle collisions (MVCs) in Phoenix, Arizona.

Methods: This study is a retrospective analysis of MVC-related trauma presentations to Phoenix, AZ, hospitals before and following haboob dust storms. These events were identified from 2009–2017 primarily using Phoenix International Airport weather data. De-identified trauma data were obtained from the Arizona Department of Health Services (ADHS) Arizona State Trauma Registry (ASTR) from seven trauma centers within a 10-mile radius of the airport. We compared MVC-related trauma using six- and 24-hour windows before and following the onset of haboob events.

Results: There were 31,133 MVC-related trauma encounters included from 2009–2017 and 111 haboob events meeting meteorological criteria during that period. There was a 17% decrease in MVC-related ED encounters in the six hours following haboob onset compared to before onset (235 vs 283, $P = 0.04$), with proportionally more injuries among males ($P < 0.001$) and higher mortality ($P = 0.02$). There was no difference in frequency of presentations ($P = 0.82$), demographics, or outcomes among the 24-hour pre- and post-haboob groups.

Conclusion: Haboob dust storms in Phoenix, Arizona, are associated with a decrease in MVC-related injuries during the six-hour period following storm onset, likely indicating the success of public safety messaging efforts. Males made up a higher proportion of those injured during the storms, suggesting a target for future interventions. Future public-targeted weather-safety initiatives should be accompanied more closely by monitoring and evaluation efforts to assess for effectiveness. [West J Emerg Med. 2023;24(4)798–804.]

INTRODUCTION

Weather events are known to have a profound effect on human health. The Sonoran Desert region, encompassing most of southern Arizona, has an extreme climate that is famous for a meteorological phenomenon known as a "haboob." The word, of Arabic origin, originally described storms in the Middle East and North Africa and was first used to describe similar events in the southwestern United States in a 1972 paper by Idso et al.[1] The haboob is a unique dust storm occurring when desert sediment is sent airborne by the convective downdrafts of thunderstorms. The advancing walls of dust typically develop southeast of Tucson and travel northeast toward Phoenix. They can reach over a kilometer in height and are accompanied by high winds, rapid decreases in visibility and temperature, and increases in airborne particulate matter.[2–4]

Dust storms exert negative health effects in different ways. For example, studies in a variety of contexts suggest that particles under 10 micrometers in diameter (PM10) from dust storms may be associated with increased hospital visits and emergency department (ED) visits, especially from cardiopulmonary disease.[5–11] Locally, Dimitrova et al showed a correlation between particulate matter and childhood asthma attacks in Phoenix, while Tong et al suggest that increased dust storm activity may be linked to an uptick in fungal *Coccidioides* infections.[12,13] The increase in particulate matter also leads to decreased visibility, which may lead to hazardous driving conditions.

Over five million motor vehicle collisions (MVCs) result in the deaths of around 40,000 U.S. residents every year.[14,15] An estimated 16–25% of traffic fatalities may be related to adverse weather, particularly due to rain and wet conditions, costing tens of billions of dollars and thousands of lives yearly.[15,16] While low-visibility conditions have been associated with MVCs and fatalities,[15] there is limited research specifically regarding the impact of haboobs on the frequency of MVC-related trauma secondary to adverse driving conditions.

Dust storms are the third leading cause of weather-related fatalities behind extreme heat/cold and flash flooding in Arizona.[3] Dust storm modeling has identified two dust storm hot spots for MVCs: at the intersection of Interstate 8 and Interstate 10 near Casa Grande, as well as at the intersection of I-10 and I-17 in Phoenix.[17] According to the National Oceanic and Atmospheric Administration, 1,521 dust-related MVCs occurred in Arizona between 1955–2011 resulting in 157 deaths and 1,324 injuries.[18]

With rapid population growth in the state and evidence for climate change causing increasing severity of haboobs, understanding the effects of severe weather on driving conditions and MVC-related health outcomes is crucial.[2–4] Elucidating this relationship can help improve driver safety as well as preparedness of EDs and emergency medical services (EMS) personnel. The primary outcome of this study was the change in frequency of ED visits for MVC-related trauma following onset of a haboob. Secondary outcomes assessed were changes in group characteristics of demographics, transport methods, and clinical outcome measures among those with MVC-related trauma following a haboob.

Population Health Research Capsule

What do we already know about this issue?
Many motor vehicle collisions (MVC) and associated injuries are due to adverse weather conditions.

What was the research question?
This study explores the relationship between MVC trauma and dust storms ("haboobs") in the Phoenix, Arizona, area.

What was the major finding of the study?
There was a 17% decrease ($P = 0.04$) in MVC injuries during the six-hour period following haboob onset.

How does this improve population health?
Public safety messaging regarding adverse weather conditions may help drivers avoid dangerous conditions.

METHODS

This was a retrospective analysis of MVC-related trauma presentations to Phoenix, Arizona, hospitals before and after haboob dust storm events from 2009–2017. This study was approved by the Arizona Department of Health Services (ADHS) Human Subject Review Board and the Valleywise Health Institutional Review Board.

Identification of Haboob Events

Haboob events are characterized by a unique array of meteorological patterns that are relatively rapid and intense compared to other types of storms. Most distinguishing is the significant decrease in visibility, along with an acute rise in the amount of dust and high winds, and a rapid drop in temperature. These changes are observed from the baseline meteorology over a period of hours. There is no established strict meteorological definition of haboob, nor is there a quantifiable method of distinguishing one from other dust storms. For the purposes of this study, we developed a set of criteria to define haboob events based on previously

published attempts at identification and simulation of haboobs in the region.[1,4,18]

Haboob event criteria consist of an acute drop in visibility to less than or equal to seven miles at Phoenix Sky Harbor International Airport weather station (KPHX) within two hours of either

1. An acute rise in PM10 to greater than or equal to 200 μg/m^3 in diameter, or
2. An acute rise in PM10 to greater than or equal to 100 μg/m^3 and wind gusts greater than 38 miles per hour.

Haboob events were identified from publicly available historical climate and air quality data for the period of January 1, 2009–December 31, 2017. Weather data for visibility and wind were obtained from the National Climate Data Center as a Local Climatological Dataset sourced from the KPHX weather station.[19] These data represent the point conditions at KPHX in central Phoenix, the most comprehensive and widely referenced weather station in the metropolitan area. Particulate matter datasets were requested from the Environmental Protection Agency Air Quality System, and daily maximum PM10 was obtained from the nearby air monitoring sites at Central Phoenix (site 04-013-3002), Tempe (site 04-013-4005,) and South Scottsdale (site 04-013-3003,)[20] Of note, the Tempe and South Scottsdale air monitoring sites did not go online until 2012. One of the authors (JW Sachs) requested and processed data from the above sources. Particulate and weather data were combined and cleaned in Excel 2019 (Microsoft Corporation, Redmond, WA) and visualized using Power BI 2019 (Microsoft) and TimeSeries 2019 (ZoomCharts, Riga, Latvia).

The identification process involved the manual review of plotted climatological data. While haboobs are known to be associated with rapid drops in temperature, the utility of this variable was poor. Classification was made challenging due to quality problems with the climate and air quality datasets. For example, daily PM10 and wind gust values were frequently missing. When severe inconsistencies arose, we attempted to correlate a suspected event with an online eyewitness account or archived news report.

Identification of Motor Vehicle Collision-related Trauma

De-identified trauma data were obtained from the ADHS Arizona State Trauma Registry (ASTR) from 2009–2017. Included patient encounters were all involved in MVC-related trauma as defined by "Data Element I2_14a: CDC Mechanism/ Cause Category for Primary ICD-10 External Cause Code." All ages were included. Data fields collected included demographics (age, gender, state, and country of residence), accident details (date and time of injury, ZIP code and county of injury), method of transportation, and outcome measures (ED disposition, total length of ED plus inpatient stay, total hospital charges, and mortality outcome).

Literature on the size of haboobs in Arizona is limited and widely variable, with storm sizes 10–20 miles in length described at Williams Air Force Base ranging up to witnessed storm walls over 100 miles long outside Phoenix.[1,18,21] To include encounters from areas most likely to be affected by haboob conditions, presentations were included from the seven Level I-designated trauma centers within 10 linear miles of the KPHX weather station. Injuries that occurred outside Maricopa County were excluded as these MVCs were deemed less likely to be linked to the haboob event measured at KPHX. Also excluded were records where the time and date of injury were not explicitly recorded.

Data Analysis

Data analysis was conducted using JASP version 0.14.1 (Jeffrey's Amazing Statistics Program, University of Amsterdam, The Netherlands, 2021). Basic descriptive statistics were performed on the entire dataset of all MVC-related encounters from 2009–2017.

As with data regarding the size of haboobs, data on their duration in Arizona is limited and variable, and some commonly cited sources use data from other countries.[22,23] Brazel described dust-related visibility reductions in Arizona occurring 78 minutes prior to and 229 minutes (SD 220) after the storm front, while Idso reported an average of one hour but up to three hours.[1,24] Eagar found that high particulates are found up to one to two hours during haboobs, while some milder dust storms had conditions lasting up to 12 hours.[4] Crooks reported that while half of haboobs lasted less than one hour, a significant number lasted longer than seven hours.[11]

Based on these studies, to create an inclusive time window capturing the majority of MVC injuries potentially linked to a haboob event we defined "post-haboob" MVC trauma as occurring up to six hours after the onset of haboob conditions. The control group of "pre-haboob" MVC trauma includes injuries occurring in the six hours leading up to haboob onset. Additionally, we repeated the analysis using a 24-hour window before and after haboob onset to assess whether lingering weather conditions were linked to changes in MVC frequency. The frequency of MVC-related trauma in the pre-haboob (control) and post-haboob (exposure) groups were compared using binomial analysis. Additionally, pre- and post-haboob MVC trauma was compared with subgroup analyses for demographics, transport methods, and outcome measures using the Student *t*-test for continuous variables and chi-squared test for categorical variables.

Occasionally, several haboobs occurred in rapid succession, for example, with a patient simultaneously qualifying as "post-" (the earlier haboob) and "pre-" (the subsequent haboob). In these cases, we considered the patient to be in the "post-haboob" group of the first event and discarded subsequent encounters linked to later overlapping haboobs.

RESULTS

From January 1, 2009–December 31, 2017, there were 31,133 patient encounters meeting criteria (MVC-related trauma presenting to one of the seven included hospitals within 10 miles of KPHX). The mean age of all encounters was 35.8 years (SD 19.6, range 0–101), and 58.9% of the patients were male. The ED disposition of 67.3% of the patients was admission from the ED; 29.6% were discharged, 2.0% died in the ED, 0.6% required transfer to another hospital, and 0.4% bypassed the ED as a direct admission. Arizona state residents included 97.0% of the patients. Ground ambulance transported 88.5% and 6.7% via helicopter, while 4.5% were ED walk-ins. The mean total length of stay for all patients (ED plus inpatient) was 3.3 days (SD 6.7 days, range 0–309 days). The mortality rate was 4.1%.

Haboob Events

From 2009–2017, there were 111 haboob events meeting our inclusion criteria. The maximum number of haboobs in a single year was 23 (in 2011) and the minimum was three (in 2010), with a mean of 12 haboobs per year (SD 6.6). The greatest number of haboobs during these years happened in the months of July (33), followed by August and September, respectively (29 and 21). See Figures 1 and 2.

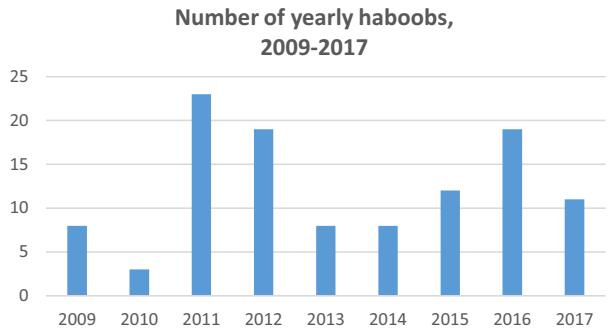

Figure 1. Number of haboobs per year from 2009–2017.

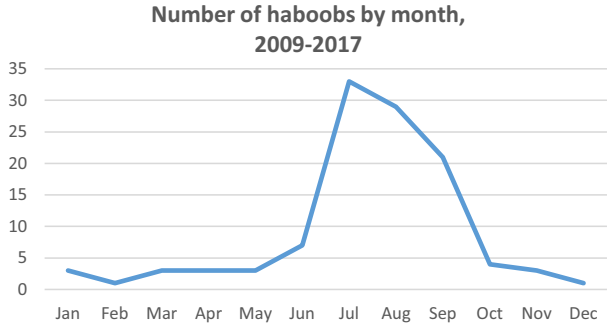

Figure 2. Number of haboobs by month, averaged from 2009–2017.

Haboob-related MVC Patient Presentations

Analysis using 24-hour pre- and post-haboob periods revealed that 815 patients were injured pre-haboob compared to 825 in a post-haboob period ($P = 0.82$). There was no demographic difference between these groups regarding age, gender, or Arizona residence ($P = 0.10$, 0.21, and 0.53, respectively). A similar number of patients in the 24-hour pre- and post-haboob periods were transported by helicopter compared to ground ambulance in both groups ($P = 0.07$). Outcomes of total length of stay, hospital charges, and mortality were also similar in both groups ($P = 0.25$, 0.88, and 0.80, respectively). We excluded 143 patient encounters (8.0% of MVC injuries within 24 hours of a haboob onset) due to overlapping haboob timeframes.

Analysis using six-hour pre- and post-haboob periods demonstrated a roughly 17% decrease in MVC injuries in the six-hour period following haboob onset (235 vs 283, $P = 0.04$). The six-hour post-haboob period had a proportionally higher number of injured males ($P < 0.001$), while there was no difference in age or Arizona residence ($P = 0.23$ and 0.50, respectively). No significant difference was noted in helicopter vs ground ambulance transport ($P = 0.06$). While LOS and total hospital charges were similar in six-hour pre- and post- haboob patients ($P = 0.52$ and 0.82), there was a higher mortality noted in the post-haboob period ($P = 0.02$). Four patient encounters (0.008% of those within six hours of a haboob onset) were excluded from two occasions of overlapping haboob timeframes. Please see Table 1.

DISCUSSION

This study evaluated the relationship between haboob dust storm events and MVC-related ED visits in Phoenix, AZ. Prior studies have demonstrated the general relationship between bad weather and poor visibility and MVC fatalities,[15,16] and quantified haboob-related MVCs and associated morbidity and mortality in Arizona.[3,17] However, we are not aware of any study comparing the number of MVC-related injuries following haboob onset compared with baseline, or any study describing changes in the numbers of MVC-related injury cases presenting to local EDs around the time of a haboob event.

Interestingly, the frequency of MVC-related injuries decreased during the six-hour period following haboob onset by approximately 17%. No significant decrease was seen when considering presentations during a 24-hour period following haboob onset; this may be because the duration of most haboobs is only several hours [1,4,11,24] and, therefore, a 24-hour period includes many non-haboob-related incidents, with the misclassification biasing our results toward the null. This drop in injury frequency noted during the six-hour post-haboob period may be due to changes in driver behavior secondary to public safety messaging systems. A large haboob-linked multicar collision in 2011 led to collaborations between the Arizona Department of

Table 1. Demographics and outcomes of patients presenting within 24- and six-hour windows following haboob event onset.

	All	24-hour haboob period			6-hour haboob period		
		pre-	post-	*P*-value	pre-	post-	*P*-value
MVC injuries (# patients)	31,133	815	825	0.82	283	235	***0.04***
Age (mean years)	35.8	34.6	36.2	0.10	33.8	36.0	0.23
Gender (% male)	58.9	58.2	61.2	0.21	51.2	65.5	***<0.001***
Place of residence (% Arizona)	96.4	96.9	96.4	0.5	96.1	94.8	0.50
Transport (% heli vs ground ambo)	7.0	7.4	5.1	0.07	7.0	3.2	0.06
Total ED + admit LOS (days)	3.3	3.5	3.1	0.25	3.5	3.0	0.52
Total hospital charges (mean $)	65,760	63,913	63,104	0.88	60,631	63,056	0.82
Final outcome (% mortality)	4.1	2.8	3.0	0.80	1.1	4.3	***0.02***
Excluded (# patients)		143			4		

MVC, motor vehicle collision; *ED,* emergency department; *LOS*, length of stay; *heli*, helicopter; *ambo*, ambulance.

Transportation, the National Weather Service, Arizona Department of Public Safety, and the Governor's Office of Highway Safety in rolling out the "Pull Aside, Stay Alive" campaign. The campaign has included radio alerts, television messaging, and increased roadside signage, even encouraging public participation via whimsical aspects such as the "Haboob Haiku Challenge."[25]

Current robust, public health messaging in Arizona may be successful in keeping drivers off the road and safe during haboobs, similarly to what was noted with a decrease in MVCs in Virginia following a rollout of wireless alerts regarding flash floods[26] and in southern California with the use of changeable message signs.[27] A Canadian study in 2010 similarly showed that risk of MVCs associated with rainfall significantly decreased over two decades, which could partially be attributed to driver behaviors, in addition to road and vehicular improvements.[28] Although MVC injuries decreased during the six hours following haboob onset, there was a higher proportion of fatalities among cases presenting to the included EDs, suggesting that those who did not stay off the roads were involved in more serious collisions; however, other outcome metrics of length of stay and hospital charges did not suggest a difference.

While males were overall more likely to suffer from an MVC injury, consistent with prior trends secondary to risky behaviors and number of miles driven,[29] males were also disproportionately represented among injuries occurring during the six-hour window following haboobs. One study found that females may be superior to males at keeping within their lanes during foggy weather conditions,[30] and even in non-US contexts surveys suggest that male driving behaviors may exacerbate risks secondary to inclement weather.[31]

It was hypothesized that non-Arizona residents may have represented a larger number of MVCs during haboobs due to unfamiliarity with these weather events, but there was no difference in residency among those injured in haboobs. There was an apparent difference in both the six- and 24-hour groups, although ultimately statistically insignificant, in transport mode with proportionally fewer helicopter EMS following haboobs, unsurprising given the association with bad weather and an increased number of fatal crashes.

LIMITATIONS

This study had several limitations. While we conducted the analysis under the presumption that MVC injuries occurring in the hours following haboob onset could be linked to weather, the datasets we used did not explicitly say whether the weather was a causative factor in the MVCs. Weather data was not available on the exact spatiotemporal patterns of the storms, and trauma data included ZIP codes as opposed to specific intersections; thus, beyond including cases presenting to hospitals within the radius and excluding injuries sustained outside Maricopa County, there was no more clear way to more precisely link weather and the MVCs. While we attributed changes in MVC frequency following haboob onset to weather conditions and visibility, there are confounders that could not be assessed in this study (such as substance or cell phone use or vehicle mechanical issues), but were likely controlled in our analysis. Additionally, because pre-/post-classification of MVCs occurring during periods when multiple haboobs happened in rapid succession was impossible, these events were removed. They represented only a small proportion of encounters, and their removal did not bias the results.

Selection of the controls for comparison to post-haboob injuries was challenging, since many changing traffic conditions could affect MVC and injury frequency (for example, decreased MVC numbers following evening storms may have been more related to natural fluctuations in commuter numbers). However, we decided that despite

time-of-day variations in traffic, the hours preceding haboobs events were otherwise the best controls, and with enough included haboob events the daily traffic variations between pre- and post- haboob time periods were negligible.

Another limitation was due to dataset completion; for example, while many fields were consistently filled out on the ASTR, others like total hospital charges were not available for many cases. Additional information for injury characterization was also unavailable; therefore, mortality, length of stay, and hospital charges were used as proxies for injury severity. The available data likely underestimated trauma because not all MVC-related injuries led to activation of hospital trauma teams (and there was likely variation in trauma team activation between institutions unaccounted for here); thus, there may have been a number of minor injuries not included, while incidents of MVC-related mortalities that were not transported from the scene also would not have been included.

CONCLUSION

Haboob dust storms in Phoenix, Arizona, may be followed by a decrease in motor vehicle collision-related injuries during the six-hour period following storm onset, perhaps due to the success of public safety messaging efforts. Males made up a higher proportion of those injured during the storms, suggesting a target for future interventions. Future public-targeted weather safety initiatives should be accompanied more closely by monitoring and evaluation efforts to assess for effectiveness.

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National Variation in EMS Response and Antiepileptic Medication Administration for Children with Seizures in the Prehospital Setting

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Background and Objectives: Prehospital Advanced Life Support (ALS) is important to improve patient outcomes in children with seizures, yet data is limited regarding national prehospital variation in ALS response for these children. We aimed to determine the variation in ALS response and prehospital administration of antiepileptic medication for children with seizures across the United States.

Methods: We analyzed children <19 years with 9-1-1 dispatch codes for seizure in the 2019 National Emergency Medical Services Information System dataset. We defined ALS response as ALS-paramedic, ALS-Advanced Emergency Medical Technician, or ALS-intermediate responses. We conducted regression analyses to identify associations between ALS response (primary outcome), antiepileptic administration (secondary outcome) and age, gender, location, and US census regions.

Results: Of 147,821 pediatric calls for seizures, 88% received ALS responses. Receipt of ALS response was associated with urbanicity, with wilderness (adjusted odds ratio [aOR] 0.44, 0.39-0.49) and rural (aOR 0.80, 0.75-0.84) locations less likely to have ALS responses than urban areas. Of 129,733 emergency medical service (EMS) activations with an ALS responder's impression of seizure, antiepileptic medications were administered in 9%. Medication administration was independently associated with age (aOR 1.008, 95% confidence interval [CI] 1.005-1.010) and gender (aOR 1.22, 95% CI 1.18-1.27), with females receiving medications more than males. Of the 11,698 children who received antiepileptic medications, midazolam was the most commonly used (83%).

Conclusion: The majority of children in the US receive ALS responses for seizures. Although medications are infrequently administered, the majority who received medications had midazolam given, which is the current standard of care. Further research should determine the proportion of children who are continuing to seize upon EMS arrival and would most benefit from immediate treatment. [West J Emerg Med. 2023;24(4)805–813.]

INTRODUCTION

Emergency medical services (EMS) personnel transport approximately three million children annually in the United States, representing 10% of all EMS transports.[1] Seizures account for 10% of these pediatric EMS encounters.[2] While many seizures resolve spontaneously and quickly without

intervention, rapid advanced-level care can be critical for improving outcomes in those who do not. The likelihood of seizure cessation, either spontaneously or with antiepileptic treatment, decreases with longer seizure duration.[3,4] Prolonged seizure duration is associated with both increased morbidity, such as chronic neurological deficit, and mortality.[5]

Seizure duration is one potentially modifiable factor that can affect outcomes, and most current treatment protocols recommend that the first antiepileptic medication be administered within five minutes of seizure onset with a second medication given by 10 minutes.[6] Seizure treatment requires Advanced Life Support (ALS) training and skill, due to the potential necessity for administering controlled antiepileptic medications or the need for airway or circulatory system support, neither of which can be provided by a Basic Life Support (BLS) response. The EMS personnel certified in BLS do not carry antiepileptic medications. A prior study evaluating prehospital treatment of status epilepticus showed that timely ALS prehospital treatment improved patient outcomes.[7]

Studies regarding the prehospital management of children with seizures have been primarily at the patient level and describe local or regional care. Those studies have not reported national level data. [8-10] There is no published national data that describes the variation in prehospital level of care and management used for children with seizures. Nationwide, BLS personnel outnumber ALS and Intermediate Life Support personnel combined by a factor of approximately three to one.[11] The distribution of these EMS personnel may introduce variability in EMS response type and management.

The National EMS Information System (NEMSIS) provides an opportunity to understand the variation in response across the country for children with high acuity complaints.[12] Identifying the variation in EMS response and understanding current practices in prehospital management are important at both the patient and system level. At the patient level, the data may identify potential areas where the care is suboptimal, such as receiving medications that are not the standard of care or prolonged time to administration of medications. At the system level, this data may reveal opportunities for system- and regional–level improvements in protocols and policies. In this study, we aimed to determine the variation in types of EMS response to 9-1-1 calls for pediatric seizures across the US, based on patient demographics and geographic location. Secondarily, we aimed to determine the frequency with which children received an antiepileptic medication and whether this differed based on patient demographics and location.

Population Health Research Capsule

What do we already know about this issue?
Timely pediatric seizure treatment is crucial to prevent morbidity and mortality. Variation in EMS seizure care underscores the need for systems improvement.

What was the research question?
Is there variation in EMS response and medication administration for pediatric seizures in the United States?

What was the major finding of the study?
Advanced Life Support response was 88%: lower in rural areas compared to urban (aOR 0.80). Antiepileptics were administered in 9%, slightly higher in older patients.

How does this improve population health?
This data enhances our understanding of national EMS responses and management for children with seizures based on patient geography and demographics.

METHODS

Study Design

We conducted a retrospective, cross-sectional analysis of the NEMSIS public research dataset.[12] Our institutional review board granted this study exempt status.

Data Source

The NEMSIS project is a national effort to standardize EMS data collected by EMS personnel. The database for the project is managed by the NEMSIS Technical Assistance Center (currently located at the University of Utah School of Medicine, Salt Lake City, UT) and supported by the Office of Emergency Medical Services of the National Highway Traffic Safety Administration. Local EMS agencies submit data to their state database, of which a subset is then exported to the national database.[13] For this study, we used the 2019 NEMSIS Public Release Dataset (version 3), which includes 22,532,890 EMS activations submitted by 9,599 EMS agencies serving 43 US states and territories during the 2019 calendar year.

Participants: Selection of EMS Responses

We included children <19 years in age who accessed 9-1-1 EMS for complaints of seizures or convulsions during the 2019 calendar year. We excluded interfacility transfers. To

identify relevant cases of EMS activations for the care of pediatric seizures, we used codes from the NEMSIS dataset that related to reason for dispatch as convulsion or seizures (eDispatch.01 - 2301025). To assess the potential differences between dispatch reason and the EMS responder's impression (eSituation.11 and eSituation.12), we also identified children for whom the primary or secondary responder impression was documented as seizure or convulsion. These impressions were documented as International Classification of Diseases, 10th Rev, Clinical Modification (ICD-10-CM) codes that were recorded by EMS personnel. We included all ICD-10-CM codes that refer to seizure, which include ICD-10-CM codes with the prefixes of R56, G40, and P90.

Outcomes

The primary outcome of our study was receipt of ALS response for patients with dispatch complaints of seizures, as BLS personnel are unable to administer antiepileptic medications. We defined ALS response as any of the following: ALS-paramedic, ALS–Advanced Emergency Medical Technician (AEMT), or ALS-intermediate (as described within NEMSIS element eResponse.15). We defined BLS response as any of the following: BLS–Basic/EMT, BLS-AEMT, BLS-First Responder, BLS–Intermediate (as described within eResponse.15).

The secondary outcome was receipt of an EMS-administered antiepileptic medication among patients with an ALS response and the EMS responder's impression of seizure. We included all formulations of the following seizure abortive medications as documented in eMedication.03: midazolam, lorazepam, diazepam, levetiracetam, phenytoin, phenobarbital, and clonazepam. We assessed the timing of medication administration in two ways: a) calculated as the time from the time of dispatch (eTimes.03) to the time of medication administration (eMedication.01); and b) calculated as the time from EMS arrival on scene (eTimes.06) to the time of medication administration (eMedication.01). We calculated these two times as the former includes the time to arrive on the scene, while the second excludes this period.

Covariates and Definitions

From the NEMSIS database, we collected the following covariates: patient demographics (age, gender, race, and ethnicity); insurance status (private insurance, Medicaid, self-pay, no insurance identified, other, or missing); census region (Midwest, Northeast, South, and West); and urbanicity based on the U.S Department of Agriculture Urban Influence Codes (urban, suburban, rural, and wilderness).

Statistical Analysis

We summarized our data using standard descriptive statistics. For our primary outcome (receipt of ALS response), we conducted a multivariable logistic regression analysis to determine its relationship to the following covariates: patient demographics (age, gender); census region; and urbanicity. We excluded any variables that were missing >20%.

For our secondary outcome (receipt of antiepileptic medication), we analyzed only those patients for whom ALS care was dispatched and had an EMS responder's impression of seizure. We conducted a logistic regression analysis to determine the relationship between receipt of an antiepileptic medication and age, gender, census region, and urbanicity. For all regression modeling, we assessed for multicollinearity using variance inflation factors and determined model goodness-of-fit. For variables that were collinear, we chose only one of the variables to further analyze.

Lastly, we calculated the number with EMS responder impression of seizure (eSituation.11 and .12) divided by number with EMS dispatch for seizure (eDispatch.01) to understand how frequently these impressions matched.

RESULTS

We identified 147,821 eligible EMS activations for pediatric patients <19 years of age with 9-1-1 dispatch for seizure or convulsion. Figure 1 and Table 1 note that the majority of children received an ALS response (88%), which was evenly distributed by age and gender. Most encounters overall occurred in urban areas (84%). Most patients had missing or unknown data for race, ethnicity, and insurance status; therefore, this data was not analyzed further. In the

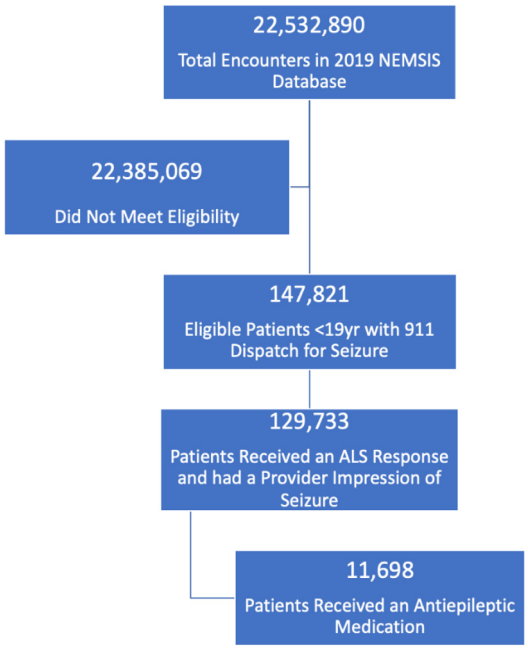

Figure 1. Patient flow diagram.
NEMSIS, National Emergency Medical Services Information System; *ALS*, Advanced Life Support.

Table 1. Level of emergency medical services care for children with dispatch seizure code.

	All Patients N = 147,821	Response Unit Level of Care		*P*-values
		Advanced Level Response n (%), N = 129,695	Basic Level Response n (%), N = 18,126	
Age group, years				0.55
<1	7,618	6,670 (88)	948 (12)	
1-4	51,676	45,303 (88)	6,373 (12)	
5-9	20,992	18,367 (87)	2,625 (13)	
10-14	26,885	23,624 (88)	3,261 (12)	
15-18	40,650	35,731 (88)	4,919 (12)	
Gender				0.66
Female	68,822	60,518 (88)	8,304 (12)	
Male	77,714	68,278 (88)	9,436 (12)	
Missing	1,285	899 (70)	386 (30)	
Region				<0.001
Northeast	15,986	11,784 (73)	4,238 (27)	
South	68,387	61,750 (90)	6,637 (10)	
Midwest	25,029	22,243 (89)	2,786 (11)	
West	38,326	33,920 (89)	4,406 (11)	
Missing	93	34 (37)	59 (63)	
Urbanicity				<0.001
Urban	123,909	109,516 (88)	14,393 (12)	
Suburban	7,813	6,921 (89)	892 (11)	
Rural	9,280	7,975 (86)	1,305 (14)	
Wilderness	1,942	1,499 (77)	443 (23)	
Missing	4,877	3,784 (78)	1,093 (22)	

Table 2. Regression model: independent associations with receipt of Advanced Life Support-level care.

	Adjusted Odds Ratio	95% Wald Confidence Limits		*P*-values
Age in years	1.002	1.000	1.005	0.07
Gender: female vs male	1.006	0.97	1.04	0.72
Urbanicity:				
Wilderness vs urban	0.44	0.39	0.49	<0.001
Rural vs urban	0.79	0.75	0.84	<0.001
Suburban vs urban	1.01	0.94	1.09	0.80

multivariable analysis (Table 2), receipt of ALS response increased marginally for every year increase in age and decreased for those living in rural or wilderness locations.

We identified 11,698 EMS activations for which patients received an antiepileptic medication, representing 9% of encounters that received an ALS response and had an EMS responder's impression of seizure. The administration of an antiepileptic medication was evenly distributed across all age groups, regions, and urbanicity (Table 3). In the multivariable analysis (Table 4), receipt of an antiepileptic medication was significantly higher in females compared to males.

Of the 147,821 EMS activations that had a dispatch indication of seizure, 109,684 (74%) also had an EMS responder's primary or secondary impression of seizure. Midazolam was the most commonly administered medication, comprising 83% of all antiepileptic medications administered (Supplement 2). The median documented time from dispatch to medication administration for all encounters was 16.75 minutes (Table 5). Urban areas had the

Table 3. Antiepileptic medication administration by patient demographics and geographic locations.

	All Patients N = 129,733	Antiepileptic Medication Administered No. (%) N = 11,698	Antiepileptic Medication Not Administered, No. (%) N = 118,035	*P*-values
Age group, years				<0.001
<1	6,893	645 (9)	6,248 (91)	
1-4	49,992	4,064 (8)	45,928 (92)	
5-9	19,016	2,093 (11)	16,923 (89)	
10-14	22,566	1,869 (8)	20,697 (92)	
15-18	31,266	3,027 (10)	28,239 (90)	
Gender				<0.001
Female	58,960	5,879 (10)	53,081 (90)	
Male	70,218	5,793 (8)	64,425 (92)	
Missing	555	26 (5)	529 (95)	
Region				<0.001
Northeast	10,943	859 (8)	10,084 (92)	
South	61,752	5,948 (10)	55,804 (90)	
Midwest	20,889	1,914 (9)	18,975 (91)	
West	36,117	2,974 (8)	33,143 (92)	
Missing	32	3 (9)	29 (91)	
Urbanicity				0.66
Urban	110,977	10,005 (9)	100,972 (91)	
Suburban	6,347	589 (9)	5,758 (91)	
Rural	7,301	656 (9)	6,645 (91)	
Wilderness	1,408	116 (8)	1,292 (92)	
Missing	3,700	332 (9)	3,368 (91)	

Table 4. Regression model: independent associations with medication being administered.

Effect	Adjusted Odds Ratio	95% Wald Confidence Limits		*P*-values
Age (in years)	1.008	1.005	1.01	<0.001
Gender: female vs male	1.22	1.18	1.27	<0.001
Urbanicity: wilderness vs urban	0.99	0.91	1.08	0.27
Urbanicity: rural vs urban	1.01	0.93	1.11	0.78
Urbanicity: suburban vs urban	0.90	0.74	1.09	0.77

fastest times to medication administration (median 16.44 minutes [min]) and wilderness the slowest (median 21.00 min). The median time to administration of antiepileptic medication from dispatch was most rapid for children in the 1–4 years age group (median 15.82 min) and slowest in those 15–18 years of age (median 18.00 min).

The median documented time from EMS arrival on scene to medication administration was 9.63 min (Table 6). From EMS arrival on scene to medication administration, children in the 1–4 years age group had the fastest medication administration time (median 8.68 min), while children in the 10–14 years age group had the slowest (median 10.53 min). Upon regression analysis, (Table 7), time to medication administration was significantly faster in urban areas and slower as patient age increased.

DISCUSSION

In this retrospective analysis of the NEMSIS database, most children with a dispatch code for seizure received an ALS response. Although ALS responses were statistically

Table 5. Time from dispatch to medication administration (in minutes).

	N	Lower Quartile	Median	Upper Quartile	*P*-values
All patients*	11,509	11.77	16.75	24.00	
Age (years)					<.001
<1	631	11.42	15.82	23.43	
1–4	3,997	11.05	15.67	22.12	
5–9	2,047	11.82	17.00	23.58	
10–14	1,837	12.67	17.88	26.03	
15–18	2,997	12.08	18.00	25.22	
Gender					0.82
Female	5,879	11.72	16.72	24.00	
Male	5,793	11.85	16.80	24.00	
Missing	26	12.00	15.32	24.43	
Region					<.001
Northeast	842	12.00	18.00	25.17	
South	5,865	12.48	17.85	25.00	
Midwest	1,862	11.05	15.51	21.47	
West	2,937	10.67	15.33	22.53	
Missing	3	18.00	19.00	30.00	
Urbanicity					<.001
Urban	9,862	11.63	16.44	23.57	
Suburban	574	13.00	18.99	27.22	
Rural	638	12.03	17.43	26.00	
Wilderness	110	14.00	21.00	34.30	
Missing	325	12.57	18.55	25.00	

*Filtered to remove times <0 minutes and >180 minutes.

Table 6. Time from emergency medical services arrival on scene to medication administration (in minutes).

	N	Lower Quartile	Median	Upper Quartile	*P*-value
All patients*	11,382	5.43	9.63	16.00	
Age (years)					<.001
<1	626	5.00	9.00	15.00	
1–4	3,940	5.00	8.68	14.72	
5–9	2,023	5.58	9.88	16.00	
10–14	1,821	6.00	10.53	18.27	
15–18	2,972	5.91	10.31	17.50	
Gender					0.72
Female	5,734	5.40	9.45	16.10	
Male	5,623	5.45	9.87	16.00	
Missing	25	5.00	9.45	16.92	
Region					<.001
Northeast	836	5.91	10.83	17.00	
South	5,814	5.88	10.00	17.00	
Midwest	1,840	5.28	8.82	14.30	
West	2,889	5.00	8.88	15.58	
Missing	3	6.00	9.00	21.00	
Urbanicity					<.001
Urban	9,751	5.40	9.50	16.00	
Suburban	565	6.00	10.63	17.00	
Rural	638	5.17	9.84	16.00	
Wilderness	108	5.27	12.00	19.02	
Missing	320	5.83	10.21	16.93	

*Filtered to remove times <0 minutes and >180 minutes.

less frequent in rural and wilderness settings, it is notable that even in wilderness settings, more than three-quarters of EMS activations for children received ALS responses. This is reassuring as BLS personnel are unable to administer antiepileptic medications, and at the time of an EMS call for seizure it is unknown whether the seizure will self-resolve, continue, or recur. As expected, seizure abortive medications were administered to a relatively small fraction (~9%) of children receiving an ALS response for seizures, consistent with previously reported rates of active pediatric seizures in the prehospital setting.[14] Despite the relatively small proportion of seizures that receive medications, those that do not self-resolve quickly may progress to result in significant morbidity and mortality without intervention.[3-6]

Midazolam was the most commonly administered medication across all regions and urbanicities, possibly due to the ability to deliver it by many routes and its heat-stability relative to other benzodiazepines.[15] While there was modest variation in median times from dispatch to medication administration based on age, region, and urbanicity, median times across locations were beyond typical seizure durations for which abortive antiepileptic medications are considered optimal.[5] The times to medication administration were not unexpected given that they include response time to the scene, time to access the patient, and initial evaluation. Similarly, there was modest variation in median times from EMS arrival on scene to medication administration based on age, region, and urbanicity. The median time of 9.63 min for all patients may be an opportunity for further research into causes of possible medication administration delays.

Prior data on ALS response as well as the receipt and timing of seizure medication administration in the prehospital setting has been limited due to the lack of national data-aggregation efforts. However, smaller scale studies noted a similar median time to intervention. This includes one study of three urban EMS systems that reported

Table 7. Regression model: independent associations with timing to medication administration.

Effect	Estimated Mean Difference	Standard Error	*P*-values
Age (years)	0.16	0.02	<.001
Gender (male referent)	−0.03	0.23	0.14
Urbanicity:			
- Wilderness vs urban (referent)	6.84	1.17	<.001
- Rural vs urban (referent)	2.20	0.50	<.001
- Suburban vs urban (referent)	2.43	0.52	<.001

a 14-min median time to intervention after arrival on scene.[14] Another study of nine children's hospitals found a 30-minute median time from onset of seizures to administration of antiepileptic drugs in the outpatient setting.[8] Our data provides a larger perspective of seizure management nationally and reflects both the time to reach a patient after dispatch and the time EMS arrives on scene to medication administration. Given that the time to medication administration exceeds the optimal time at which medication is expected to have effect, our data strongly suggests the need for abortive medications to be readily available in the homes of children with seizure disorders, including newer products such as intranasal midazolam and diazepam. Prior studies have demonstrated reduction in morbidity and costs associated with hospital visits when seizure abortive medication is available for at-home administration.[16]

The high frequency of midazolam use across patient demographics and geography suggests adoption of best clinical practice and recommendations.[9] Among benzodiazepines, midazolam can be administered by multiple routes, including intramuscular and intranasal, which bypasses the potentially time-intensive step of obtaining peripheral intravenous (IV) access. In 2012, publication of the results of the Rapid Anticonvulsant Medication Prior to Arrival Trial (RAMPART), a large, multicenter, randomized clinical trial of prehospital patients with seizures, demonstrated that intramuscular midazolam was superior to IV lorazepam at terminating convulsions prior to arrival to the emergency department.[17,18] A national study using NEMSIS demonstrated substantial increase in midazolam use after the publication of RAMPART.[19] Another study of three EMS agencies in an urban setting similarly found high rates of midazolam use.[14] Our data did note that urban settings had the highest proportionate use of midazolam, which could reflect the contributions of medical directors with board-certification in EMS at urban academic institutions or more practical issues related to availability or storage.

The development and growth of NEMSIS allows for a robust assessment of national prehospital data. In this study, NEMSIS contributed to our understanding of national EMS responses for higher acuity pediatric complaints based on patient geography and demographics. The American Academy of Pediatrics and other professional organizations have recommended that EMS systems and agencies contribute to the database.[20] As NEMSIS expands and the data available becomes more granular, other studies regarding resource use and the quality of care will become increasingly possible to better understand trends and opportunities for improvement in pediatric prehospital care. For example, we were unable to analyze insurance status or race and ethnicity due to large amounts of missing data. As EMS documentation advances and NEMSIS becomes more complete, future research will be able to determine equity of access to high level pediatric care.

LIMITATIONS

Our study has limitations inherent to retrospective large database studies. Identification of the target population can be challenging, as the accuracy of documentation collected and catalogued within NEMSIS could not be verified. However, by capturing both reason for dispatch and EMS responder impression, we were able to best estimate the degree to which our target population may have represented those who had seizures. Although it was impossible to identify those who actually seized during EMS care or the etiology of their seizure, our data is consistent with smaller research studies on this topic. Regardless of etiology of the seizure, prior data suggests that seizures of longer duration are harder to abort and are associated with higher morbidity and mortality with recommendations to administer abortive medications within five minutes.

The lack of standardization across EMS electronic health record systems and documentation affects data consistency. We attempted to overcome the potential variation in identifying children with seizures by using an inclusive list of ICD-10-CM codes. However, different agencies may have used different codes when mapping their locally collected data into the EMS database. Additionally, we recognize that the database did not allow us to ascertain whether children who received an antiepileptic medication required one and whether children who did not receive an antiepileptic medication did not require one. However, the similar proportion of children receiving abortive therapy across geographic locations is reassuring.

Finally, an important potential limitation is that ALS and BLS may be defined differently across EMS agencies and geography such that truncating multiple categories of EMS professionals into ALS and BLS may not reflect the

differences in capabilities across responders (e.g. ability to provide medications) across settings. Further, from our data, we were unable to differentiate between patients served in a two-tiered EMS system and those who were not.

CONCLUSION

The majority of pediatric patients across the US received an Advanced Life Support response for seizures; however, those in rural or wilderness settings were somewhat less likely to receive an ALS response. Although medications are infrequently administered, the majority of those who were administered a medication received midazolam, which is the current standard of care. Further research is required to determine the proportion of children who are continuing to seize upon EMS arrival and would most benefit from immediate and appropriate treatment.

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Contribution of 15 Years (2007–2022) of Indo-US Training Partnerships to the Emergency Physician Workforce Capacity in India

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Background: Indo-US Masters in Emergency Medicine (MEM) certification courses are rigorous three-year emergency medicine (EM) training courses that operate as a partnership between affiliate hospitals or universities in the United States with established EM training programs and local partner sites in India. Throughout their 15 years of operation, these global training partnerships have contributed to the EM workforce in India. Our objective in this study was to describe Indo-US MEM program graduates, their work environments, and their contribution to the growth of academic EM and to the coronavirus disease 2019 (COVID-19) response.

Methods: An electronic survey was created by US and Indian MEM course stakeholders and distributed to 714 US-affiliated MEM program graduates. The survey questions investigated where graduates were working, their work environments and involvement in teaching and research, and their involvement in the COVID-19 response. We consolidated the results into three domains: work environment and clinical contribution; academic contribution; and contribution to the COVID-19 response.

Results: The survey response rate was 46.9% (335 responses). Most graduates reported working within India (210, 62.7%) and in an emergency department (ED) setting (304, 91.0%). The most common reason for practicing outside of India was difficulty with formal MEM certificate recognition within India (97, 79.5%). Over half of graduates reported dedicating over 25% of their work hours to teaching others about EM (223, 66.6%), about half reported presenting research projects at conferences on the regional, national, or international level (168, 50.5%), and almost all graduates were engaged in treating COVID-19 patients during the pandemic (333, 99.4%). Most graduates agreed or strongly agreed that they were satisfied with their overall MEM training (296, 88.4%) and confident in their ability to practice EM (306, 91.6%).

Conclusion: Indo-US MEM graduates have made a notable contribution to EM in India through clinical service delivery, teaching, and research, even more essential in the context of the COVID-19 pandemic. The roles of these graduates should be acknowledged and can contribute further to expand EM specialty and systems development across India. [West J Emerg Med. 2023;24(4)814–822.]

INTRODUCTION

Emergency medicine (EM) in India has reached many developmental milestones since its formal recognition in 2009 by the Medical Council of India. Postgraduate EM training programs have grown in number in recent years; however, the number of available training positions remains vastly inadequate for a country of 1.32 billion people.[1,2] Road traffic injuries and non-communicable diseases, such as ischemic heart disease and stroke, are amongst the top causes of morbidity and mortality across India with a growing prevalence across all states.[1,2] These conditions require time-sensitive interventions and diagnostics that emergency physicians (EP) are trained to recognize and provide.

Accreditation of EM training programs in India is overseen by the National Medical Commission (NMC, formerly the Medical Council of India) and the National Board of Examinations (NBE).[3–6] As of 2018, the Medical Council of India had fully approved only 73 training positions for EM within government-funded public hospitals, offered in 29 of 460 medical colleges in India covering just eight states and two union territories. As of March 2022, these had increased to 187 training positions.[4] In 2014 the NBE, which oversees residency training in private hospitals, also recognized EM as a specialty and set out its EM curriculum and examination process. By 2018, the NBE was offering an additional 121 training positions, although 52 of these remained vacant as of July 2017.[7]

Even if all the training positions were filled, India has the capacity to train only 308 EPs annually. By comparison, the United States has 2,278 EM training seats per year, and 58,000 active board-certified EPs for a population less than one quarter the size of that of India.[8,9] The United Kingdom's (UK) publicly funded National Health Service has one EP for every 10,000 people. India would need about 132,000 EPs *today* to reach similar doctor-population ratios.[10] This gap in clinician ratios has been felt by hospitals keen to provide emergency and urgent care services in India. In response to the EM training gap, a wide array of EM educational programs, courses, and conferences have been developed in India over the last two decades.[3,10]

Similar partnerships to develop EM exist in other countries in the early stages of specialty development.[11] US-MEM programs operate as a partnership between affiliate hospitals or universities in the US that have established EM training programs and local partner sites in India.[10–13] The MEM programs are rigorous three-year programs that emulate the structure of US training programs, including supervised clinical experience in EM, clinical rotations throughout relevant specialties, didactics, trainee assessment, and examinations to measure competence.[14] Similar to many Western residency training programs, most Indo-US MEM courses follow a 36-month modular curriculum with required readings from EM texts (eg, *Tintinalli's Emergency Medicine*) and assigned questions from purchased question banks.[15]

Institutional faculty affiliates from the US visit India throughout the year to assist local faculty in bedside teaching, didactics, resident assessments, and exams.[15] Most course sites offer residents the opportunity to participate in a rotation at the partnering US institution, although most residents complete their MEM course entirely in India. Since the inception of the first MEM program in 2007, MEM programs have trained over 700 graduates throughout India. Given the duration of operation of these training programs, we sought to describe the contributions of Indo-US MEM graduates as part of the postgraduate EM training landscape in India.

We believe that understanding these Indo-US models is of particular importance and relevance now, both because of the vast, unmet clinician gap and the evolving political and regulatory landscape in India, which is edging towards more international university-partnership models of education and training. Of note, on 5 January 2023, the University Grants Commission unveiled a draft seeking public feedback on the proposal to facilitate entry and operation of foreign universities in India.[16] In this paper, we focus on describing details of 15 years (2007–2022) of Indo-US training

Population Health Research Capsule

What do we already know about this issue?
Emergency medicine training positions in India have increased but remain insufficient. Indo-US Masters in EM (MEM) programs build emergency physician capacity in India.

What was the research question?
How have Indo-US MEM graduates contributed to physician workforce capacity in India over the last 15 years?

What was the major finding of the study?
Most MEM graduates work within India (210, 62.7%) in an ED setting (304, 91.0%).

How does this improve population health?
Developing emergency physician workforce capacity will contribute to improved population health through clinical service delivery and EM specialty development.

partnerships and their impact on EP workforce capacity in India with respect to the graduates' work environments and their contribution to the growth of academic EM and more recent contribution to the coronavirus 2019 (COVID-19) response.

METHODS

An electronic survey was created and distributed to 714 US-affiliated Indian MEM program graduates. Survey questions were written by US institutional stakeholders involved in Indian MEM program development and operations, namely Northwell Health in New York and George Washington University (GW) in Washington, DC. Key program faculty members in India, all of whom are MEM alumni, were asked to review the survey questions and provide feedback during the survey development phase. Some changes were made based on these recommendations prior to its distribution. The survey was written in English, as a working proficiency in English is a requirement of MEM course admission. No identifying information was collected, and the project was deemed exempt by the Northwell Health Institutional Review Board.

The survey consisted of 32–40 items, dependent on the use of branching logic to create a flow of relevant questions. Response options were a combination of multiple-choice; a "check all that apply" click box; short-answer questions with free text; and questions with a five-point Likert scale. The purpose of the questions was to determine where graduates were working (inside or outside India), their work environments (clinical, non-clinical, research, within an emergency department [ED] vs another setting, etc), involvement in teaching and research, confidence in their EM practice, satisfaction with their MEM training, and involvement in the COVID-19 response. The survey instrument is included in Appendix A.

Survey recipients included only MEM programs affiliated with US institutions. Program directors were contacted to collect contact information for program graduates. The MEM training sites that we contacted include those that work with the following affiliates in the US: GW; Northwell Health; State University of New York (SUNY) Upstate (Syracuse, NY); and the University of Maryland (UMD) (Baltimore, MD). At the time of our project, the total number of MEM graduates for each site was as follows: 647 (GW); 46 (Northwell Health); 13 (SUNY Upstate); and 20 (UMD). Of the 726 MEM graduates, contact information was obtained for 714 graduates (98.3%). Surveys were distributed via email to all 714 MEM program graduates from December 2021–February 2022 with 2–3 reminder emails sent to increase response rates. Survey results were collected electronically with REDCap research software hosted at Northwell Health and consolidated into domains for analysis. REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies.

RESULTS

The total survey response rate was 46.9% (335 responses). The survey response rate for each institutional affiliate was as follows: GW, 46% (300 responses); Northwell Health 70% (32 responses); SUNY Upstate 15% (two responses); and UMD, 5% (one response). Results were categorized into three major domains. These domains included the clinical contribution to EM, academic contribution to EM, and involvement in the COVID-19 response. Key results are described below with more detailed results depicted in Tables 1–5. The responses to each question are expressed in the tables in order of decreasing prevalence. Demographic information is summarized in Table 1.

The majority of MEM graduates reported working within India (210, 62.7%) and within an ED work environment (304, 91.0%). The UK (54, 19.4%) and United Arab Emirates (17, 5.1%) were the most common locations for work outside India. The most common reason for choosing to practice outside India was due to difficulty with formal recognition of the MEM certificate within India (97, 79.5%), followed by differences in salary (71, 58.2%) and standard of living (58, 47.5%). Most graduates practicing outside India reported the decision to leave India was made after completing the MEM program (96, 80.0%). Graduates reported working mainly in the Delhi National Capital Region (NCR) (35, 16.8%), Maharashtra (28, 13.5%), and Kerala (31, 14.9%); however, graduates' practice locations were broadly located throughout India.

More than half of graduates reported dedicating over 25% of their work hours to teaching others about EM, with nurses (218, 66.5%), other physicians (191, 58.2%), paramedics (191, 58.2%), and community members (129, 39.3%) listed as common recipients of educational activities. About half of all graduates reported presenting research projects at academic conferences (168, 50.5%) and endorsed membership in national EM professional organizations, such as the Society for Emergency Medicine India (SEMI) and INDUS-EM (170, 50.7%). Almost all graduates were engaged in treating COVID-19 patients during the pandemic (333, 99.4%) with more than 70% of graduates dedicating over half of their work hours to COVID-19 patient care. Most graduates agreed or strongly agreed that they were satisfied with their overall MEM training (296, 88.4%), well prepared to work in the ED (311, 92.8%), and confident in their ability to practice EM (306, 91.6%).

Table 1. Demographics of survey participants.

(# of respondents, % of respondents)	
What year did you graduate from your MEM program?	
2020 (60, 17.9%)	
2019 (46, 13.7%)	2013 (13, 3.9%)
2018 (42, 12.5%)	2012 (7, 2.1%)
2017 (42, 12.5%)	2011 (5, 1.5%)
2016 (40, 11.9%)	2010 (3, 0.9%)
2015 (32, 9.6%)	2009 (0, 0.0%)
2021 (27, 8.1%)	2008 (0, 0.0%)
2014 (18, 5.4%)	2007 (0, 0.0%)
Which United States-affiliate is associated with your MEM program?	
George Washington University (300, 89.6%)	
Northwell Health (formerly North Shore – LIJ Health System) (32, 9.6%)	
State University of New York Upstate (2, 0.6%)	
University of Maryland (1, 0.3%)	
Within which hospital did you complete your MEM training?	
Kokilaben Dhirubhai Ambani Hospital (KDAH) (49, 14.6%)	
Peerless (48, 14.3%)	MAX Shalimar Bagh (11, 3.3%)
Aster MIMS Calicut (36, 10.7%)	Believer's Church (8, 2.4%)
Mission Hospital - Durgapur (32, 9.6%)	Aster CMI Bangalore (6, 1.8%)
MAX SAKET (25, 7.5%)	MAX Smart (6, 1.8%)
Moolchand (18, 5.4%)	Other (4, 1.2%)
Baby Memorial Hospital (16, 4.8%)	MAX Dehradun (3, 0.9%)
MAX PPG (14, 4.2%)	Global Hospital - Chennai (2, 0.6%)
Aster Medcity Kochi (14, 4.2%)	MAX Vaishali (2, 0.6%)
Meenakshi Mission Hospital & Research Center (12, 3.6%)	KIMS - Trivandrum (2, 0.6%)
AMRI - Bhubaneswar (12, 3.6%)	MAX Mohali (1, 0.3%)
Global Hospital - Bangalore (12, 3.6%)	DM Academy Wayanad (1, 0.3%)
	Apollo Glenn Eagles Hospital - Kolkata (1, 0.3%)

MEM, Masters in Emergency Medicine.

DISCUSSION

Data from the current study describes the contribution of Indo-US MEM graduates to EM specialty development in India over the last 15 years.

Work Environment and Clinical Contribution

The majority of graduates reported that they continue to practice within India (62.7%) and in an ED setting (91%). Of those that did leave, the main reasons cited include lack of recognition of their MEM certificate in India (79.5%), better salaries (58.2%), and greater opportunities for professional growth (56.6%). Since their inception in 2007, Indo-US MEM courses have trained over 700 EPs, and a majority are still working in EDs in India. The number of postgraduate Diplomate of National Board (DNB) and MD seats offered in EM are still far fewer than those offered in other countries, such as the US or UK, despite India having a substantially larger population.[5,13,17] The MEM seats may continue to fill the gap in India's EM clinical workforce until DNB and MD seats in EM have significantly increased. Graduates of MEM programs working in India should be looked at as a resource for specialty development in India. Many serve in leadership roles in their hospitals and take part in educating medical students and future EPs.

Steps should be taken to recognize MEM graduates as EM specialists to improve retention of physicians who receive additional EM training after their MBBS [Bachelor of Medicine and Bachelor of Surgery, which is equivalent to MD degree in the US]. This may lead to more professional opportunities throughout the private and public sector, improved job security, and more competitive salaries.

Geographical Distribution of Skilled Emergency Workforce

Our data indicates that many graduates choose to work in more well-resourced urban areas, such as Delhi NCR, Kerala, and Maharashtra, a common trend seen across different types of healthcare workers throughout India.[18] These same states have doctor densities above the national average of 79.7 doctors per 100,000 population.[18] While this is not surprising, it is also noteworthy that 10.6% of MEM graduates are practicing in lower-income-per-capita states, such as Uttar Pradesh (eight, 3.8%), Jharkhand (seven,

Table 2. Work environment and clinical contribution of Masters in Emergency Medicine graduates.

(# of respondents, % of respondents)	
Where do graduates work?	
Within India (210, 62.7%)	Qatar (8, 2.4%)
United Kingdom (65, 19.4%)	Kuwait (5, 1.5%)
United Arab Emirates (17, 5.1%)	Bahrain (2, 0.6%)
Other (10, 3.0%)	Australia (1, 0.3%)
United States (9, 2.7%)	New Zealand (0, 0.0%)
Saudi Arabia (8, 2.4%)	
Within which Indian states are graduates working?	
Delhi NCR (35, 16.8%)	Uttarakhand (3, 1.4%)
Kerala (31, 14.9%)	Assam (3, 1.4%)
Maharashtra (28, 13.5%)	Chhattisgarh (3, 1.4%)
West Bengal (27, 13.0%)	Nagaland (1, 0.5%)
Karnataka (12, 5.8%)	Meghalaya (1, 0.5%)
Odisha (12, 5.8%)	Manipur (1, 0.5%)
Tamil Nadu (10, 4.8%)	Telangana (1, 0.5%)
Uttar Pradesh (8, 3.8%)	Madhya Pradesh (1, 0.5%)
Jharkhand (7, 3.4%)	Arunachal Pradesh (0, 0.0%)
Bihar (6, 2.9%)	Goa (0, 0.0%)
Andhra Pradesh (6, 2.9%)	Himachal Pradesh (0, 0.0%)
Gujarat (4, 1.9%)	Mizoram (0, 0.0%)
Haryana (4, 1.9%)	Sikkim (0, 0.0%)
Punjab (4, 1.9%)	Tripura (0, 0.0%)
Rajasthan (3, 1.4%)	
Why are some graduates practicing outside of India?	When did graduates who are practicing outside of India decide to leave India?
Difficulties with formal recognition of your MEM certificate in India (97, 79.5%)	After finishing the MEM program (96, 80.0%)
Difference in salary (71, 58.2%)	While I was enrolled in the MEM program (14, 11.7%)
Difference in standard of living (58, 47.5%)	Before enrolling in the MEM program (10, 8.3%)
Working environment in India (46, 37.7%)	
Lack of job opportunities in EM in India (15, 12.3%)	
Relocate to be near family (5, 4.1%)	
Opportunity for professional growth (69, 56.6%)	
Other (4, 3.3%)	

MEM, Masters in Emergency Medicine, *NCR*, National Capital Region.

Table 3. Academic contribution of Masters in Emergency Medicine graduates.

(# of respondents, % of respondents)	
How much time do graduates report teaching emergency medicine to others?	What types of education and training are graduates engaged in?
26–50% (129, 38.5%)	Education and training for nurses (218, 66.5%)
0–25% (112, 33.4%)	Education and training for other physicians (191, 58.2%)
51–75% (83, 24.8%)	Education and training for paramedics (191, 58.2%)
76–100% (11, 3.3%)	Community/layperson education (129, 39.3%)
Have graduates attended faculty development or teaching courses?	Prehospital care development (113, 34.5%)
No (203, 60.6%)	Education and training for ayurvedic healers (34, 10.4%)
Yes (132, 39.4%)	Other (18, 5.5%)
Have graduates presented research projects or abstracts at a regional, national, or international conference or meeting?	Have graduates published an abstract, textbook chapter, or research article in a peer-reviewed medical journal?
Yes (168, 50.5%)	No (215, 64.2%)
No (165, 49.5%)	Yes (120, 35.8%)
Are graduates members of emergency medicine professional organizations within India?	Have graduates been a part of organizing an emergency medicine conference (national or international)?
(eg, SEMI, INDUS)?	No (209, 62.4%)
Yes (170, 50.7%)	Yes (126, 37.6%)
No (165, 49.3%)	
Have graduates attended or completed training in diversity and inclusion or health equity?	
No (227, 68.0%)	
Yes (107, 32.0%)	

MEM, Masters in Emergency Medicine; *SEMI,* Society of Emergency Medicine India.

3.4%), Bihar (six, 2.9%), and Madhya Pradesh (one, 0.5%). These states have some of the lowest physician densities with Bihar state being one of the lowest at 52.6 physicians per 100,000 population.[9] Lower-income-per-capita states in India have been transitioning, albeit at a slower rate than the wealthier states, towards a predominant non-communicable disease burden, similar to the patterns of disease seen around the world.[19] Since 2000, lower income states have attributed more than 50% of their total deaths to non-communicable diseases.[1] This is relevant to EM workforce distribution as the acute management of non-communicable disease complications, such as myocardial infarctions, strokes, and diabetic emergencies, is an area of EM expertise. Although MEM graduate numbers from the current study in low-income states are small, their contribution is notable in the context of low specialist-physician densities and poor funding. To highlight this concept, we created geographical heat maps of India describing the locations of active US-MEM programs (Figure 1A) and the locations

Table 4. Involvement in the COVID-19 response.

(# of respondents, % of respondents)	
Did graduates treat COVID-19 patients during the COVID-19 pandemic? Yes (333, 99.4%) No (2, 0.6%)	How much time did graduates report spending caring for COVID-19 patients during the pandemic? 76–100% (131, 39.1%) 51–75% (114, 34.0%) 26–50% (76, 22.7%) 0–25% (14, 4.2%)
Did graduates participate in COVID-19 response planning? Yes, within my department (i.e., emergency department, ICU, etc) (178, 53.1%) Yes, within my hospital (105, 31.3%) No (30, 9.0%) Yes, within my city or region (12, 3.6%) Yes, within my state (10, 3.0%)	

MEM, Masters in Emergency Medicine; *ICU*, intensive care unit.

Table 5. Satisfaction and confidence in Masters in Emergency Medicine training.

(# of respondents, % of respondents)	
My MEM training has made me confident in my ability to practice emergency medicine. Strongly agree (264, 79.0%) Agree (42, 12.6%) Neutral (9, 2.7%) Disagree (3, 0.9%) Strongly disagree (16, 4.8%)	My MEM training has prepared me well for working in the emergency department. Strongly agree (267, 79.7%) Agree (44, 13.1%) Neutral (5, 1.5%) Disagree (3, 0.9%) Strongly disagree (16, 4.8%)
I am satisfied overall with my MEM training. Strongly agree (218, 65.1%) Agree (78, 23.3%) Neutral (12, 3.6%) Disagree (9, 2.7%) Strongly disagree (18, 5.4%)	

MEM, Masters in Emergency Medicine.

of working US MEM graduates (Figure 1B) using a web-enabled heat geo-mapping tool.[20] A heat map of India demonstrating differences in disease burden as all-cause disability-adjusted life years (DALYs) [years of life lost due to premature mortality] (Figure 1C) was created using the Global Burden of Disease India Compare tool from the Indian Council of Medical Research, Public Health Foundation of India, and Institute for Health Metrics and Evaluation.[21]

Locations of active training programs (Figure 1A) and states where graduates choose to work (Figure 1B) overlap with Indian states with mid-range to high disease burdens (Figure 1C) as expressed by states with light blue-white and maroon colors. Some examples in Figure 1C are Uttar Pradesh, Bihar, Maharashtra, and West Bengal. Although the high disease burden of these states may in part be due to these being some of the most populous states of India, the high DALYs of these locations cannot be denied. Many of these states also house US-affiliated MEM programs to promote the clinical and academic development of EM.

In addition to the need to grow EP training opportunities, emigration of skilled physicians from India is another barrier to creating and maintaining a robust workforce. We found that 37.3% of MEM graduates report practicing medicine outside India after graduation. High-income countries, such as the UK, Canada, the US, Gulf countries, and Australia, have historically functioned as common emigration sites for trained medical specialists from India.[22,23] The Organization for Economic Cooperation and Development estimated that over 90,000 physicians who trained in India now work outside India with the US and UK as the most common receiving countries.[22] This migration of MEM graduates is not unique to EM, to this partnership program, or to India. The net migration of healthcare workers from low- and middle-income countries to higher income countries is a cause for growing concern globally, resulting in a few articles on a more managed form of circular migration.[24,25] This consideration could prompt action in higher recognition of MEM training and the need for more opportunities for professional growth.

Academic Contributions

Many graduates report involvement in academic teaching and research activities. While more than half of graduates cite involvement in the education and training of other physicians, nurses, paramedics, laypeople, and ayurvedic healers are also taught by MEM graduates. This illustrates the broad reach across disciplines and fields by which graduate-led education can occur. It also highlights an important concept in global EM capacity-building as the training of one EP can impact the knowledge and experience of multiple other members of the healthcare team and surrounding community. Graduates imparting their EM knowledge to others reaches far beyond their contribution to the country's specialized clinical workforce; it expands the competency and specialized clinical knowledge of the hospital-based healthcare team, nurses, prehospital personnel, and community members. Education may also empower others to continue to grow their knowledge and participate in other EM-based initiatives and training.

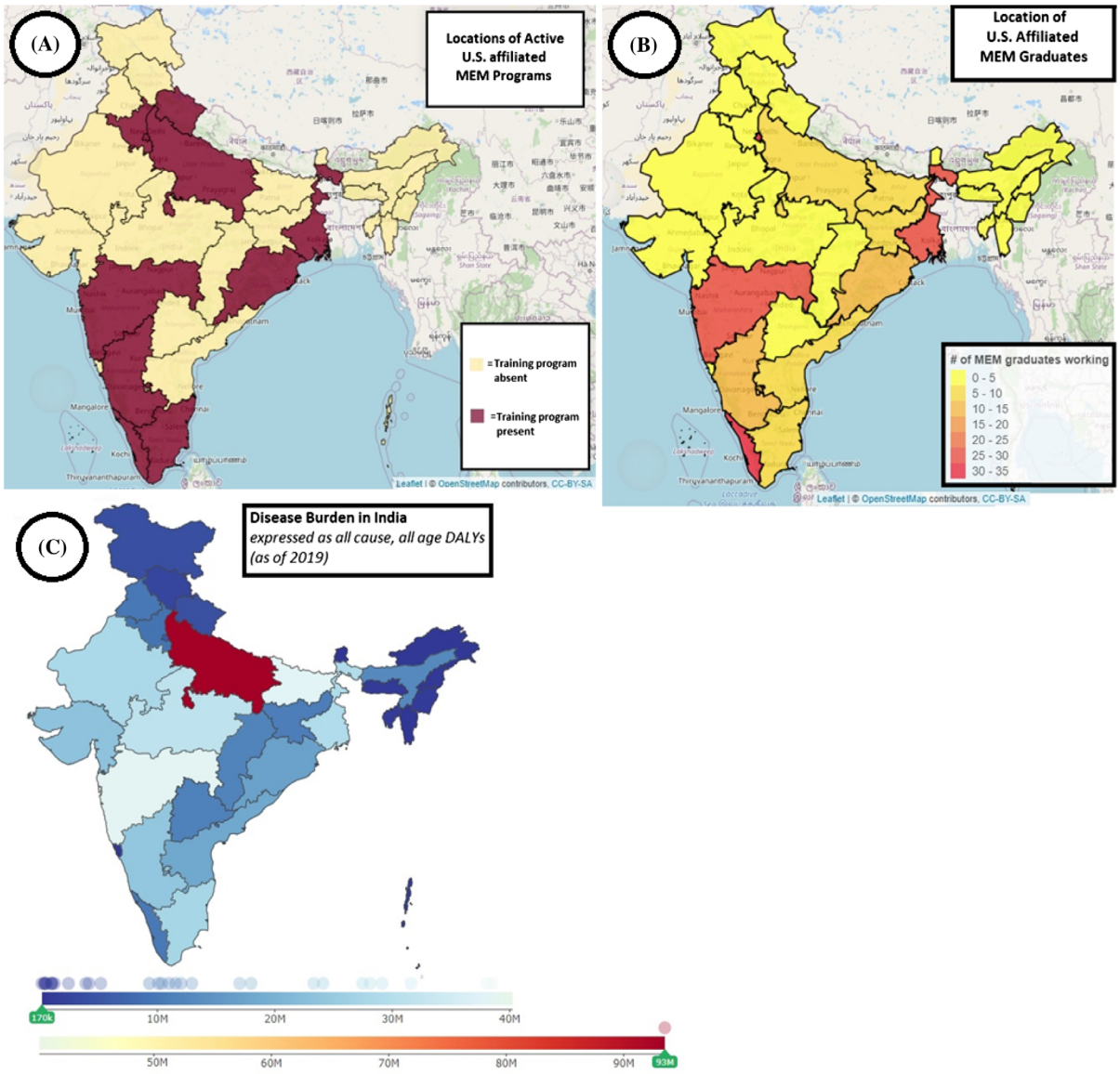

Figure 1. Geographical heat maps of India depicting the locations of active U. S. Masters in Emergency Medicine (US-MEM) (1A), the locations of US-MEM graduates (1B), and differences in disease burden as all-cause disability-adjusted life years (1C) depicted using the GBD India Compare tool from the Indian Council of Medical Research.

Other academic pursuits reported by graduates include presenting research abstracts or projects at conferences, membership in national EM organizations, and publishing abstracts, textbook chapters, or research articles. Publishing research and educational materials creates concrete deliverables that can enhance the knowledge of others. Publications can be used to support context-specific EM policies, such as new emergency medical services protocols, and they can assist in local advocacy. Publication of scholarly work also connects India to a global academic community and establishes the role of MEM graduates as an emerging expert resource in the field of EM.

Academic EM organizations in India, such as SEMI, INDUS-EM, and the Academic College of Emergency Experts in India, should focus on expanding opportunities for professional growth. Offering more courses on professional development, expanding teaching and research skills, and increasing the number of educational conferences and professional networking events are some actions that could help create an environment where greater professional growth is possible.

Contribution to COVID-19 Response

The COVID-19 pandemic devastated many health systems globally. While the availability of vaccinations and enforcement of basic public health precautions are crucially important in reducing morbidity and mortality, having a well-equipped EM workforce on the front line is another

important aspect of pandemic management and planning. Of the US-affiliated MEM graduates who participated in this study, 99.4% reported being involved in caring for COVID-19 patients during the pandemic. Almost 40% reported that 76-100% of their work time was spent caring for COVID-19 patients. More than half of graduates were involved in higher level COVID-19 response planning within their clinical department or hospital. The importance of these contributions cannot be understated, particularly considering the devastating impact of the COVID-19 pandemic in India, and the contributions of MEM graduates to the COVID-19 response. Furthermore, our findings highlight the challenges faced by these EPs and exemplify the need for changes to be instituted around the formal recognition of US-affiliated MEM graduates to retain more EM-trained doctors in India.

LIMITATIONS

This descriptive study focused on the contributions of US-affiliated MEM training program graduates. Therefore, the data is not inclusive of all types of MEM programs in India. Alongside the US-affiliated MEM programs described in this study, other MEM programs have emerged frequently affiliated with local Indian professional societies. We opted to not include non-US affiliated MEM programs in our study. This was a choice we made during the development phase of our project as US-affiliated programs have a more comparable structure, design, and assessment of residents than non-US-affiliated MEM programs.

The survey response rate for this study was 46.9% and may not represent the majority of US- affiliated MEM graduates. The majority of survey respondents also reported graduating within the last five years; thus, older graduates who may be working in other geographic or clinical settings may be under-represented. Nevertheless, our results report the feedback of almost half of all graduates. Given the survey format, this study may have been subject to selection bias, as residents who had a more negative or more positive experience with their MEM education may have felt more or less compelled to complete the survey. The survey was designed and distributed by key US institutional stakeholders in MEM programs, and although no identifying information was collected from respondents, this may have led to bias in the responses. The majority of respondents came from the GW-affiliated MEM programs. This was expected as GW-affiliated MEM programs possess the majority of the Indo-US program sites and seats compared to other US institutions. As a result, this study may overly represent these graduates. Graduates from Northwell Health-affiliated programs had the highest survey response rate compared to other programs, although they only contributed to 9.6% of all survey respondents. Contact information was unavailable for 22 of the 736 (1.7%) MEM graduates; thus, they were not included in the study. This small percentage is likely negligible, and we do not believe it significantly influenced the findings of our study.

CONCLUSION

The results of this report describe the contributions of US-affiliated Masters in Emergency Medicine graduates on EM specialty development in India. Our survey-based report highlights the important role of MEM graduates over the last 15 years. The role of these graduates should be considered as a means to expedite EM specialty development, systems development, and clinical care across India. As India works to develop more formal training pathways, MEM graduates will continue to contribute to the delivery of patient care and the growth of the emergency care system.

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