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Western Journal of Emergency Medicine:

Integrating Emergency Care with Population Health

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Expert Commentary

378 **Ending Nuclear Weapons, Before They End Us**
K Abbasi, P Ali, V Barbour, M Birch, I Blum, P Doherty, A Haines, I Helfand, R Horton, K Juva, JF Lapena Jr, R Mash, O Mironova, A Mitra, C Monteiro, EN Naumova, D Onazi, T Ruff, P Sahni, J Tumwine, C Umaña, P Yonga, C Zielinski

Health Equity

381 **Social Determinants of Health and Health Literacy in Emergency Patients with Diabetic Ketoacidosis**
DF Suarez, RM Schneider, M Girardi, G LaRossa, J Yeary, T Kaser, R Ancona, P Cruz Bravo, RT Griffey

387 **Emergency Department Comprehensive Social Risk Screening and Resource Referral Program**
K Stillman, A Dahut, A Caudill, K Hren, K Green, M Lauzon, S Jackman, A Lawton, T Chopra, J Geiderman, S Torbati

396 **Feasibility of an Emergency Department-based Food Insecurity Screening and Referral Program**
V Cisneros, IDC Olliffe, MS Esteban, J Bui, A Takallou, S Lotfipour, B Chakravarthy

406 **Exposure to Community Violence and Adverse Childhood Experiences in the Emergency Department**
L Cachola, Y Guevara, S Ansari

413 **Legislating Fear: How Immigration Status Mandates Threaten Public Health**
P Sangeyup Yun, L Williams, J Blanchard

415 **Evaluation of Disparities in Emergency Department Admission and Wait Times for Non-English Preferred Patients**
J Wong-Castillo, D Berger, JC Montoy, R Alwan

425 **Validation of a Methodology to Investigate Care Inequities for Transgender Patients**
K Engstrom, F Bellolio, MM Jeffrey, SC Sutherland, KP Carpenter, G Jackson, K Cole, V Chedid, CJ Davidge-Pitts, KL Sungga, C Gonzalez, CS Brown

Contents continued on page iii

CALIFORNIA ACEP

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

Table of Contents

431 **A Systematic Review of Guidelines for Emergency Department Care of Sexual Minorities: Implementable Actions to Improve Care**
MI Kruse, S Karabelas-Pittman, G Northrop, J Stuart, S Upadhye, BL Bigham

441 **Moving Beyond "Check A Box": Shifting Physician Perceptions and Culture with an Antiracism and Equity Curriculum**
H Barber Doucet, T Lin, T Wilson

452 **Images in Black and White: Disparities in Utilization of Computed Tomography and Ultrasound for Older Adults with Abdominal Pain**
IC Unachukwu, MN Adjei-Poku, OC Sailors, R Gonzales, E South, Z Meisel, RR Kelz, AR Cappola, AB Friedman

458 **Emergency Medical Service Responders' Perspectives on Transgender, Intersexual, and Non-Binary Patients in Germany**
T Brod, K Afshar, C Schroeder, C Stoetzer, S Stiel

Ultrasound

465 **Simulation-based Training Changes Attitudes of Emergency Physicians Toward Transesophageal Echocardiography**
M Danta, AY Nguyen-Phuoc, S Gupta, A Sakhpara, J Kurbedin, E Khordipour,A. Likourezos, L Haines, A Aghera, J Drapkin, J Lin

469 **Trends in Studies on Transesophageal Echocardiography in Emergency Medicine: A Scoping Review**
B-Y Tseng, C-J Yang,J-T Sun, YT Liu, K Yadav, Y-L Hseih, S-E Chu, C-W Lee, Y-K Lee, T-Y Tsai

478 **Evaluation of Point-of-Care Ultrasound Use in Emergency Medicine Residents: An Observational Study**
M Fareri, M VandeHei, B Schnapp, C Jewell, MR Lasarev, R Alexandridis, D Resop, S Damewood, HI Kuttab

486 **Patient Sociodemographic Factors Are Associated with Receiving Point-of-care Ultrasound in the Emergency Department**
BM Wubben, D Spolsdoff, KK Harland, M Del Rios

491 **Non-invasive Monitor of Effective Chest Compressions with Carotid and Femoral Artery Ultrasound in the Emergency Department**
F Yang, H Zou, J Gan, X Zhao, X Tu, C Jiang, J Xia

Emergency Department Operations

500 **Emergency Physician Assessment of Productivity and Supervision Practices**
K Schreyer, D Kuhn, V Norton

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Western Journal **of** *Emergency Medicine*:
Integrating Emergency Care with Population Health
Indexed in **MEDLINE, PubMed, and Clarivate Web of Science, Science Citation Index Expanded**

Table of Contents *continued*

507 **Evaluating the Implementation of a "COVID-19 Test" Chief Concern in the Emergency Department**
C Michels, DJ Hekman, RJ Schwei, RE Tsuchida, J Gauger, I Hurst, J Glazer, J Brink, C Barclay-Buchanan, MN Shah, AG Hamedani, M Pulia

513 **Risk Factors for Hospital Admissions Among Emergency Department Patients: From Triage to Admission**
J Koh, OH Choon, S Lim

523 **Case Study of How Alleviating "Pebbles in the Shoe" Improves Operations in the Emergency Department**
D Savitzky, Y Chavda, S Datta, A Reens, E Conklin, M Scott, C Caspers

Emergency Medical Services

528 **Epidemiology of 911 Calls for Opioid Overdose in Nogales, Arizona**
M Glenn, D Stratton, K Primeau, A Rice

535 **Development and Evaluation of a Novel Curriculum for Whole Blood Transfusion by Paramedics in the Prehospital Environment**
E Garfinkel, R May, A Margolis, E Cohn, S Colburn, T Grawey, M Levy

541 **Variations in Out-of-Hospital Cardiac Arrest Resuscitation Performance and Outcomes in Ohio**
MMJ Nassal, HE Wang, JR Powell, JL Benoit, AR Panchal

549 **Dispatch Decisions and Emergency Medical Services Response in the Prehospital Care of Status Epilepticus**
RP McInnis, AJ Wood, CL Shay, AA Haggart, RP Crowe, EL Guterman

Medical Education

556 **Creation and Implementation of an EMS Elective for Final- Year Medical Students: A 5-year Evaluation**
E Peralta, C Evers, T Gonell, M Hodges, D Cohen, LM Maloney

564 **Harnessing Residents' Practice-based Inquiries to Enhance Research Literacy: The Thoughtful Reading of Evidence into Clinical Settings (T-RECS) Initiative**
E Worley, EH Suh, L Abrukim, M DeFilippo, JJ Kamler, M Polavarapu, PC Wyer

569 **Descriptive Analysis of Resources Used to Learn About Residency Programs Since Transition to Virtual Interviews**
R Bounds, J Priester, B Lewis, R King, S Lentz

573 **Emergency Medicine Residency Website Wellness Pages: A Content Analysis**
A Sappington, B Milman

Behvioral Health

573 **Effects of Emergency Department Training on Buprenorphine Prescribing and Opioid Use Disorder-Associated ED Revisits: Retrospective Cohort Study**
A Torchiano, B Roberts, R Haroz, C Milburn, K Baston, J Heil, V Ganetsky, M Salzman

588 **"Oh, Another Overdose, for the Love of Pete": First Responder Perspectives on Overdose Response Technology**
W Rioux, S Jones, SM Ghosh

Western Journal **of** *Emergency Medicine*:
Integrating Emergency Care with Population Health
Indexed in **MEDLINE, PubMed, and Clarivate Web of Science, Science Citation Index Expanded**

Table of Contents *continued*

Infectious Disease

600 **Randomized Controlled Trial of Atorvastatin in Acute Influenza in the Emergency Department**
M CHase, MN Cocchi, AV Grossestreuer, X Liu, J Vine, AL Moskowitz, MW Donnino

609 **Age-stratified Association Between Plasma Adiponectin Levels and Mortality in Septic Patients**
H Wang, M Ma, J Dong, J Duan

617 **Developing Machine-Learning Models to Predict Bacteremia in Febrile Adults Presenting to the Emergency Department: A Retrospective Cohort Study from a Large Center**
C-M Fu, I Ngo, P Sheung Lau, Y Ivanchuk, F-Y Chou, C-H Wang, C-Y Lin, C-L Tsai, S-Y Chen, T-C Lu, H-Y Wei

Injury Prevention

627 **A Review of Sports-Related, Life-Threatening Injuries Presenting to Emergency Departments, 2009-18**
A Ibiebele, R Mannix, W Meehan

632 **National Study of Firearm Presence and Storage Practices in Homes of Rural Adolescents**
B Linden, M Sinik, K Wetjen, P Hoogerwerf, J Liao, C Jennissen

Toxicology

643 **Incidence and Characteristics of Alcohol-Based Hand Sanitizer Ingestion in Florida before and during the Coronavirus Pandemic**
J Arnold, A Athanasios, D Nguyen, R Mhaskar

650 **Comparing Prehospital Time Among Pediatric Poisoning Patients in Rural and Urban Settings**
AT Phillips, M Denning, E Long-Mills, D Tumin, J Parker-Cote, K Bryant

Climate Change

657 **Predictive Factors and Nomogram for 30-Day Mortality in Heatstroke Patients: A Retrospective Cohort Study**
A Li, Y Zhang, X Zhang, Z Duan, Y Chen, X Jiang, W Deng

667 **Association of Heat Index and Patient Presentation Rate at a Stadium**
J Wolin, D Wolf, J Su, E Quinn, D Eng, H Ali, D Lobel, M Friedman

Critical Care

674 **Emergency Department Blood Pressure Management in Type B Aortic Dissection: An Analysis with Machine Learning**
N Chen, JV Downing, J Epstein, S Mudd, A Chan, S Kuppireddy, R Tehrani, I Vashee, E Hart, E Esposito, R Chasm, QK Tran

685 **Ultrasound-guided Emergency Pericardiocentesis Simulation on Human Cadavers: A Scoping Review**
L Ünlü, F Margenfeld, A Zendehdel, JA Griese, A Poilliot, M Müller-Gerbl, CH Nickel, M Dedic

Neurology

692 **Diagnostic Delays Are Common, and Classic Presentations Are Rare in Spinal Epidural Abscess**
EJ Durant, S Copos, BF Folck, M Anderson, MS Ghiya, ER Hofmann, P Vuong, J Shan, M Kene

700 **Practical Status and Social Background of Current Mobile Stroke Units Worldwide: A Survey and Investigation**
M Hiroki, M Kohno, Y Kohno, M Misawa

Western Journal **of** *Emergency Medicine*:
Integrating Emergency Care with Population Health
Indexed in **MEDLINE, PubMed, and Clarivate Web of Science, Science Citation Index Expanded**

Table of Contents *continued*

Emergency Department Administration

712 **Civil Monetary Penalties from Violations of the Emergency Medical Treatment and Labor Act for Patients Arriving or Leaving with Law Enforcement**
A Ahmed, Z Reichert, G Santillanes, C Toomer, S Tyler-Mills, N Vontela, J Hsia, S Axeen, S Kashani, J Nakagawa, M Menchine, S Terp

Clinical Practice

720 **Validating an Electronic Health Record Algorithm for Diabetes Screening Eligibility in the Emergency Department**
MH Smart, JY Lin, BT Layden, Y Eisenberg, KK Danielson, R Pobee, C Tang, B Rydzon, A Bairavi Maheswaran, AS Pickard, LK Sharp, A King

Cardiology

729 **Coronary Artery Bypass Grafting Is Rarely Done in the Acute Care of ST-elevation Myocardial Infarction Patients Treated by Emergency Medical Services**
J Toy, C Lauer, AH Kaji, JL Thomas, N Megowan, N Bosson, M Gausche-Hill, P Dhawan, RA Kloner, S Rasnake, W French, S Schlesinger

Clinical Operations

737 **Real-time Ultrasound-guided Lumbar Puncture: A Comparison of Two Techniques Using Simulation**
K Samsel, D Wasiak, E Situ-LaCasse, S Adhikari, J Acuña

Disaster Medicine

743 **Post-Concussion Syndrome Following Blast Injury: A Cross- Sectional Study of Beirut Blast Casualties**
H Anan, M Al Hariri, E Hitti, F Kobeissy, A Mufarrij

Trauma

751 **Field vs. Emergency Department Intubation: A Retrospective Review of Hospital Outcomes of Trauma Patients**
M Vorce, S Galwankar, J Shuck, A Agrawal

Women's Health

758 **Caught Unprepared: The Urgent Need for Reproductive Health Training in Emergency Medicine**
P Sangeyup Yun, M Saxena

Letters to the Editor

760 **Response to the Letter to the Editor Regarding "Bicarbonate and Serum Lab Markers as Predictors of Mortality in the Trauma Patient"**
MM Talbott, D Jehle, K Paul

761 **Beyond Efficiency: Considering the Benefits of Residents in the Emergency Department**
RE Armstrong

762 **Beyond Efficiency: Considering the Benefits of Residents in the Emergency Department**
J Valentine, J Poulson

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CPCEM Clinical Practice & Cases

Ending Nuclear Weapons, Before They End Us

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This May, the World Health Assembly (WHA) will vote on re-establishing a mandate for the World Health Organization (WHO) to address the health consequences of nuclear weapons and war.[1] Health professionals and their associations should urge their governments to support such a mandate and support the new UN comprehensive study on the effects of nuclear war.

The first atomic bomb exploded in the New Mexico desert 80 years ago, in July 1945. Three weeks later, two relatively small (by today's standards), tactical-size nuclear weapons unleashed a cataclysm of radioactive incineration on Hiroshima and Nagasaki. By the end of 1945, about 213,000 people were dead.[2] Tens of thousands more have died from late effects of the bombings.

Last December, Nihon Hidankyo, a movement that brings together atomic bomb survivors, was awarded the Nobel Peace Prize for its "efforts to achieve a world free of nuclear weapons and for demonstrating through witness testimony that nuclear weapons must never be used again".[3] For the Norwegian Nobel Committee, the award validated the most fundamental human right: the right to live. The Committee warned that the menace of nuclear weapons is now more urgent than ever before. In the words of Committee Chair Jørgen Watne Frydnes, "it is naive to believe our civilisation can survive a world order in which global security depends on nuclear weapons. The world is not meant to be a prison in which we await collective annihilation."[4] He noted that our survival depended on keeping intact the "nuclear taboo" (which stigmatises the use of nuclear weapons as morally unacceptable).[5]

The nuclear taboo gains strength from recognition of compelling evidence of the catastrophic humanitarian consequences of nuclear war, its severe global climatic and famine consequences, and the impossibility of any effective humanitarian response. This evidence contributed significantly to ending the Cold War nuclear arms race.[6,7]

While the numbers of nuclear weapons are down to 12,331 now, from their 1986 peak of 70,300,[8] this is still equivalent to 146,605 Hiroshima bombs,[9] and does not mean humanity is any safer.[10] Even a fraction of the current arsenal could decimate the biosphere in a severe mass extinction event. The global climate disruption caused by the smoke pouring from cities ignited by just 2% of the current arsenal could result in over two billion people starving.[11]

A worldwide nuclear arms race is underway. Deployed nuclear weapons are increasing again, and China, India, North Korea, Pakistan, Russia and UK are all enlarging their arsenals. An estimated 2,100 nuclear warheads in France, Russia, UK, US and, for the first time, also in China, are on high alert, ready for launch within minutes.[8] With disarmament in reverse, extensive nuclear modernisations underway, multiple arms control treaties abrogated without replacement, no disarmament negotiations in evidence, nuclear-armed Russia and Israel engaged in active wars involving repeated nuclear threats, Russia and the US deploying nuclear weapons to additional states, and widespread use of cyberwarfare, the risk of nuclear war is widely assessed to be greater than ever. This year the Doomsday Clock was moved the closest to midnight since the Clock's founding in 1947.[10]

Led by Ireland and New Zealand, in late 2024, the United Nations General Assembly (UNGA) voted overwhelmingly to establish a 21-member independent scientific panel to undertake a new comprehensive study on the effects of nuclear war,[12] with its final report due in 2027. Noting that "removing the threat of a nuclear war is the most acute and urgent task of the present day", the panel has been tasked with examining the physical effects and societal consequences of a nuclear war on a local, regional and planetary scale. It will examine the climatic, environmental and radiological effects of nuclear war, and their impact on public health, global socioeconomic systems, agriculture and ecosystems.

The resolution calls upon UN agencies, including WHO, to support the panel's work, including by "contributing expertise, commissioned studies, data and papers". All UN Member States are encouraged to provide relevant information, scientific data and analyses; facilitate and host panel meetings, including regional meetings; and make budgetary or in-kind contributions. Such an authoritative international assessment of evidence on the most acute existential threat to humankind and planetary health is long overdue. The last such report dates from 1989. It is shameful that France, UK and Russia opposed this resolution.[13]

In 1983 and 1987,[14] WHO convened an international committee of scientists and health experts to study the health effects of nuclear war. Its landmark, authoritative reports were influential and an excellent example of WHO fulfilling its constitutional mandate "to act as the directing and coordinating authority on international health work". In 1993, WHO produced an additional shorter report on the health and environmental effects of nuclear weapons, which included discussion of the production chain of nuclear weapons, including processing, testing and disposal.[15]

However, despite WHA having mandated WHO to report periodically on relevant developments, no further work was undertaken and in 2020 WHO's mandate on nuclear weapons and health lapsed.

The Marshall Islands, Samoa and Vanuatu, supported by seven co-sponsoring states and International Physicians for the Prevention of Nuclear War (IPPNW), are working to renew WHO's mandate. They are seeking wide support for a resolution on the health effects of nuclear weapons/war at this year's WHA in Geneva on 19-27 May.[1] WHO would then re-establish a programme of work on this most critical threat to health, and be able to lead strongly in providing the best health evidence to the UN panel.

Health professionals are well aware how crucial accurate and up-to-date evidence is to making good decisions. We and our organisations should support such a renewed mandate by urging our national WHA delegates to vote in support and commit the modest funds needed to re-establish WHO's work programme, especially now, as the organisation faces severe financial strain with the US decision to withdraw its membership.

Our joint editorial in 2023[16] on reducing the risks of nuclear war and the role of health professionals, published in over 150 health journals worldwide, urged three immediate steps by nuclear-armed states and their allies: adopt a "no first use" policy, take their nuclear weapons off hair-trigger alert, and pledge unequivocally that they will not use nuclear weapons in any current conflicts they are involved in. We also urged nuclear-armed states to work for a definitive end to the nuclear threat by urgently starting negotiations for a verifiable, timebound agreement to eliminate their nuclear arsenals, and called on all nations to join the Treaty on the Prohibition of Nuclear Weapons.[17]

It is an alarming failure of leadership that no progress has been made on these needed measures, nor on many other feasible steps away from the brink, acting on the obligation of all states to achieve nuclear disarmament. Nine states jeopardise all humanity and the biosphere by claiming an exclusive right to wield the most destructive and inhumane weapons ever created. The world desperately needs the leaders of these states to freeze their arsenals, end the modernisation and development of new, more dangerous nuclear weapons, and ensure that new technology such as artificial intelligence can never trigger the launch of nuclear weapons.

The UN scientific panel and a renewed mandate for WHO's work in this area can provide vital authoritative and up-to-date evidence for health and public education, evidence-based advocacy and policies, and the mobilised public concern needed to trigger decisive political leadership. This is a core health imperative for all of us.

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Social Determinants of Health and Health Literacy in Emergency Patients with Diabetic Ketoacidosis

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Introduction: Social determinants of health (SDoH) and health literacy have been demonstrated to significantly impact health outcomes. As part of a study of diabetic ketoacidosis (DKA) treatment from the emergency department (ED), we assessed the burden of SDoH and health literacy among patients with DKA to identify potentially modifiable risk factors in the development of DKA.

Methods: This was an exploratory, prospective, cross-sectional study of adult patients with DKA in a large urban academic ED from March 2023–March 2024. We administered the Centers for Medicare & Medicaid Services Accountable Health Communities Health-Related Social Needs Screening Tool (SNST) and the Brief Health Literacy Screen (BHLS).

Results: Of 126 identified ED patients with confirmed DKA, 57 completed the SNST and 72 completed the BHLS. Nearly all patients (56 patients, 98%) reported at least one unmet SDoH need, and 32 (56%) patients reported five or more. The most frequently reported SDoH needs were physical activity (77%), mental health (63%), financial strain (60%), substance use (54%), and food insecurity (51%). Seventy-two patients completed the BHLS, which demonstrated high levels of health literacy, with median responses ranging from 4-5 on a Likert scale with 5 corresponding to highest health literacy.

Conclusion: Social determinants of health needs are prominent among patients who develop DKA, highlighting an opportunity for ED-based interventions to address specific SDoH factors to prevent the development of this disease. Self-reported health literacy scores were high in this patient population. [West J Emerg Med. 2025;26(3)381–386.]

INTRODUCTION

Diabetes is one of the most significant diseases afflicting the global population, affecting 8.5% of adults aged 18 years or older.[1] Diabetic ketoacidosis (DKA) is the most common acute hyperglycemic emergency in patients with diabetes and is associated with over 200,000 annual emergency department (ED) visits in the United States,[2] with a mortality rate of 2-5%.[3] Hospitalization for DKA is costly and traumatic for individuals; it is on the rise but often preventable. The development of DKA is related to poor glycemic control and has been found to disproportionately affect racial and social minorities.[1,4] The contemporary study of diabetes and DKA is

expanding focus to emphasize human factors and population-based outcomes to better understand the socioeconomic distribution of patients who present in DKA. Increasingly, prevention efforts are focusing on social determinants of health (SDoH) that contribute to acute exacerbations of chronic disease.

The World Health Organization defines SDoH as "non-medical factors that influence health outcomes" including "the conditions in which people are born, grow, work, live and age, and the wider set of forces and systems shaping the conditions of daily life."[5] Poor SDoH are associated with negative diabetes-related outcomes including the development of DKA.[6] Personal health literacy—the degree to which individuals understand and use information and services to inform health-related decisions[7]—is an important interface between the healthcare system and the public. Low scores on health literacy measures correlate with poor health outcomes including increased ED utilization and hospital admission.[8-10] Varying levels of health literacy can limit patients' understanding of their disease process and limit participation in their healthcare plan, which illustrates a modifiable risk factor for the improvement of their health.

At our institution, we implemented a new treatment protocol for mild-to-moderate DKA that uses subcutaneously administrated insulin instead of the traditional insulin infusion, which has been successful in safely treating patients with DKA in a non-intensive care unit setting.[11] Implementation of this new treatment initiative provided an opportunity for us to examine health literacy and SDoH data with the aim to identify potentially modifiable risk factors leading to the development of DKA in our patient population.

Population Health Research Capsule

What do we already know about this issue?
The development of diabetic ketoacidosis (DKA) has been found to disproportionately affect racial and social minorities.

What was the research question?
Can we identify specific social determinants of health (SDoH) as potentially modifiable risk factors in the development of DKA?

What was the major inding of the study?
98% of patients (56/57 patients, 95% CI 89-100%) reported at least one unmet SDoH need, and 56% (32 patients) had five or more.

How does this improve population health?
We identified several SDoH burdens among ED patients presenting in DKA, which represent potentially modifiable risk factors for the development of DKA.

METHODS

Design, Setting, Participants

As part of a broader study related to treatment of DKA, we collected data on SDoH burdens and self-reported health literacy in patients with DKA. This prospective, cross-sectional study took place over one year (March 2023–March 2024) in a large, urban, academic ED. Electronic surveillance notified a research assistant (ML) to contact the patient by telephone while in the hospital for consent and data collection. This study was approved by our hospital institutional review board.

Measurements

We used the Centers for Medicare & Medicaid Services Accountable Health Communities Health-Related Social Needs Screening Tool (SNST), where patients answer a 26-item questionnaire spanning 13 domains of SDoH.[12] We dichotomized patient responses for each domain into "one or more unmet needs" or "no unmet needs" according to the tool guidelines. We also employed the Brief Health Literacy Screen (BHLS), a three-item questionnaire that evaluates self-reported health literacy using a five-point Likert scale from 1 (lowest health literacy) to 5 (highest health literacy).[13]

Data Analysis

Because this was an exploratory analysis we did not perform a sample size calculation but aimed to enroll patients over a one-year period. In an attempt to determine whether patients completing each questionnaire were similar in demographics to DKA patients who did not complete the surveys (patients who could not be reached for survey participation and patients who initiated the surveys but did not complete them), we used the Mann-Whitney U test to compare age and chi-squared tests and the Fisher exact test to compare sex, race, and ED disposition, where appropriate. We present summary descriptive statistics, reporting frequencies and proportions for the prevalence of all SDoH categories among our patient population and medians and interquartile ranges (IQR) for BHLS scores. We conducted all data management and computed descriptive statistics in R version 4.3.1, employing the packages tidyverse versions 1.3.0 and 1.4.3 (R Foundation for Statistical Computing, Vienna, Austria).[14,15]

RESULTS

Among 95 patients with DKA contacted, 78 consented to participate with 57 (60% response rate) completing the SNST and 72 (76% response rate) completing the BHLS (Figure 1). Participants completing the SNST were similar to the 36 eligible non-respondents with DKA (31 patients who could not be reached and fivc who initiated the surveys but did not complete them) in terms of age, sex, race, and ED disposition (all $P > 0.96$) (Table 1). Of the 57 patients, 56 (98%, 95% confidence interval

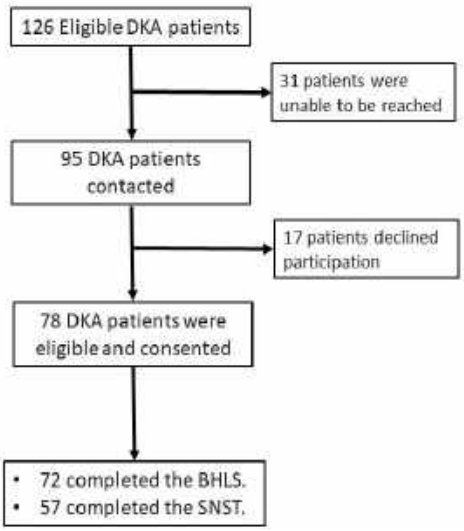

Figure 1. Study flow diagram.
BHLS, Brief Health Literacy Screen; *DKA,* diabetic ketoacidosis; *SNST,* Social Needs Screening Tool.

Table 1. Sociodemographics of patients with diabetic ketoacidosis.

	DKA patients who did not participate (N=36)	DKA patients who completed the BHLS (N=72)	DKA patients who completed the SNST (N=57)
Age (years) – median (IQR)	43 (28, 64)	47 (33, 57)	48 (32, 57)
Sex – n (%)			
Male	22 (61)	42 (58)	33 (58)
Female	14 (39)	30 (42)	24 (42)
Race – n (%)			
Black	24 (67)	52 (72)	40 (70)
White	11 (31)	15 (21)	13 (23)
Other	1 (3)	1 (1)	1 (2)
Not available	0 (0)	4 (6)	3 (5)
ED disposition – n (%)			
Discharged from the ED	1 (3)	6 (8)	4 (7)
Admitted to observation floor	14 (39)	31 (43)	24 (42)
Admitted to medical floor	8 (22)	11 (15)	9 (16)
Admitted to ICU	13 (36)	24 (33)	20 (35)

The group of individuals who did not participate is comprised of 31 patients who could not be reached for survey participation and five who initiated but did not complete either survey and, thus, were dropped from the analysis.
BHLS, Brief Health Literacy Screen; *ED,* emergency department; *ICU,* intensive care unit; *IQR,* interquartile range; *SNST,* Social Needs Screening Tool.

[CI] 89-100%) reported at least one unmet SDoH need, and 32 (56%) patients had five or more. Of the identified unmet SDoH needs, the most frequently reported were physical activity (77%), mental health (63%), financial strain (60%), substance use (54%), and food insecurity (51%) (Figure 2).

Patients who completed the BHLS were similar to non-respondents in terms of age, sex, race, and ED disposition (all $P > 0.90$). For patients completing the BHLS, health literacy was high, with median responses to all three questions ranging from 4-5 on a Likert scale with 5 corresponding to highest health literacy (Table 2).

DISCUSSION

Social determinants of health are increasingly recognized as significant contributors in the development of DKA. Identifying potentially modifiable factors may be the first step in helping prevent the development of DKA altogether. Using the SNST inventory, we identified several prominent and potentially modifiable SDoH burdens across several domains among ED patients presenting in DKA. Greater than 50% of patients identified physical activity, mental health, financial strain, food insecurity, and substance use as areas of need. Physical activity was the most prominent area of identified SDoH need, affecting over three-quarters of our study population. These results are consistent with previous studies, which have identified specific SDoH factors correlating to higher incidence of DKA including area-level economic deprivation[16] and substance use.[17] Hamblin et al similarly found recurrent episodes of DKA to be associated with unemployment, low education level, less medical contact, and drug and tobacco use.[18]

Diabetic ketoacidosis in patients with type 1 diabetes mellitus has also been associated with increased rates of suicide, particularly within 12 months of the DKA episode.[19] We were surprised to find health literacy scores were high, despite the high rates of self-reported SDoH burdens. In prior evaluations of health literacy in our ED we found approximately 24% of ED patients had limited or poor health literacy.[20] Objective health literacy assessment tools are generally preferred over self-reported instruments, which are felt to be more accurate, but the brief health literacy questions fared well in the ED in our prior study.[21]

In their 2021 review of SDoH and diabetes, Hill-Briggs noted a paucity of US-based research examining the impact of interventions designed to target education, income, occupation, toxic environmental exposures, social cohesion, and social capital on diabetes outcomes.[6] Since this publication, a number of studies have evaluated the impact of interventions targeted at various SDoH factors on outcomes in diabetes. For example, "produce prescription programs," which provide vouchers for fresh fruits and vegetables and diabetes education are one area being investigated for their impact on diabetes outcomes including reductions in hemoglobin A1C levels, although results are

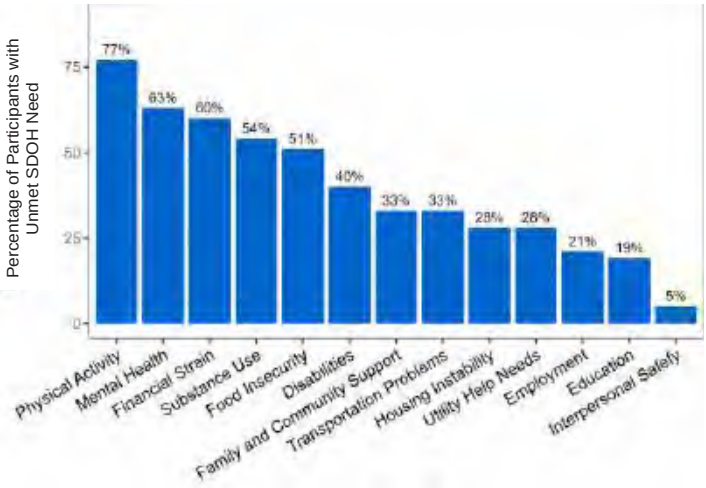

Figure 2. Unmet social determinants of health needs by category in patients with diabetic ketoacidosis.
SDOH, social determinants of health.

Table 2. Health literacy survey results of patients with diabetic ketoacidosis.

BHLS screening question	Median (IQR) (N=72)
How often do you have problems learning about your medical condition because of difficulty understanding written information?	4.00 (3.00, 5.00)
How confident are you filling out medical forms by yourself?	5.00 (4.00, 5.00)
How often do you have someone help you read hospital materials?	4.00 (3.00, 5.00)

mixed.[22,23] Educational campaigns to increase awareness of the importance of physical activity and encourage home exercise and lifestyle modifications to prevent the development of type 2 diabetes have also been described.[24] However, we are not aware of studies that have specifically explored the impact of interventions on the development of DKA.

Discussions in the diabetes literature also focus on policy, research, and practice pattern adjustments that may reduce diabetes-related health disparities, including the development of DKA. A 2024 international consensus report recognizes SDoH as a "major risk factor" for the development of DKA or hyperosmolar hyperglycemic state and recommends screening for SDoH prior to discharge in patients admitted for DKA. They further assert: "In the USA, policy solutions such as increasing access to health insurance, affordable insulin, medical care, nutritious food and housing would be expected to reduce the incidence of DKA."[25] Levi et al explore specific paths toward improving health outcomes through federal and community-based initiatives aimed at improving glycemic control in patient with diabetes. They propose strategies to expand "food-is-medicine" programs (produce prescriptions, medical meal-delivery platforms), strengthen existing federal nutrition assistance programs such as the Supplemental Nutrition Assistance Program and Special Supplemental Nutrition Program for Women, Infants and Children, and emphasize the importance of future research to understand the ideal dose and duration of nutritional support programs.[26]

LIMITATIONS

This was a single-center study with potential limitations related to generalizability. As this study was exploratory, a sample size calculation was not performed. We aimed to enroll 100 patients, but this number was somewhat arbitrary. Our sample size was lower than anticipated, in part due to a lower volume of patients with DKA during the study period compared to historical averages. In addition, although prior research experience favored the use of telephone contact of patients while in the hospital, we faced some limitations in this area, impacting our enrollment. An evaluation at one year of data collection noted marked stability and lack of variation in our results over time with a low likelihood that additional data would have impacted our results. This prompted us to truncate data collection at that point, which coincided with the end of our funding period.

Additionally, the self-reported nature of these data is a limitation given its reliance on personal perception and vulnerability to recall, social desirability bias, selection bias, and other biases. This work was also limited by the lack of a control group to determine which identified SDoH burdens are unique to ED patients with DKA vs being reflective of our population more broadly. We did attempt but discontinued an effort to capture SDoH information among type 1 diabetes patients not in DKA in the ED due to exceedingly low numbers.

A study comparing SDoH and health literacy among diabetic patients who develop DKA vs those who do not would provide interesting context to the impact of these social factors on glycemic control. A 2011 study found that poor adherence to insulin therapy impacted by behavioral, socioeconomic, psychosocial, and educational factors was the leading cause of recurrent admissions for DKA in urban patients from racial and ethnic minorities.[27] A survey of DKA patients on perceptions of the factors that led to the development of DKA and factors impacting their glycemic control, including missed insulin doses, concomitant illness, and/or polypharmacy would be useful. We expect there may be opportunities for local initiatives to make meaningful impacts on selected SDoH burdens.

Our future work will focus on further investigation, perhaps including qualitative methods and obtaining more detailed information about needs within the broad SDoH

domains identified and the degree to which these are modifiable. We also anticipate partnership with our social work, addiction, and mental health colleagues to identify screening, brief intervention, and referral for treatment approaches to improving substance use and mental health burdens identified.

CONCLUSION

We identified several potentially modifiable burdens of social determinants of health among emergency patients with diabetic ketoacidosis. Further study is needed to identify more specific needs, develop interventions to address these burdens, and determine whether these interventions may reduce recurrence of DKA.

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Emergency Department Comprehensive Social Risk Screening and Resource Referral Program

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Introduction: The emergency department (ED) is an appropriate location to screen for and address social risks among patients; however, a standardized process does not currently exist. Our objective in this study was to describe the implementation and findings of a social risk screening and resource referral program using a comprehensive screening questionnaire.

Methods: We conducted a prospective, cohort study between July 2022–April 2023 at a single academic, urban ED in Los Angeles, CA. Trained staff on rotating shifts recruited ED patients between 6 AM to midnight, with an average of 40 hours of coverage per week including weekends. Patients were excluded if they were <18 years of age, could not provide informed consent, or were deemed too medically unstable. Trained staff screened eligible consenting patients at ED bedside for social risks within 12 different domains of social determinants of health using a 19-question survey. Personalized resources were provided through an online platform or through direct communication with a social worker. Demographic data and patient responses were recorded in a deidentified database. We used a univariate logistic regression analysis to evaluate associations between demographic information and burden of social risk.

Results: A total of 4,277 ED patients were considered for screening, and 1,677 (39.2%) were eligible: 1,473 (87.8%) patients consented to social risk screening, and 1,078 (73.2%) of them had at least one social risk as indicated by the screening questionnaire. The most commonly reported social risks were social isolation (39%) and depression (23%). Between 88.9-96.8% of patients categorized as medium social risk were successfully provided resources through the online platform. Between 80.8-100% of patients categorized into high social risk had successfully connected with a social worker while in the ED. In this sample, there were significantly higher odds of having greater than one social risk for female (odds ratio [OR] 1.30, 95% confidence interval [CI] 1.02-1.67) and Black patients (OR 1.37, 95% CI 1.02-1.85) compared to male and White patients, respectively.

Conclusion: This study describes the findings from a comprehensive social risk screening and resource referral program at a large, urban, academic ED. The results will inform resource prioritization at the study institution. This model can serve as a basis for similar institutions to use, while individualizing their own approach. [West J Emerg Med. 2025;26(3)387–395.]

INTRODUCTION

The emergency department (ED) is a medical safety net for sociodemographically underserved populations.[1] Because many ED patients have significant social needs, it is important that emergency clinicians be able to recognize and help address the upstream social and systemic factors that may have contributed to these patients' ED presentations.[1-11] Social risk is the term used to describe these specific adverse social conditions that lead to poor health.[12,13] To assist ED recognition and mitigation of social risks, there has been a growing body of literature on the design and implementation of ED social risk screening.[3,14-24] Institutions nationwide have developed their own social risk screening and resource referral programs, with many in the literature citing the use of a pre-validated screening tool for select populations only (eg, Medicaid patients) followed by referral to community-based resources.[19,21,23] Some institutions have developed ED-based medical-legal partnerships to help address patient social needs.[25] Despite these innovative practices, a standardized process does not currently exist, likely due to the variability in regional prevalence of social risk and institutional resources.[19,21,25-28]

Our objective in this study was to describe the implementation and findings of a social risk screening and resource referral pilot program at an urban, academic medical center's ED. The unique screening questionnaire used in this study was developed at the study institution by an executive leadership steering committee with representation from all service lines across the health system. Questions were selected based on gaps in existing screening workflows, validated tools in the literature, needs specific to the community the hospital serves, federal mandates, and ease of patient understanding. The screening tool had already served as standard of care at several other access points in the hospital and was proposed for use in the ED to bridge the social needs gap of the health system where it is most needed. Unlike many other programs, this screening program was designed to capture as many different patient populations within the ED as possible, regardless of sociodemographic. While previous studies have evaluated screening tools with up to 10 different social risk domains (most using much fewer domains), in this study we also sought to evaluate more comprehensive social risk data than has previously been described in the literature by using a single screening questionnaire covering 12 different domains of social determinants of health.[19,21,25-28]

Population Health Research Capsule

What do we already know about this issue?
Many institutions nationwide have implemented varying forms of social risk screening and resource referral programs to promote health equity.

What was the research question?
What were the findings from a social risk screening program which used a more comprehensive screening tool?

What was the major finding of the study?
Among patients screened, 73% had at least one social risk with the most common being social isolation (39%) and depression (23%).

How does this improve population health?
By describing the implementation of this comprehensive social risk screening program, other institutions may utilize these tools in their own practice toward promoting health equity.

METHODS

Study Design and Setting

This was a prospective cohort study conducted between July 2022–April 2023 in an ED at a single academic, urban, quaternary medical center in Los Angeles, CA. The study was approved by the center's institutional review board. Nineteen questions comprise the social risk screener and cover 12 domains of social determinants of health. Each individual question had been separately validated in previous studies to screen for its intended social risk within that domain (Table 1 and Figure 1).

Selection of Participants

Trained research associates (RA) performed the bedside screening of ED patients. The RAs assessed patients for eligibility during scheduled shifts between 6 AM and midnight, which provided 30-80 hours of coverage per week, including weekends. During the first month pilot of the screening process, we excluded patients who did not speak English and those who were in hallway beds. After this pilot, these patients were then included. A Martti translator (UpHealth Inc, Delray Beach, FL) assisted communication via iPad with patients whose native language was not English. Exclusion criteria were primarily age <18, appearing agitated or unstable, receiving active medical treatment, or having a primary psychiatric complaint as these patients are already screened for social risks by a dedicated psychiatric social worker at the study ED (Table 2).

Interventions

During working hours, a RA pre-screened current ED patients for eligibility. To assess exclusion criteria, the RA would first review a read-only version of the patient's ED chart to obtain demographic information, primary chief complaint, emergency severity index (ESI), disposition, and

- In the last two weeks, how often have you had little interest or pleasure in doing things?
  - Not at all
  - Several days
  - More than half the days
  - Nearly every day
- In the last two weeks, how often have you been feeling down, depressed or hopeless?
  - Not at all
  - Several days
  - More than half the days
  - Nearly every day
- How hard is it for you to pay for the very basics like food, housing, medical care, and heating?
  - Very hard
  - Hard
  - Somewhat hard
  - Not very hard
  - Not hard at all
  - Patient chose not to respond
- In the past 12 months, has lack of transportation kept you from medical appointments, from getting medications, getting things needed for daily living?
  - Yes
  - No
  - Patient chose not to respond
- Within the past 12 months, you worried that your food would run out before you got the money to buy more.
  - Never true
  - Sometimes true
  - Often true
  - Patient chose not to respond
- Within the past 12 months, the food you bought just didn't last and you didn't have money to get more.
  - Never true
  - Sometimes true
  - Often true
  - Patient chose not to respond
- How often do you have a drink containing alcohol?
  - Never
  - Monthly or less
  - 2-4 times a month
  - 2-3 times a week
  - 4 or more times a week
  - Patient chose not to respond
- How many drinks containing alcohol do you have on a typical day when you are drinking?
  - 1 or 2
  - 3 or 4
  - 5 or 6
  - 7 to 9
  - 10 or more
  - Patient chose not to respond
- How often do you have six or more drinks on one occasion?
  - Never
  - Less than monthly
  - Monthly
  - Weekly
  - Daily or almost daily
  - Patient chose not to respond
- In the past year have you used an illegal drug or used a prescription medication for non-medical reasons?
  - Yes
  - No
  - Patient chose not to answer
- In the last 12 months, have you needed to see a doctor, but could not because of cost or insurance issues?
  - Hardly ever
  - Some of the time
  - Often

Figure 1. Social risk screening tool.

Table 1. Social determinant of health domains and the pre-validated tools from which screening questions are derived.

Domain	Pre-validated assessment tool	# of questions
Depression	PHQ-2	2
Financial Resource Strain	Accountable Health Communities Health-related Social Needs Screening Tool	1
Food Insecurity	Hunger Vital Signs	2
Housing Stability	PRAPARE	2
Transportation Needs	Modified PRAPARE (Epic)	1
Access to Care	Health Leads (modified)	1
Health Literacy	Short Test of Functional Health Literacy in Adults	1
Independent Living	CDC Behavioral Risk Factor Surveillance System	1
Intimate Partner Violence	Partner Violence Screen	1
Social Connections	UCLA 3-Item Scale	3
Alcohol Use	AUDIT-C	3
Substance Use	DAST-10	1
Total		19

CDC, US Centers for Disease Control and Prevention*; PHQ-2*, Patient Health Questionnaire-2; *PRAPARE*, Protocol for Assessing and Responding to Patients Assets, Risks, and Experiences; *AUDIT-C*, Alcohol Use Disorders dentificationn Test-Consumption; *DAST-10*, Drug Abuse Screening Test.

"break the glass"/"research opt out" status. The rest of the exclusion criteria were assessed through communication with the medical team about the patient's medical stability and whether any active bedside interventions were ongoing. All demographic information of these pre-screened patients were recorded in a de-identified REDCap (Reearch Electronic Data Capture) database, hosted at Cedars-Sinai Medical Center. The RA then approached eligible patients for consent and subsequently asked the screening questions at bedside. The social risk screener took an average of approximately five minutes to answer. The patient's answers were recorded in the de-identified database. Positive social risks were stratified into moderate or high risk based on the patient's answers to the individual pre-validated screening tools that comprise the comprehensive screener. Workflows were developed such that high levels of risks often triggered a social work referral, while moderate levels of risk were addressed with referral to available community-based resources (Figure 2).

Resource referrals were made using an electronic platform provided by a third-party vendor, findhelp (Aunt Bertha, Austin, TX).[29] Through this platform, the RA entered the patient's ZIP code and selected local resources pertaining to the patient's social risks identified by the screener. The patient then received a printout, text message, or an email with these resources.

Measurements and Analysis

Demographic characteristics were recorded for all patients in this sample. Other patient-level measurements

Table 2. Reasons for exclusion from screening (not mutually exclusive).

Exclusion criteria	Frequency (%) N=2,600
Pediatric patient <18 years old	29 (1.1)
Adults who lack capacity to consent	86 (3.3)
Non-English speaking patient (first month of pilot only)	210 (8.08)
Patient in acute distress, ill-appearing, or agitated	1,621 (62.3)
Patients with a primary psychiatric chief complaint	231 (8.9)
Patients receiving active nursing, PA, or MD assessment or intervention	164 (6.3)
Patient with suspected COVID-19 or other airborne disease	355 (13.7)
Patients who will be imminently discharged	482 (18.5)
Clinician does not believe participation would be in patient's best interest	30 (1.2)
Patient previously participated in the same social risk screening study	28 (1.1)
Medical records flag "break the glass" or "research opt out"	84 (3.2)

PA, physician assistant; *MD*, doctor of medicine, *"break the glass*," access restricted patient's record in an emergency.

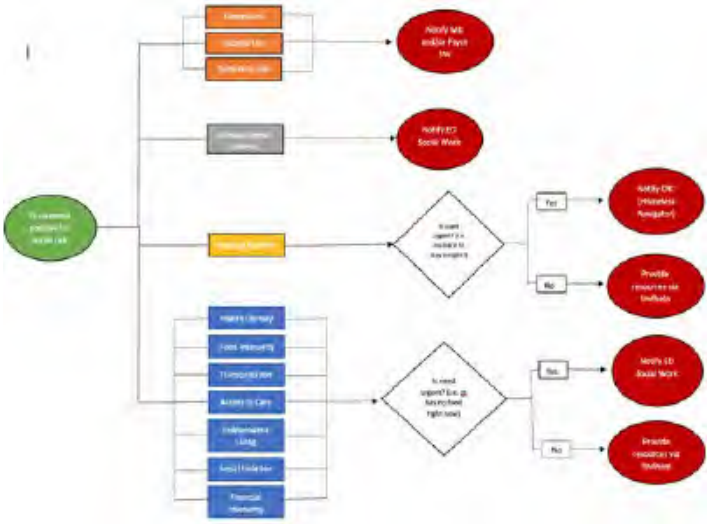

Figure 2. Social risk screening and referral workflow.
ED, emergency department; *CRC*, community resource coordinator,

were number of social risks present (if any), category of social risk, degree of risk (medium vs high), and whether resources were provided by the RA through the online platform or by communication with a social worker. We compared demographic characteristics between the total pre-screened population and the screened sub-population. Demographics associated with screening positive for at least one social risk and for greater than one social risk compared to no social risks were assessed by univariate logistic regression analysis. We reported odds ratios (OR) and their 95% confidence intervals (CI). A two-sided 0.05 significance level was used throughout. We made calculations using VassarStats, available online at http://vassarstats.net/.

RESULTS

A total of 4,277 ED patients were pre-screened by RAs over the study period. Of these patients, 1,677 (39.2%) were eligible for social risk screening. The most common reason for exclusion (62.3% of excluded patients) was that the patient was in acute distress, ill-appearing, or agitated (see Table 2). Among the eligible patients, 1,487 (88.7%) consented to undergoing social risk screening, and ultimately 1,473 (99.1% of consented patients) were successfully screened.

The demographic features of the pre-screened patients and the screened patients were similar in terms of sex, race, and ethnicity. However, pre-screened patients were older on average than screened patients (Table 3). Among screened patients, 1,078 (73.2%) had at least one social risk as indicated by the screening questionnaire. The most commonly reported social risks were social isolation (39%) and depression (23%). Least frequently reported social risks were intimate partner violence (1%) and drug use (5%). Between 88.9-96.8% of patients categorized as medium social risk were successfully provided resources through the online platform. Between 80.8-100% of patients categorized into high social risk had successfully connected with a social worker while in the ED. Screened patients with social risks who did not receive resources or speak to a social worker where indicated had declined to engage in this option (Table 4). In the univariate logistic regression analysis (Table 5), we found that there were significantly higher odds of having greater than one social risk vs no social risks for female (OR 1.30, 95% CI 1.02-1.67) and Black patients (OR 1.37, 95% CI 1.02-1.85) compared to male and White patients, respectively.

DISCUSSION

The goal of this study was to describe the implementation of a social risk screening and resource referral program in an ED at a large, urban, academic institution. A standardized program for social risk screening does not currently exist in large part due to the variability in needs of local patient populations and resource barriers to implementation that exist among regions and institutions.

Table 3. Demographic information for pre-screened and screened patients.

Demographic variable	Pre-screened patients (%) N=4,277	Screened patients (%) N=1,473
Sex		
Male	2,080 (48.6)	724 (49.2)
Female	2,195 (51.3)	748 (50.8)
Unknown	2 (0.0)	1 (0.1)
Race		
White	2,623 (61.3)	890 (60.4)
Black	959 (22.4)	363 (24.6)
Asian	244 (5.7)	69 (4.7)
American Indian or Alaskan Native	26 (0.6)	9 (0.6)
Native Hawaiian or Other Pacific Islander	12 (0.3)	5 (0.3)
Other	413 (9.7)	137 (9.3)
Age		
18-24	261 (6.1)	117 (7.9)
25-34	635 (14.8)	261 (17.7)
35-44	644 (15.1)	245 (16.6)
45-54	574 (13.4)	202 (13.7)
55-64	630 (14.7)	222 (15.1)
≥65	1,519 (35.5)	426 (28.9)
Unknown	14 (0.3)	0 (0.0)
Ethnicity		
Hispanic	762 (17.8)	247 (16.8)
Not Hispanic	3,437 (80.4)	1,202 (81.6)
Prefer not to answer	78 (1.8)	24 (1.6)

Table 4. Social risks of patients screened in the emergency department and resources provided.

Social risk	Frequency of social risk (%) (N=1,473)	Local resource referrals (% of those at risk)	Successful connections with social worker (% of those at high risk)
Social connections			
High risk	565 (38.3)	539 (95.4)	-
Independent living			
High risk	222 (15.1)	207 (93.2)	-
Transportation needs			
High risk	120 (8.1)	114 (95.0)	-
Health literacy			
High risk	117 (7.9)	104 (88.9)	-
Housing stability			
Moderate risk	145 (9.8)	139 (95.9)	-
High risk	19 (1.3)	-	16 (84.2)
Intimate partner violence			
High risk	16 (1.1)		16 (100.0)
Alcohol use			
High risk	155 (10.5)	-	[#]
Depression			
High risk	338 (22.9)	-	[#]
Drug use			
High risk	79 (5.4)	-	[#]
			[#]467 (81.6)
Financial strain			
Moderate risk	272 (18.4)	262 (96.3)	-
High risk	233 (15.8)	-	*
Food insecurity			
Moderate risk	217 (14.7)	210 (96.8)	-
High risk	18 (1.2)	-	*
Access to care			
Moderate risk	134 (9.1)	127 (94.8)	-
High risk	67 (4.5)	-	*
			*257 (80.8)

[#]Combined connections to social work for alcohol use, depression, and drug use.
*Combined connections to social work for high-risk financial strain, food insecurity, and access to care.

Therefore, it is crucial for each institution to assess its own capacity to screen for and address social risks among its ED patients and develop a program individualized to their needs and abilities. The ED involved in this study is fortunate to have several resources at its disposal including social workers, homeless navigators, clinical RAs supported by internal funding, and an online referral platform with thousands of resources available for patients within its catchment area. The program designed and piloted in this study enabled this ED to maximally harness its resources while creating little to no disruption in the ED workflows. The high percentages of patients with social risks who were appropriately connected with resources or with a social worker suggest that patients are generally receptive to resource referral and may have a high proportion of social needs in our population.

The demographic data collected for this study demonstrated that the patients who were eligible for screening for social risks were collectively a representative sample in terms of sex, race, and ethnicity of the larger ED patient population. However, patients screened for social risks were younger on average than those of the total pre-screened population. This is likely explained by the exclusion criteria of the study, encompassing patients who are ill-appearing, agitated, or lacking capacity to consent. Elderly patients are more susceptible to delirium and dementia, thus precluding

Table 5. Demographic characteristics and odds ratios of social risks.

Demographic variable	No social risks (%) n=395	At least 1 social risk (%) n=1,078	OR for at least 1 vs no social risks (95% CI)	>1 social risks (%) N=699	OR for >1 vs no social risks (95% CI)
Sex					
Male	205 (51.9)	519 (48.1)	Reference	316 (45.2)	Reference
Female	190 (48.1)	558 (51.8)	1.16 (0.92-1.46)	382 (54.6)	1.30 (1.02-1.67)
Unknown	0	1 (0.1)	*	1 (0.1)	*
Race					
White	242 (61.3)	648 (60.1)	Reference	400 (57.2)	Reference
Black	86 (21.8)	277 (25.7)	1.20 (0.91-1.60)	195 (27.9)	1.37 (1.02-1.85)
Asian	26 (6.6)	43 (4.0)	0.62 (0.37-1.03)	25 (3.6)	0.58 (0.33-1.03)
American Indian or Alaskan Native	2 (0.5)	7 (0.6)	*	7 (1.0)	*
Native Hawaiian or other Pacific Islander	2 (0.5)	3 (0.3)	*	3 (0.4)	*
Other	37 (9.4)	100 (9.3)	1.01 (0.67-1.51)	69 (9.9)	1.13 (0.73-1.73)
Age					
18-24	30 (7.6)	87 (8.1)	Reference	54 (7.7)	Reference
25-34	64 (16.2)	197 (18.3)	1.06 (0.64-1.75)	142 (20.3)	1.23 (0.72-2.10)
35-44	66 (16.7)	179 (16.7)	0.94 (0.57-1.54)	115 (16.5)	0.97 (0.56-1.66)
45-54	49 (12.4)	153 (14.2)	1.08 (0.64-1.82)	102 (14.6)	1.16 (0.66-2.03)
55-64	59 (14.9)	163 (15.1)	0.95 (0.57-1.59)	110 (15.7)	1.04 (0.60-1.79)
≥65	127 (32.1)	299 (27.7)	0.81 (0.51-1.29)	176 (25.2)	0.77 (0.47-1.27)
Ethnicity					
Hispanic	72 (18.2)	175 (16.2)	Reference	117 (16.7)	Reference
Not Hispanic	318 (80.5)	884 (82.0)	1.14 (0.84-1.55)	571 (81.7)	1.11 (0.80-1.53)
Prefer not to answer	5 (1.3)	19 (1.8)	*	11 (1.6)	*

*Frequency too small.
OR, odds ratio; *CI*, confidence interval.

them from social risk screening. However, it is worth noting that this institution also has access to a geriatric care coordinator who assists these patients with social needs outside the social risk screening program.

A major advantage of social risk screening is that it can inform investment in resources. Based on the findings from this screening program, the study ED plans to strengthen its availability of psychiatric social work services and has also educated the department's clinicians about mental health resources for patients. The results of this study also identified female patients and Black patients as being populations vulnerable to an increased burden of social risk, and further work at the study institution should focus on identifying strategies to better address the needs of these ED patients. Knowing and addressing these needs is important not only so we may better understand the physiologic reasons for and treatment of disease in the ED, but also to help reduce health disparities among vulnerable populations in our region.[32]

The success and sustainability of a social risk screening program depends largely on its acceptability and accessibility to ED patients.[15-17,26,28,30,31] Therefore, future directions for the program will include 30-day follow-up with patients who were screened and referred to resources to assess their satisfaction with the process, and to evaluate the success of community resource connections. The program will also be qualitatively studied to assess patient acceptability of the screening process. This is important because many questions related to assessing social risk are potentially stigmatizing, and screening for social risks is only useful when patients feel safe and comfortable answering. For example, this study found a low prevalence of reported intimate partner violence, but it is unclear whether this was due to the fact that intimate partner violence is a highly stigmatizing topic.

LIMITATIONS

Limitations to interpretation of this study's results are in large part due to the exclusion criteria that were applied and

the resulting potential for selection bias. These criteria were imposed to maintain patient autonomy, research staff safety, minimize system redundancies, and work within resource availability. For example, patients with primary psychiatric complaints were excluded because these patients are already thoroughly screened for social risks by a dedicated psychiatric social worker whose position already existed at this institution. Due to the exclusions, the results of this study are subject to potential selection bias, especially with regard to the medical team's interpretation of whether a patient was medically stable enough to undergo screening. However, because this program was a pilot the exclusion criteria were necessary to create a feasible model that could be continued within the study institution's resource constrictions while creating minimal disturbance to clinical workflows. The COVID-19 exclusion was in place due to epidemiologic recommendations around contact precautions and resource maximization at the time the pilot was conducted, but it will be relaxed moving forward. Additionally, we recognize that social risks for an individual are often dynamic; so, future plans are to screen every eligible patient at each ED encounter, regardless of their previous screening status.

Patients in this sample were limited to those who were present during research staff working hours. Also, during the first month of enrollment, non-English speaking and hallway patients were excluded to assess process feasibility. This initial exclusion may have impacted the demographic makeup of our screened sample; however, it was unlikely to have had a major effect given the very small sample size recruited in the first month. Another limitation of the study is that demographic information was collected from chart reviews. At the study institution, demographic data is self-reported and documented by registration staff; however, errors of input are possible. Additionally, we do not have available data on why 190 (11.3%) eligible patients declined consent for screening. We also do not know why 14 (0.9%) consented patients did not ultimately receive screening; however, anecdotal reports from RAs indicate that these consenting patients were likely discharged or transferred to an inpatient room before screening could be performed.

CONCLUSION

This study describes the findings from a social risk screening and resource referral program at a large, urban, academic ED. The screening tool used in this study is more comprehensive than has previously been described in the literature. The results will inform future directions in terms of resource prioritization. This model can serve as a basis for similar institutions to use, while individualizing their own approach. The next steps for this program will be to study patient acceptability of social risk screening and 30-day follow-up of resource utilization.

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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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Feasibility of an Emergency Department-based Food Insecurity Screening and Referral Program

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Introduction: Food insecurity (FI) remains a pervasive issue in the United States, affecting over 12.8% of households. Marginalized populations, particularly those in urban areas, are disproportionately impacted. The emergency department (ED) holds potential as a vital outreach hub, given its diverse patient population and extensive service coverage. In this study we explore the feasibility of implementing an ED-based FI screening and referral program at an urban, academic teaching hospital. We aimed to assess the prevalence of FI among ED patients and evaluate the feasibility of a three- and six-week follow-up to assess patients' FI and related barriers to resource referral utilization.

Methods: This single-center, observational study was conducted at an urban, academic ED from 2018-2024. Initial FI screening was performed using a validated two-question survey adapted from the Hunger Vital Sign screening tool. Participants who screened positive were enrolled and completed the 10-item US Department of Agriculture Adult Food Security survey, received a food assistance guide, and were followed up at three- and six-week intervals to assess changes in FI status.

Results: Among 6,339 participants, 1,069 (16.9%) experienced FI, with the highest rates among Black non-Hispanic (24.7%) and Spanish-speaking participants (28.7%). Of the 1,069 participants who screened positive for FI, 630 (59.0%) were enrolled in the study. Of the enrolled participants, 161 (25.6%) completed the three-week follow-up phone calls, and 48 (7.6%) completed the six-week follow-up. The mean FI score for these 48 participants decreased from 6.67 (SD 2.68) at enrollment to 4.75 (SD 2.85) at the three-week follow-up ($P < 0.001$), and to 4.25 (SD 3.48) by the six-week follow-up ($P < 0.001$). Barriers to using the food resource guide, such as time constraints, transportation, and misplacement of resources, limited many participants' engagement.

Conclusion: This study demonstrated the feasibility and effectiveness of an ED-based food insecurity screening and resource referral program, associated with a significant reduction in food insecurity scores among participants. However, barriers such as time constraints, transportation issues, and misplacement of referral materials limited engagement. Addressing these barriers through tailored follow-up and systematic support systems, including universal screening during ED intake and personalized assistance, can enhance the program's accessibility and impact. [West J Emerg Med. 2025;26(3)396–405.]

INTRODUCTION

Food insecurity (FI), defined as limited or uncertain access to adequate food for an active, healthy life, continues to affect over 12.8% of US households, including 44.2 million individuals and 7.3 million children by the end of 2022.[1] Despite hopes for improvement following the COVID-19 pandemic, ongoing challenges such as inflation and supply chain disruptions have exacerbated vulnerabilities, particularly among marginalized populations.[2] In Orange County, California, 10.4% of adults faced food insecurity as of 2022, highlighting persistent disparities even in economically prosperous regions.[3] The consequences of FI extend beyond immediate hardship, with long-term health impacts including chronic illnesses like diabetes and obesity, driven by reliance on cheaper, calorie-dense, and nutritionally inadequate foods.[4–6] Financial strain often forces individuals to choose between food and other essentials such as medications, which leads to worsening health outcomes in people with lower socioeconomic status.[7]

While primary care settings are essential for interventions, the emergency department (ED) holds potential as a vital outreach hub, given its diverse patient population and extensive service coverage. A notable proportion of ED patients in both pediatric and adult hospitals experience FI, with previous rates of FI reported above 20%.[8] While existing ED-based FI screening and referral programs for FI have primarily focused on screening using tools such as the Hunger Vital Sign,[2,9] few studies have examined the implementation of an ED-based FI screening coupled with a referral program that includes patient follow-ups, assessment of FI severity in food insecure patients, and investigation of barriers to utilization of referral resources. Recognizing this gap, we sought to investigate the feasibility and effectiveness of implementing a FI screening and referral program with patient follow-ups in an urban, academic ED. We hypothesized that implementing a food resource referral program in the ED would significantly reduce FI among patients, as evidenced by lower FI scores in follow-up assessments. We also aimed to investigate the barriers ED-presenting patients have in using FI resources.

Population Health Research Capsule

What do we already know about this issue?
ED patients have elevated food insecurity (FI) rates; FI screening is feasible, but the impact of resource referrals and utilization barriers are not well understood.

What was the research question?
Can ED-based FI screening and resource referral reduce FI, and what are the barriers to resource utilization?

What was the major finding of the study?
FI prevalence in the ED was 16.9%; FI scores decreased from 6.67 to 4.75 at 3 weeks ($P < 0.001$).

How does this improve population health?
ED-based interventions can reduce FI. Identifying and addressing utilization barriers can improve access to essential resources for those most at risk.

METHODS

Part 1: Screening

This single-center, observational study was conducted with institutional review board approval at a large, urban, academic medical center ED and adhered to federal guidelines. Research associates (RA) stationed at the ED from 8 AM to midnight, May 2018–October 2024, conducted the screening process. Inclusion criteria were as follows: adults ≥18 years of age who were able to understand and communicate in English or Spanish and exhibited full cognitive abilities to provide informed consent. Exclusion criteria included critically ill patients, non-communicative patients, those under <18, psychiatric patients, and those who spoke languages other than English or Spanish.

The preliminary assessment of FI was based on a validated and abbreviated two-question survey called the Hunger Vital Sign, which indicates FI adapted from the US Department of Agriculture (USDA) Adult Food Security Survey Module (Supplementary File A).[10,11] Participants were selected using convenience sampling during the RAs' working hours and were administered the screening questions orally. For non-English speaking participants, bilingual RAs translated and orally conducted the survey. A positive response to either of the preliminary survey questions classified the individual as experiencing FI, leading to further steps in the enrollment process. Conversely, those who responded negatively had their data anonymized and did not proceed further in the study. This streamlined two-question assessment ensured that targeted assistance and resource guides to food pantries were directed exclusively to individuals identified as food insecure, while assessing the percentage of individuals that were food insecure in the ED in the context of all patients.

Part 2: Enrollment

After the initial two-question survey, patients identified as food insecure were invited to enroll in the second portion of the study. The research team provided an overview of the study objectives, procedures, potential risks, and benefits, and answered any questions. Written informed consent was

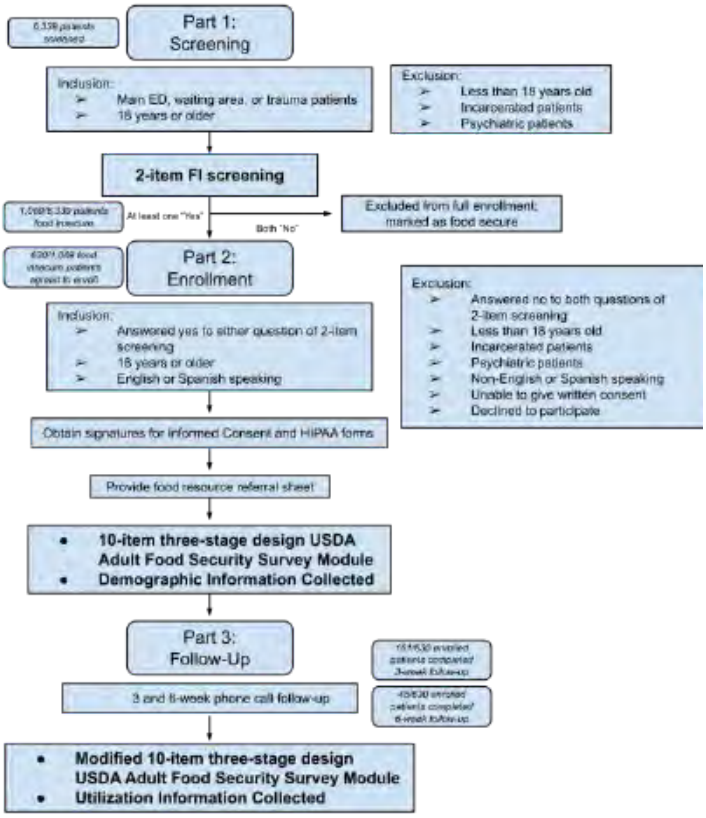

Figure 1. Flowchart depicting screening, enrollment, and follow-up methodology.
HIPAA, Health Insurance Portability and Accountability Act*; USDA*, US Department of Agriculture.

obtained prior to participation. After consent, participants completed the 10-item three-stage design USDA Adult Food Security Survey Module to assess the severity of their FI (Supplementary File A).[11] Additional data collected included demographic information such as age, gender, race/ethnicity, language preference, and other relevant socioeconomic factors. Participants were provided with a food assistance and resource guide, which included information on existing food assistance programs, such as the Supplemental Nutritional Assistance Program/CalFresh, as well as enrollment instructions and contact information for 2-1-1 Orange County.[12, 13] The guide also contained a comprehensive list of local food pantries, sourced from the Second Harvest Food Bank digital resource (Supplementary File B).[14] The RAs explained the contents of the guide and how to access the resources.

Part 3: Follow-up

Following enrollment, telephone surveys were scheduled at three- and six-week intervals. During these calls, a modified version of the USDA Adult Food Security Survey Module was administered, adjusted to assess food security status over the prior three weeks instead of the standard 12-month period. The purpose of these calls, conducted by designated RAs, was to assess the impact of FI interventions on improving food accessibility for patients. These calls were not recorded; however, responses were securely stored using Research Electronic Data Capture tools (REDCap) hosted at University of California, Irvine.

Sample Size

A university-affiliated statistician conducted power analyses to estimate the required sample size for each survey component. Based on these calculations, we aimed to recruit at least 4,900 participants for the initial two-item screening tool to achieve sufficient power. For the 10-item USDA Adult Food Security Survey Module, an estimated 85 participants were required for adequate power; to account for attrition, we targeted enrolling at least 95 individuals. Due to greater-than-anticipated attrition during follow-up, we continued enrollment beyond initial estimates.

Statistics

We calculated descriptive statistics for demographic variables and the prevalence of FI. Differences in FI prevalence across demographic groups, including gender, race/ethnicity, language, and age, were assessed using chi-squared tests. We used paired *t*-tests to compare mean FI scores at enrollment, and at three-week and six-week follow-ups among participants who completed all follow-ups. Independent samples *t*-tests evaluated differences in FI scores between participants who used the food resource guide and those who did not. We conducted multiple linear regression analysis to assess predictors of change in FI scores, adjusting for baseline FI score and potential confounders such as age, gender, ethnicity, language, marital status, and education level. Non-response bias was evaluated by comparing baseline demographics between respondents and non-respondents through logistic regression analysis, following Phillips et al (2015).[15] Due to study constraints, it was not feasible to perform wave analysis and follow-up analysis of nonresponse bias. We analyzed qualitative data on barriers to resource utilization using inductive coding of interview notes. All statistical analyses were performed using RStudio software (RStudio PBC, Boston, MA), with a significance level set at $P < 0.05$.

RESULTS

A total of 6,339 participants were screened for FI at a large, urban, academic medical center ED between May 2018–October 2024. The overall prevalence of FI was 16.9% (1,069 of 6,339 participants). When stratified by gender, the FI rate was 17.9% among men and 15.8% among women ($P = 0.02$). Racial and ethnic disparities were evident: Asian or Pacific Islanders and White non-Hispanic individuals had the lowest FI rates at 9.1% and 13.8%, respectively. Black non-Hispanic individuals had the highest at 24.7%. American

Table 1. Food insecurity prevalence by demographics.

Category	n	n Positive	n Negative	Rate FI Positive (%)
All	6,339	1,069	5,270	16.9%
Sex				
Men	3,259	584	2,675	17.9%
Women	3,080	485	2,595	15.8%
Race				13.8%
White, non-Hispanic	2,595	358	2,237	13.8%
Black, non-Hispanic	271	67	204	24.7%
Hispanic or Latino/a	2,390	515	1,875	21.6%
Asian or Pacific Islander	828	75	753	9.1%
American Indian, Alaskan, or Hawaiian Native	60	14	46	23.3%
Other	195	40	155	20.5%
Language				
English	5,622	896	4,726	15.9
Spanish	534	153	381	28.7%
Other	183	20	163	12.3%
Age				
18-29	1,287	211	1,076	16.4%
30-44	1,442	293	1,149	20.3%
45-59	1,390	314	1,076	22.6%
≥60	2,220	251	1,969	11.3%

FI, food insecurity.

Indian, Alaskan, or Hawaiian Natives had an FI rate of 23.3%, and Hispanic or Latino/a individuals had an FI rate of 21.6%. Among language groups, Spanish speakers exhibited the highest FI rate at 28.7%, compared to 15.9% for English speakers. Age also influenced FI rates, with the 45-59 age group experiencing the highest rate at 22.6%, and those ≥60 of age the lowest at 11.3%.Of the 1,069 participants who screened positive for FI, 630 (59.0%) were enrolled in the study. Among the enrolled participants, 161 (25.6%) completed the three-week follow-up phone calls, and 48 (7.6%) completed the six-week follow-up. Among the 48 participants who completed all follow-up surveys, the mean FI score decreased from 6.67 (SD 2.68) at enrollment to 4.75 (SD 2.85) at the three-week follow-up ($P < 0.001$), and to 4.25 (SD 3.48) at the six-week follow-up (($P < 0.001$). The change between the three-week and six-week follow-ups was not statistically significant (($P = 0.25$), suggesting stabilization of FI scores after the initial intervention (Figure 2). We used paired *t*-tests for these comparisons.

We conducted a comparison of FI scores between the 35 participants who used the food resource guide and the 126 who did not. An independent samples *t*-test revealed that guide users had a higher mean initial FI score (7.60 ± 2.43) compared to non-guide users (6.46 ± 2.86; $P = 0.02$). At the three-week follow-up, paired samples *t*-tests showed that FI scores decreased significantly in both groups (guide users: 4.03 ± 3.08, $P < 0.001$; non-guide users: 4.49 ± 3.44, $P < 0.001$). Furthermore, an independent samples *t*-test comparing the unadjusted difference in the decrease in FI scores between the groups was statistically significant ($P = 0.03$). However, this initial observation did not account for baseline differences between the groups.

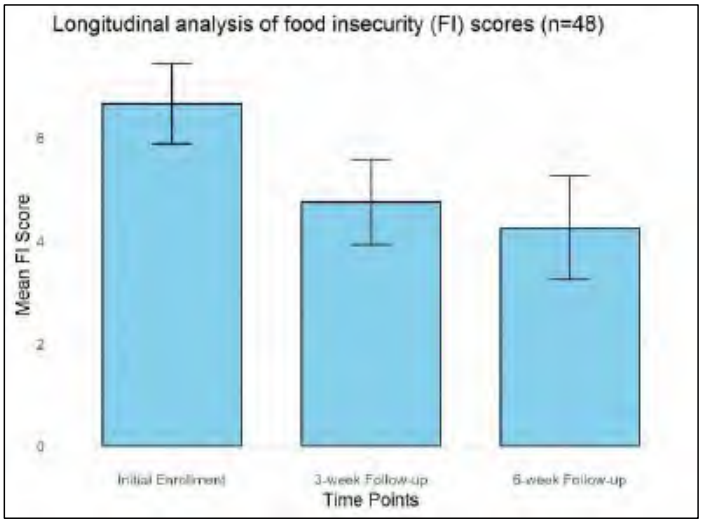

Figure 2. Longitudinal analysis of food insecurity (FI) scores among 48 participants who completed all follow-up surveys. *FI,* food insecurity.

To account for baseline differences and potential confounders, we conducted a multiple linear regression analysis with FI change (follow-up FI score minus initial FI score) as the dependent variable. The model adjusted for baseline FI score, age, gender, ethnicity, language, marital status, and education level (adjusted R^2 0.281, Table 2). The regression analysis revealed that guide use was not a significant predictor of FI change (β -0.649, SE 0.645, t -1.006, $P = 0.316$). This indicates that, after adjusting for other factors, participants who used the guide did not experience a significantly greater reduction in FI scores compared to those who did not use the guide.

Higher baseline FI scores were significantly associated with greater reductions in FI scores (β -0.655, SE 0.095, t -6.907, $P < 0.01$), suggesting that participants with higher initial FI experienced more substantial improvements over time. Ethnicity also emerged as a significant factor. Hispanic or Latino/a participants showed significantly greater reductions in FI scores compared to White non-Hispanic participants (β -1.284, SE 0.615, t -2.087, $P = 0.039$).To evaluate potential non-response bias due to the low response rate during follow-up phone calls, we conducted a logistic regression analysis comparing baseline demographics between those who completed follow-up surveys and those who did not. The analysis identified that participants identifying as Black non-Hispanic ($P = 0.02$) and those with education levels of elementary/high school/General Educational Development ($P = 0.04$), two-year college (AA/AS) ($P = 0.01$), and Master's degree ($P = 0.02$) were significantly less likely to complete follow-up surveys compared to their respective reference groups. These findings suggest that non-response bias may be present, particularly among Black non-Hispanic participants and individuals with certain educational backgrounds.

The perceived helpfulness of the food resource referral was assessed during phone call follow-ups with patients who cited usage of the referral. They were asked: "On a scale of 1 to 5, how helpful was this food resource referral in reducing your concerns about food availability?" The majority of participants found the referral to be extremely helpful (Figure 3).

Of the 163 patients who completed the three-week follow-up, 128 did not use the resource guide. Inductive coding revealed that the most frequently reported barriers included time constraints (20%), transportation issues (16%,), and medical concerns (14%). Some participants misplaced or did not recall the referral paper (13%) or simply forgot about it (9%). Other reasons ranged from personal or external life

Table 2. Multiple linear regression analysis predicting change in food insecurity scores.

Predictor	Estimate (β)	Std. Error	t value	P-value
(Intercept)	3.1162	1.4927	2.0876	0.04
Guide use (Guide users)	-0.5046	0.6791	-0.7430	0.46
Initial FI Score upon enrollment	-0.6520	0.0972	-6.7087	<0.01
Age	0.0006	0.0004	1.4562	0.15
Gender				
Women	0.9453	0.5353	1.7661	0.08
Ethnicity				
Black, non-Hispanic	-21071	1.1498	-1.8326	0.07
Hispanic or Latino/a	-1.4533	0.6428	-2.2608	0.03
Asian or Pacific Islander	-2.0153	1.2529	-1.6085	0.11
Other	-0.8435	1.2998	-0.6490	0.52
Language				
Spanish	0.7896	1.0656	0.7410	0.46
Other	-0.4686	2.5972	-0.1804	0.86
Marital Status				
Married	-0.1308	0.6784	-0.1928	0.85
Domestic partnership	-3.8145	3.2871	-1.1605	0.25
Education Level				
Elementary/high school/ GED	-0.0109	1.1640	-0.0094	>0.99
Some college	-0.4453	1.2090	-0.3683	0.71
2-year college (AA/AS)	-1.4074	1.4004	-1.0050	0.32
4-year college degree (BA/BS)	-1.7590	1.4477	-1.2151	0.23
Master's degree	0.2879	2.5746	0.1118	0.91

FI, food insecurity; *GED*, General Educational Development.

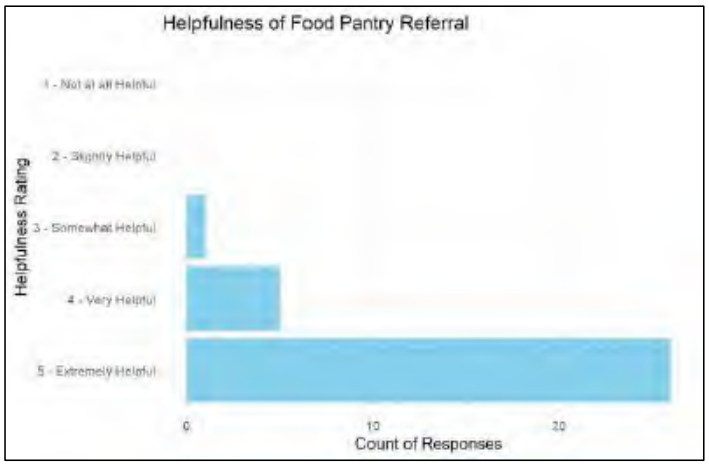

Figure 3. Helpfulness of food resource referral rated by participants during phone follow-ups.

circumstances (6%) to uncertainty about using the referral (6%). Finally, 16% reported no longer needing the guide because their situation had improved.

DISCUSSION

This study demonstrated that implementing an ED-based FI screening and referral program is feasible and can reduce FI levels among patients. Our findings also revealed significant demographic disparities in FI rates in the ED. Although the intervention was beneficial, certain groups benefited more than others, and several barriers hindered the referral's optimal utilization.

Compared to other ED-based interventions focusing on FI, which often involve smaller samples or rely solely on a single screener,[2,8,9] this study offers several notable strengths. First, it employed multiple validated measures (the Hunger Vital Sign and the 10-item USDA Adult Food Security Survey Module) to screen 6,339 patients—a relatively large sample size for this setting—and assess varying degrees of FI severity. Second, its longitudinal design with three- and six-week follow-up enabled a better understanding of how FI status evolved over time post-intervention, rather than relying on a single snapshot. Third, qualitative insights on patients' barriers provided a more nuanced perspective of real-world challenges faced by individuals at risk. These features helped to contextualize the findings while indicating where further refinement of ED-based interventions may be needed.

Demographic Disparities in Food Insecurity

Our ED's overall FI rate of 16.9% highlights the substantial presence of FI in vulnerable populations, even in affluent areas like Orange County, CA, which had a general population FI rate of 10.4% in 2022.[3] This elevated rate in the ED aligns with studies that have found higher FI rates in ED settings compared to the general population, suggesting a correlation between FI and ED visits.[2, 15] Analysis revealed significant disparities, with Black non-Hispanic individuals experiencing the highest FI rates (24.7%). This mirrors literature indicating that systemic inequalities, such as historical marginalization, limited access to economic opportunities, and healthcare disparities, contribute to higher FI rates among racial and ethnic minorities.[16, 17] Addressing these underlying social determinants is crucial for developing effective interventions.

Spanish speakers exhibited a significantly higher FI rate of 28.7% compared to 15.9% among English speakers ($P < 0.001$). This underscores the impact of language barriers in regular access to food resources. Implementing multilingual outreach programs and providing resources that are linguistically and culturally tailored could enhance awareness and utilization among non-English-speaking populations.[18] Age-related differences in FI were also evident, with the highest prevalence among individuals 45-59 years of age (22.6%) and the lowest among those ≥60 (11.3%). The higher rates in middle-aged groups may be related to economic pressures, employment instability, and health issues that impact their ability to secure adequate nutrition.[19] For seniors, increased social support (eg, such as through increased asset limits for Supplemental Nutrition Assistance Program eligibility) likely contributed to their relatively lower rates of FI.[20]

Effectiveness of the Food Resource Guide Intervention

The implementation of the food resource referral intervention demonstrated a significant reduction in FI scores among participants. Participants saw their mean FI score decrease from 6.67 to 4.75 within three weeks, which stabilized at 4.25 during the six-week follow-up. While the initial drop from enrollment to both follow-ups was statistically significant, the slight decrease from 4.75 to 4.25 between the three- and six-week follow-ups was not significant. Notably, RAs did not actively advocate for referral usage during follow-up calls. Enhancing follow-up interventions by incorporating personalized support, such as assistance with resource navigation or scheduling visits to food pantries, could further improve outcomes. Previous studies have shown that active follow-up and collaboration by community health workers can lead to significant improvements in social determinants of health.[21, 22] Particularly, *promotoras de salud* (community health workers) in Hispanic communities have been effective in building trust and facilitating access to resources to overcome health barriers.[23, 24] Implementing similar strategies may increase the effectiveness of FI interventions in the ED setting.

Although the unadjusted analysis indicated that participants who used the paper referral guide experienced greater reductions in FI scores than non-users ($P = 0.03$), the multiple linear regression analysis revealed that this

Table 3. Barriers to use of food assistance resources.

Theme code	Example quote from notes taken during phone follow-up conversation	% of Patient interviews including theme (N=128)
Time Constraints	"Haven't had the time yet" "Busy with work" "Busy with school and other things" "Homeless, so has not had time to go"	20.31% (n=26)
Transportation Issues	"Homeless, so no transportation" "Don't have a car" "Transportation Issues"	16.41% (n= 21)
Not Needed Anymore	"I do not need it anymore" "Using EBT at the moment but will still use food pantries in the future" "Already have it covered by psychiatric coverage"	15.63% (n=20)
Health Issues/Medical Recovery	"Sick often" "Been recovering from treatment, sleeping a lot, feels weak" "Admitted to the hospital again and did not feel healthy enough to go out." "In a rehabilitation facility at the moment"	14.06% (n=18)
Didn't Receive or Lost Referral	"Claims did not receive the food pantry listing, wants us to mail" "Claims did not receive the paper" "Did not know about referral"	12.5% (n=16)
Forgot About Referral	"Forgot about it" "Forgot it at the hospital" "Forgot about it because of medication"	8.59% (n=11)
External Life Circumstances	"Staying in a shelter" "Just became homeless/evicted" "Not mobile but has the printout."	6.25% (n=8)
Uncertainty About Use	"Said she got a job, may or may not use the service, we can call her back but she sounded like she might not really use it" "May or may not use it" "Still unsure about using the referral"	6.25% (n=8)

EBT, Electronic Benefits Transfer.

difference was not statistically significant after accounting for baseline differences, age, socioeconomic status, and other relevant factors (β -0.649, SE 0.645, t -1.006, P = 0.316). This suggests that the paper referral guide, on its own, may not have been the primary driver behind the reduction in FI scores. However, the regression analysis showed that participants with higher baseline FI scores were more likely to experience greater reductions in FI (β -0.655, SE 0.095, t -6.907, $P < 0.001$), indicating that individuals with higher levels of FI at enrollment tended to benefit the most from the intervention. Overall, the improvements in FI scores appear to be primarily explained by participants' higher initial FI levels rather than by guide use alone, suggesting that individuals with the greatest need for food resources experienced the most substantial improvements from the intervention.

The multiple linear regression analysis revealed that ethnicity also played an important role in FI score reductions, with Hispanic or Latino/a participants experiencing significantly greater improvements compared to White non-Hispanic participants (β -1.284, SE 0.615, t -2.087, P = 0.039). This suggests that Hispanic or Latino/a individuals may have responded particularly well to the intervention or that other unmeasured factors, such as differences in community support or resource utilization, might have influenced these outcomes.

Barriers to Use of Food Assistance Resources

Of the 163 three-week follow-ups completed, only 35 participants cited specifically using the paper food resource guide since leaving the ED. Thus, understanding the barriers to using those assistance resources is crucial. The most common barrier identified among patients who didn't use the paper guide was time constraints (20.31%). These time constraints could be related to an intersection of socioeconomic constraints, such as having multiple jobs and family responsibilities.[25, 26] Additionally cited barriers reflect other social determinants of health, such as transportation issues (16.41%), which have been shown to correlate with FI.[27] Providing transportation support or partnering with local organizations to deliver food could minimize these barriers. Programs that offer tailored home delivery services such as grocery bags or the Meals on Wheels program for seniors have been shown to increase access to food assistance for those with similar barriers.[28-30] Many outpatient clinics have demonstrated success in reducing FI through food prescription programs.[31,32] Implementing hospital-based

prescriptive food services could help bridge some of the gaps observed in this study.[33]

A notable portion of guide non-users cited losing the referral or not recalling receiving it in the first place (12.5%), pointing to a need for more reliable delivery of food assistance information. These challenges highlight the necessity for a more systematic and technology-driven approach in delivering food resources to patients with FI. Given that this study is among several that have successfully screened ED patients for FI using the Hunger Vital Sign,[2, 34] future strategies should consider incorporating universal food security screening during ED intake, using electronic health records (EHR) to streamline the process. Some prominent EHR systems, such as Epic's Foundation System (Epic Systems Corporation, Verona WI) have already integrated the Hunger Vital Sign screener,[35] making it feasible to conveniently assess all patients. Patients identified as food insecure through universal screening could then be automatically flagged to receive resource referral guides included in their discharge papers, or even through scheduled follow-up texts and/or emails. This approach would standardize the screening and intervention process, reducing the chance of human error (such as patients not receiving the guide) and potentially increasing the use of available food resources.

LIMITATIONS

This study has several limitations that should be considered when interpreting the results. First, as a single-center observational study, the findings may not be generalizable to other settings or populations. The study was conducted at one urban, academic ED, and the sample may not represent the broader population of ED patients or those in different geographic areas. Another notable limitation is the lack of a formal control group. Because participants who received the food resource referral were not compared directly against a similar group without the intervention, it remains uncertain whether the observed reductions in FI scores can be fully attributed to the referral program. External unmeasured factors, such as shifts in employment or economic fluctuations, may also have influenced reductions in FI. As a result, we cannot definitively conclude that the referral alone caused the decrease in FI scores.

Additionally, attrition throughout the study was high, which may affect both the magnitude and direction of FI score reductions. Although we targeted at least 95 participants for the USDA Adult Food Security Survey Module, only 161 (25.6%) of the 630 enrolled patients completed the three-week follow-up phone calls, and 48 (7.6%) completed the six-week follow-up. This low follow-up rate not only reduces the overall sample size but also introduces the possibility of attrition bias: it is possible that those who continued in the study either experienced greater improvements (making our observed results more optimistic) or were, conversely, more motivated to respond due to persistent challenges (leading to an underestimation of potential improvements). Although baseline demographics between respondents and non-respondents were compared to partially assess non-response bias, the inability to perform wave analysis and additional follow-up assessments limited our capacity to fully evaluate how attrition might have skewed the results.

The reliance on verbal administration of the screening questions may have affected the accuracy of the responses. Previous literature suggests that written questionnaires during administration of the Hunger Vital Sign may yield more accurate responses due to increased patient comfort and privacy.[36] This could have influenced the identification of food-insecure individuals. Screening was also limited by language barriers. Due to limited availability of bilingual RAs, Spanish speakers were under-screened, and patients who spoke other languages were rarely screened due to their exclusion from full enrollment. In an area as linguistically diverse as Orange County,[37] this limits the generalizability of certain results and suggests that language-inclusive strategies are necessary for comprehensive screening. This is reflective of the overall limitation of the study's reliance on convenience sampling, which is less generalizable compared to random sampling or universal screening.

Finally, assessment of the food resource intervention was held back by limitations. The follow-up questions were adapted from the USDA Adult Food Security Survey Module to assess food security over the previous three weeks. However, the module is generally validated for a 12-month period.[38] This adaptation may have affected the validity of the results. It should be noted, too, that the follow-up periods of three and six weeks were relatively short compared to the persistent nature of FI.[39]

CONCLUSION

This study reaffirmed the persistent issue of food insecurity among ED patients, particularly within vulnerable demographics. The implementation of an ED-based food resource referral guide was associated with a significant decrease in FI scores, demonstrating its potential effectiveness as an intervention. However, barriers such as time constraints and transportation issues emphasize the need for more personalized and systematic support systems. Future strategies could incorporate universal food security screening during ED intake and offer personalized follow-up interventions to address these nuanced barriers and improve outcomes for food-insecure individuals.

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Exposure to Community Violence and Adverse Childhood Experiences in the Emergency Department

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Introduction: Adverse childhood experiences (ACEs) and exposure to community violence are public health issues linked to negative mental and physical health outcomes. The emergency department (ED) can play a critical role in the care of patients with a history of trauma exposure. Unfortunately, patients' experiences often go unidentified, leading to missed opportunities to address and prevent further harm.

Methods: We administered a 22-question survey of trauma exposure in ED patients to 1) identify the prevalence of exposure to community violence and ACEs and resulting post-traumatic stress disorder (PTSD) symptoms, and 2) determine perceived social service needs. This self-administered survey study was conducted on a convenience sample of 267 adult patients at one academic hospital in Chicago, IL, between July 2018–December 2019. This ED sees approximately 70,000 patients annually. These were fluent English-speaking patients who were non-critically ill or altered and chosen randomly after being assigned to an ED room, typically during regular business hours based on research associate availability. They were not offered compensation for study participation. The survey included demographic information and questions modified from the Adverse Childhood Experiences Study questionnaire, the 54-item Survey of Exposure to Community Violence, and the Primary Care PTSD screen. Participants were also asked to identify resources to address their exposure to trauma.

Results: Of 268 surveys, 267 were completed; 88% of participants endorsed exposure to ACEs or community violence (95% confidence interval [CI] 84.1-91.9%, $p < 0.001$ compared to general US population rate of 61%). A total of 53.6% of respondents endorsed exposure to at least one ACE (95% CI, 47.6-59.6%), and 15.7% were exposed to ≥4 ACE (95% CI, 11.3-20.1%). The most commonly endorsed categories of ACE were "emotional neglect" (30.3%, 95% CI 24.8%-35.8%); "emotional abuse" (25.8%, 95% CI 20.6%-31.1%); and "exposure to family substance use" (21%, 95% CI 16.1%-25.9%). When asked about personal experience with violence in the community, 47.9% said they had been shoved, kicked or punched (95% CI 41.9%-53.9%), 8% had been stabbed (95% CI 4.8%-11.3%), and 6.7% had been shot (95% CI 3.7%-9.7%). Among the survey participants, 26.2% said they had seen someone die from violence either in their home or in their neighborhood (95% CI 20.9%-31.5%). ZIP Code analysis indicates that most patients resided in neighborhoods near our ED and were likely to utilize it for medical care. Of respondents with exposure to trauma 38% asked for resources through their primary care clinic (95% CI 32.2%-43.8%), while 77.4% asked for resources through faith-based organizations (95% CI 72.4%-82.4%).

Conclusion: These findings suggest that most respondents in the ED have experienced trauma, and many are interested in community and clinical resources. These results demonstrate the need for trauma-informed screening in the ED and support for institutional and community-level interventions to address patient experiences. [West J Emerg Med. 2025;26(3):406–412.]

INTRODUCTION

Exposure to trauma is a public health issue for adults and children. The emergency department (ED) plays a critical role in caring for patients potentially exposed to trauma. Research has shown that lower socioeconomic status is associated with experiencing and witnessing violence and trauma, particularly for minority communities.[1-3] Patients with lower socioeconomic status have shown a preference for the acute care hospital setting, such as the ED, for medical care compared to ambulatory services due to better access and perceived higher quality of care.[4] A cross-sectional study of urban ED visits showed a significant increase in pediatric mental health-related ED encounters after exposure to neighborhood gun violence, particularly within two weeks of the shooting and among children living within four to five blocks from the incident.[5]

A study of adults with moderate to severe asthma living in low-income urban neighborhoods demonstrated that violence-exposed participants had 2.27 times more asthma-related ED visits and 2.49 times more asthma-related hospitalizations. Overall, the participants had 1.71 times more ED visits per month.[2] The ED already plays an important role in the identification and prevention of certain health-related behaviors, such as substance use, tobacco smoking, high-risk sexual practices, and intimate partner violence.[6-9] Zun et al[10] demonstrated reduced self-reported re-injury rates among victims of interpersonal violence who received interventions in the ED. Generally, however, the ED care experience for patients with a history of trauma is mixed, prompting the need for additional training and implementation of trauma and violence-informed care (TVIC) among emergency clinicians.[11] Lack of TVIC and adequate patient care plans including TVIC principles may lead to missed opportunities to address and prevent further mental, physical, and emotional harm in susceptible individuals.

We performed a survey of trauma exposure in patients presenting to the Rush University Medical Center (RUMC) ED. An academic medical center located in the Illinois Medical District in Chicago's near West Side, RUMC includes a 671-bed hospital serving adults and children from the City of Chicago and its eight surrounding counties. The ED delivers care to 70,000 patients per year.

Population Health Research Capsule

What do we already know about this issue?
Trauma exposure, including adverse childhood experiences (ACEs) and community violence, is a public health issue with significant mental and physical health impacts.

What was the research question?
What are the prevalence and effects of trauma exposure in emergency department (ED) patients, and what resources do they need?

What was the major finding of the study?
88% of ED patients reported exposure to ACEs or community violence, demonstrating widespread trauma in this population ($P<0.0001$).

How does this improve population health?
Findings highlight the need for trauma-informed care and targeted community resources to address trauma in underserved populations.

METHODS

This prospective and self-administered survey study was performed on a convenience sample of patients in the ED of an urban academic medical center between July 2018–December 2019. The survey was only distributed in English. Patients who were approached were chosen randomly after they had been assigned a room in the ED. Patients were offered the survey based on the inclusion and exclusion criteria. They were not offered compensation for study participation. Inclusion criteria for the study were >18 years of age, ability to self-administer the survey, and ability to read and understand English. Exclusion criteria were <18 years of age, inability to self-administer the test, altered mental status, critical illness, and inability to read and understand English.

Patients were told that the survey was voluntary and would not affect their care in the ED since research staff were not members of their care team. Patients were informed that the paper survey itself would not contain any identifying information but that the patient's medical record number, ZIP Code, and chief complaint for that visit would be extracted from their chart. They were offered a written consent form if they agreed to take the survey, which was reviewed and approved by the medical center's institutional review board. Due to the sensitive nature of the questions, patients were informed of the survey content and that they could discontinue participation at any time.

Study participants were left alone by study staff to complete the survey. Once completed, the surveys were collected by study staff, along with the medical record numbers of study participants to verify the ZIP Code and chief complaint for the ED visit that day. Survey responses were transferred from paper to the password-secured, online platform RedCap (Research Electronic Data Capture hosted at Rush University Medical Center) by the principal investigator (PI) and a study staff member. Responses transferred by the study staff member were reviewed by the PI for accuracy.

Survey Design

The survey contained 22 questions. The first three questions collected demographic information such as date of birth, race, and sex. The next four questions were borrowed and modified from the Adverse Childhood Experiences Study questionnaire.[12-13] These questions cover childhood abuse, neglect, and household dysfunction. The questions were modified only so that they could be presented in a condensed format in our survey. The next eight questions covered exposure to community violence and were borrowed and modified from the 54-item Survey of Exposure to Community Violence developed by Richters and Saltzman.[14] These were followed by four questions from the Primary Care Post-Traumatic Stress Syndrome (PC-PTSD) screen.[15] The final questions asked the study participant to identify the need for resources and specify resources they would find helpful in light of their exposure to trauma.

RESULTS

A total of 268 surveys were administered, and 267 were completed. As shown in Figure 1, 135 respondents (50.5%) identified as Black, 53 (19.8%) identified as Hispanic, 61 (22.8%) identified as non-Hispanic White, 7 (2.6%) identified as Asian, and 9 (3.3%) identified as other. Of the respondents, 165 (61.8%) identified as female and 96 (36%) identified as male, with one identifying as other. Two respondents did not answer this question specific to demographics.

Adverse Childhood Experiences

As seen in Figure 2, 143 respondents (53.6%) endorsed exposure to *at least* one adverse childhood experience. Forty-two (15.7%) endorsed exposure to one ACE (95% confidence interval [CI] 47.6-59.6%); 34 (12.7%) endorsed exposure to two ACEs; 25 (9.36%) were exposed to three ACEs; 14 (5.2%) were exposed to four ACEs; 16 (5.99%) were exposed to five ACEs; 2 (0.75%) were exposed to six ACEs; 5 (1.87%) were exposed to seven ACEs; 4 (1.5%) were exposed to eight; and 1 (0.37%) was exposed to nine ACEs. 15.7% of total respondents were exposed to 4 or more ACEs (95% CI, 11.3-20.1%). The most commonly-identified ACEs categories were "emotional neglect" (81, 30.3%; 95% CI 24-35.8%), psychological trauma" (69, 25.8%; 95% CI 20.6%-31.1%), and "exposure to family substance use" (56, 21%; 95% CI 16.1%-25.9%).

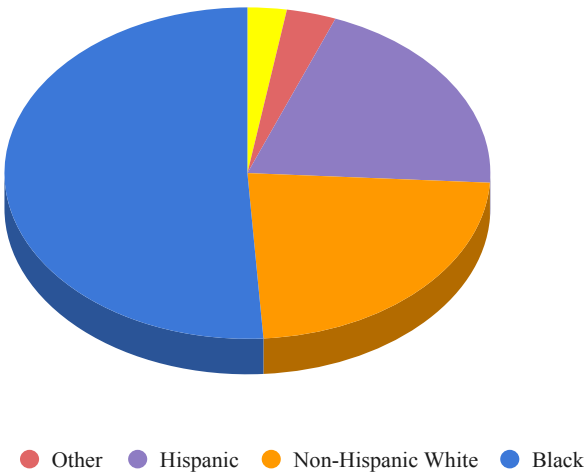

Figure 1. Demographics of 267 survey respondents: 135 (51%) self-identified as Black, 53 (19.8%) Hispanic, 61 (22.8%) non-Hispanic White, 7 (2.6%) Asian, and 9 (3.3%) other. Two survey respondents did not answer this specific question.

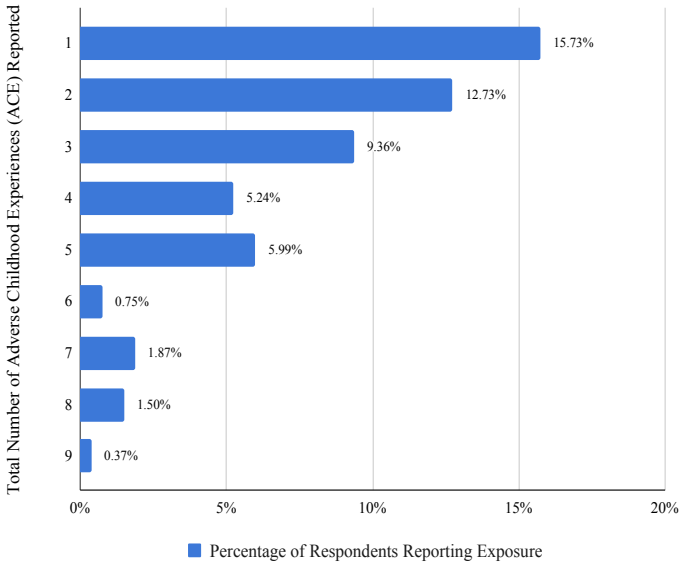

Figure 2. Percentage of survey respondents who reported the number of times they had experienced exposure to adverse childhood experiences (ACEs). Of all 267 respondents, 53.6% experienced at least one ACEs exposure.

Exposure to Community Violence

A total of 213 (79.8%) respondents endorsed hearing gunshots in their communities, which is seen in Figure 3. When asked about witnessing violence in the community, 176 (66%) said they had seen someone shoved, kicked, or punched, 57 (21.3%) had seen someone stabbed, and 28.1% (75) had seen someone shot. 70 (26.2%) of ED patients who responded to our survey said they had seen someone die from violence either in their home or in their neighborhood (95% CI, 20.9%-31.5%). Seventy ED patients who responded to our survey (26.2%) said they had seen someone die from violence either in their home or in their neighborhood (95% CI, 20.9-31.5%). When asked about personal experience with violence in the community, 128 (47.9%) said they had been shoved, kicked, or punched (95% CI, 41.9-53.9%), 22 (8%) had been stabbed (95% CI, 4.8-11.3%), and 18 (6.7%) had been shot (95% CI, 3.7-9.7%).

Patients provided their ZIP Codes as part of their demographic information. Figure 4 shows the most frequent ZIP Codes where patients endorsed exposure to violence. The blue bar denotes the total number of patients surveyed from that ZIP Code, and the red bar denotes the number of patients

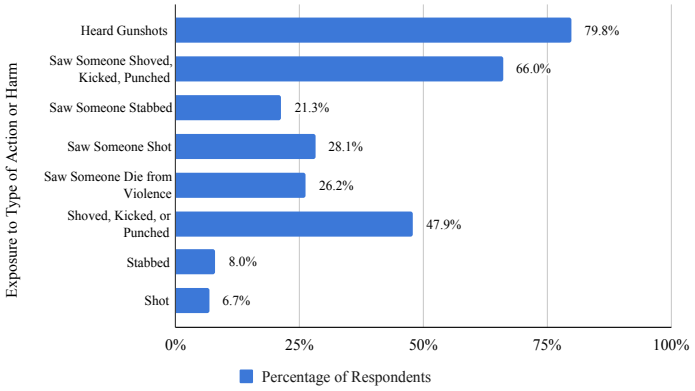

Figure 3. Percentage of respondents' exposure to community violence based on the type of action or harm.

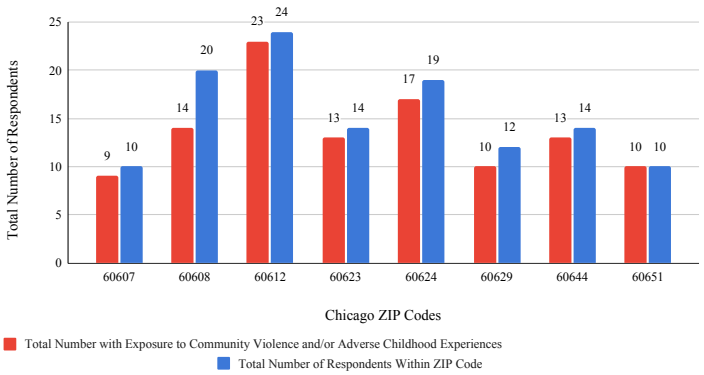

Figure 4. Number of survey respondents with exposure to community violence and/or adverse childhood experiences (ACE) and their respective Chicago ZIP Codes, which are located within the west and south sides of Chicago. The blue bar denotes the total number of patients surveyed from that Zip Code, and the red bar denotes the number of patients who endorsed exposure to community violence and ACEs.

who endorsed exposure to community violence. At least 70% of respondents from all provided ZIP Codes reported exposure to violence.

Post-Traumatic Stress Disorder Screen

Patients were asked to answer the PTSD screen based on their responses to the ACEs and community violence questions, a shown in Figure 5. Of 267 respondents, 235 (88%) endorsed exposure to ACEs or community violence ($p < 0.001$ compared to general US population rate of 61%)[17]. Of these 235 respondents, 28 (12%) endorsed having nightmares in the prior month; 81 (34.5%) endorsed avoiding certain situations that reminded them of their past experiences; 93 (40%) endorsed frequently being on their guard, watchful or

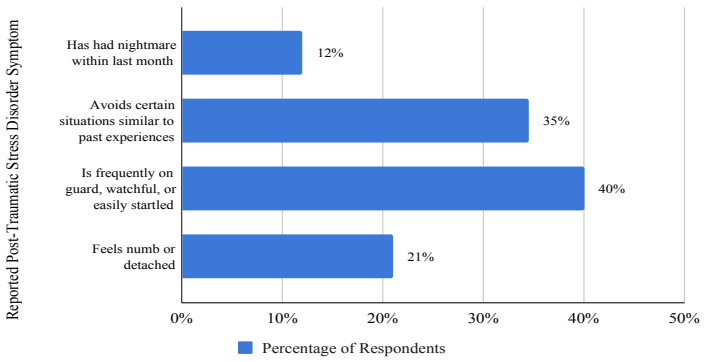

Figure 5. Of 267 respondents, 88% reported exposure to at least one adverse childhood experience or community violence. Of these respondents, 235 (88%) reported post-traumatic stress disorder symptoms as described above.

easily startled; and 49 (21%) endorsed feeling numb or detached from others, their surroundings or situations.

Access to Resources

The last part of the survey asked respondents whether they would be interested in resources to cope with their experiences and to specify what type of resources in which they would be interested, shown in Figure 6. They were provided some choices and space for free-text responses. Of the 235 survey respondents with exposure to ACEs or community violence, 89 (38%) asked for resources through their primary care clinic (95% CI, 32.2-43.8%). Specifically, 34 (14.5%) said it would be helpful to discuss their concerns with their primary care doctor, and 55 (23.4%) said it would be helpful if their primary care doctor asked them about how they were coping in addition to asking their usual medical questions.

A total of 182 (77.4%) respondents asked for resources through faith-based organizations (95% CI, 72.4-82.4%); 46 (20%) said they would like to speak to a pastor/priest; 53 (22.6%) said they would find it helpful to attend church; 40 (17%) said they would find Bible study class helpful; and 43 (18.3%) said that they would find it helpful to have opportunities to discuss their trauma experiences in a church setting. Of the 115 respondents (49%) who chose mental health organizations as a resource, 69 (29.4%) said it would be helpful to speak with a social worker, therapist, or counselor, and 46 (20%) said it would be helpful to meet with mental health professionals to discuss their trauma experiences. Finally, 46 (20%) respondents said it would be helpful to speak with a community member with similar experiences.

DISCUSSION

We set out to survey a sample of patients in our ED to better understand ACEs, exposure to community violence,

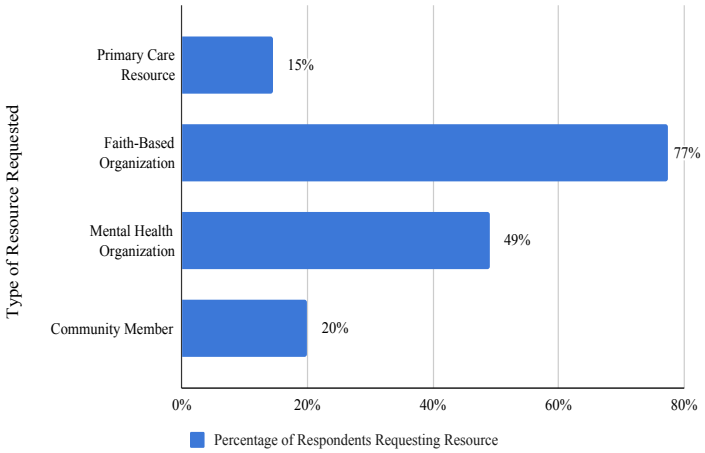

Figure 6. Thirty-eight percent of all respondents with at least one adverse childhood experience requested resources involving primary care clinics (e.g., discussion with primary care physician), faith-based organizations (e.g., discussion with pastor/priest, church attendance, Bible study participation), mental health organizations (e.g., discussion with social worker, counselor), and/or community member support.

symptoms of PTSD, and the resource needs in our patient population. We created a 22-question survey that included abbreviated forms of the Adverse Childhood Experiences survey, the 54-item Survey of Exposure to Community Violence, and the Primary Care PTSD screening survey.

Adverse Childhood Experiences

The ACEs section of our survey included the categories of experiences first identified by Felitti and Anda in their seminal study.[12] The first three categories pertain to personal exposure to abuse, including physical abuse, emotional abuse, and sexual abuse. The next categories pertain to neglect, including physical and emotional neglect. The final categories pertain to household dysfunction such as seeing one's mother abused or living with someone who used alcohol or illicit drugs, went to prison, or suffered from mental health issues. Similar to the original ACEs study and subsequent others, our study revealed that more than half of respondents had been exposed to ≥1 ACEs. However, 15.7% of respondents endorsed exposure to ≥4 ACEs, much higher than the 6.2% reported in the original study.

This is particularly important given that the study conducted by Felitti noted a graded relationship between number of childhood exposures and adult health risk behaviors and conditions studied: participants with ≥four childhood exposure categories vs none had a 4- to 12-fold increased risk of alcoholism, substance use disorder, depression, and suicide attempts as well as a 2- to 4-fold increased risk of smoking, poor self-rated health, ≥50 sexual partners, and sexually transmitted disease. An increase in the number of categories of ACEs was associated with an increase in the presence of multiple risk factors in adulthood, including ischemic heart disease, cancer, chronic lung disease, fractures, and liver disease. Thus, identifying those with the highest risk of poor health outcomes (eg, exposure to ≥4 ACEs) would allow a more targeted approach to improve care and allot resources for these groups of individuals. The most common ACEs categories identified by our respondents were "emotional neglect" (81, 30.3%); "emotional abuse" (69, 25.8%); and "exposure to family substance use" (56, 21%). The least prevalent category endorsed by our respondents was exposure to sexual abuse (19, 7.1%).

Community Violence

The next section of our survey included questions divided into witnessing and having personal experiences with violence in the community. Almost 80% of respondents reported that they have heard gunshots in their neighborhoods. More than a quarter had seen someone die from violence, with 21% endorsing seeing someone stabbed and 28% endorsing seeing someone shot in their community. Almost half of respondents endorsed having personal experience with violence in their communities, including being shoved, kicked, or punched.

We examined the ZIP Codes of respondents and found that the highest frequency of ZIP Codes correlated with the greatest exposure to community violence. Most of these ZIP Codes are located on the west side of Chicago and include the communities that we traditionally serve, thus highlighting areas that may benefit from additional medical resources. Notably, Chicago is one of the most segregated cities in the US, and while there have been strides in integration, many neighborhoods remain divided by racial/ethnic and income lines. A large portion of the Black and Hispanic population live on the west and south sides of Chicago, which include University Village (60607), Pilsen (60608), Near West Side (60612), South Lawndale (60623), West Garfield (60624), Chicago Lawn (60629), Austin (60644), and Humboldt Park (60651). These areas have faced disinvestment, crime, and acceleration of health disparities at higher rates.

People from these communities also tend to use the ED more often. According to the Cook County Department of Public Health, South Lawndale (60623) had a 2,797 count of avoidable visits to the ED, while having a primary care physician rate of 75.6 ±7.2% of adults compared to Chicago's overall rate of 81.1. It stands to reason that if the communities from which the most patients frequent our ED are also experiencing the highest levels of community violence, we have an opportunity to intervene with both medical- and trauma-informed care resources within and outside of the institution.

Post-Traumatic Stress Disorder

We looked at the responses to the PTSD screen of the respondents with ACEs or exposure to community violence. Many of these respondents were experiencing psychological

effects of their exposure at the time of the survey, including feeling guarded or watchful, feeling numb or detached, and avoiding certain triggering situations. These results suggest that many of our patients are experiencing the effects of trauma while also being in vulnerable and challenging situations in the ED. This data should encourage more education and enforcement of trauma-informed care in the ED setting.

Resources

The majority of respondents with exposure to ACEs or community violence wanted more resources through faith-based organizations. Almost half wanted assistance through mental health organizations and more than a third wanted resources through primary care clinics. More than a fifth of respondents wanted their primary care physician to include questions about coping with trauma exposure in their medical evaluation. These results suggest that while many patients are interested in resources in their communities, there is an opportunity within primary care settings to identify trauma exposure and offer resources.

LIMITATIONS

There are many limitations to this study. While we interviewed a sample of ED patients, we had to exclude patients who were critically ill or had language barriers, which excluded a significant portion of patients who used the ED. Additionally, we recognize that convenience sampling has an inherent disadvantage, which may result in sampling bias. This was also a survey study, which could have resulted in reporting and recall bias. We acknowledge that this was a small sample size; however, our study came to a halt as COVID-19 measures were put in place and many nonclinical activities were discontinued.

The combination of the three validated surveys has not been validated. While we suspect an association between ACEs, exposure to community violence, and PTSD, an analysis of possible interdependent relationships between these experiences was not the aim of the study. We believe that further research is warranted given that the aforementioned respective studies on each (ACEs, exposure to community violence, PTSD) suggest negative impacts on longitudinal patient health outcomes.

CONCLUSION

Our survey study revealed that more than half of respondents had been exposed to ≥1 adverse childhood experiences, similar to the original ACE study. However, a far larger proportion was found to have exposure to ≥4 ACEs, while half of all respondents endorsed personal experience with community violence. Of all those exposed to ACEs and community violence, 88% experienced symptoms of PTSD, thus highlighting the importance of trauma-informed care in the ED along with resource allocation and attention toward disproportionately affected communities.

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Legislating Fear: How Immigration Status Mandates Threaten Public Health

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A mother hesitates in a Texas emergency department, cradling her feverish child, unsure whether to proceed with treatment. Her fear isn't just about the illness—it's about the question she knows the hospital will ask: "What is your citizenship status?"

With the implementation of Executive Order GA-46 in Texas and Florida's Senate Bill 1718 earlier this year, such fears have become widespread. These laws mandate that hospitals gather immigration status information from patients upon admission or registration. Proponents claim this ensures accountability for public resources, but the truth is far more complex and potentially harmful.

Contrary to the assumptions underpinning these policies, undocumented immigrants use healthcare services far less frequently than US citizens or other migrant groups. Research by Pourat et al revealed that California's undocumented population accessed significantly fewer health services compared to US-born residents.[1] Another study demonstrated that immigrants, whether documented or not, incur lower per capita healthcare expenditures than their US-born counterparts. Annual expenditures were $1,629 per undocumented immigrant, $3,795 per documented immigrants, and $6,088 per US-born individual.[2] These findings counter the myth that immigrants disproportionately burden the healthcare system. Furthermore, these policies burden the healthcare system by increasing costs to hospitals. According to Florida Bill 1718, hospitals will be required to collect data, provide analysis, and generate both quarterly and annual reports. This data collection and analysis require both human and financial resources. For institutions operating at low margins such as rural hospitals or safety-net hospitals, these policies place undue strain and provide questionable benefit.[3]

The harm caused by these laws at all levels is undeniable. Health and social disparities already disproportionately affect undocumented families, who face higher barriers to care. Studies show that these populations experience worse physical and mental health outcomes compared to the general US population.[4] Laws targeting immigrant communities exacerbate these disparities, creating an environment of fear that discourages them from seeking care, even in life-threatening emergencies.[5]

Supporters of these policies argue that patients are not required to answer questions about their immigration status and that responses remain confidential under HIPAA. However, this reassurance often fails to reach the patient. Patients may not understand their rights, and the very act of asking these questions can sow mistrust. Delayed or forgone care due to fear can lead to worsened health outcomes, driving up costs for more severe and complex treatments.[6]

These laws impact not only undocumented adults but entire families. In Texas, more than one million US-born children live in households with at least one undocumented family member. When parents feel discouraged from seeking medical care, it can place their children's health at risk as well.[7] Such policies disproportionately affect our most vulnerable populations, posing challenges to individual lives and the well-being of entire communities.

Hospitals, as trusted institutions, are deeply affected by these challenges. Trust forms the backbone of public health, and its erosion can have widespread consequences for communities. Access to care should not be limited by immigration status. As physicians, our ethical responsibilities guide us to protect and advocate for all patients, regardless of their legal status.[8] Our mission rises above political differences, grounded in the shared need for equitable and compassionate care.

To mitigate the harm caused by these laws, we propose the following immediate actions:

1. **Standardized Messaging:** Develop hospital-wide policies and training for staff to ask citizenship questions in a non-threatening, scripted manner. For instance: "You are not required to answer, and this is a question we ask everyone: Are you a citizen of the United States?" National physician organizations, such as the American Medical Association, should issue clear

guidelines for implementing these laws ethically.
2. **Interpreter Training:** Train interpreters to deliver sensitive information in a culturally appropriate and non-judgmental way, ensuring equitable communication for patients with limited English proficiency.
3. **Community Outreach:** Collaborate with local organizations to educate communities about their rights, emphasizing that patients are entitled to emergency care regardless of immigration status.
4. **Patient Education:** Provide multilingual informational sheets or badges explaining the new laws and patients' rights and display them prominently in hospitals and clinics.
5. **Community Partnerships:** Work with advocacy groups and pro bono organizations to disseminate accurate information and provide resources for undocumented patients.
6. **Data Transparency:** Advocate for access to the data collected under these mandates. If this data is to be gathered, it should serve public health goals, enabling physicians and policymakers to better understand trends and improve care for underserved populations.

These measures are an important step forward, but much more needs to be done. A lasting solution requires dismantling policies that create barriers to healthcare for vulnerable communities. As medical professionals, we are guided by the principles of beneficence, nonmaleficence, and justice. To truly honor these values, we may need to extend our advocacy beyond the clinic, emergency department, or operating room and engage with our communities. Our voices carry weight, and we must continue to affirm that immigration status should never stand in the way of accessing care.

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Evaluation of Disparities in Emergency Department Admission and Wait Times for Non-English Preferred Patients

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Introduction: Patients who prefer to communicate in a language other than English are vulnerable to the consequences of medical communication barriers. Studies of non-English language preferred (NELP) and English language preferred (ELP) patients have shown differences in rates of hospital admission and wait times—factors known to be related to increased costs and lower patient satisfaction. However, few studies include languages other than Spanish or account for patient acuity level.

Methods: We performed a retrospective cohort study at an urban, Level I trauma center from January–December 2020. Patients were grouped by language preference, with NELP languages grouped into three categories: Spanish; Chinese (Mandarin, Cantonese, Taishanese, Taiwanese, and Zhongshan-Chinese dialect); and other (all other remaining languages). We extracted age, sex, race, ethnicity, language preference, emergency department (ED) discharge disposition, and Emergency Severity Index Score (ESI) from the electronic health record. The primary outcome was the hospital admission rate. Secondary outcomes were the time from patient arrival to placement in the treatment room and the time from patient arrival to disposition. We analyzed data with chi-square tests, logistic, and linear regressions.

Results: Of the 58,079 unique ED encounters, 26.4% (15,307) patients identified as NELP. Within NELP patient encounters, 75.0% preferred Spanish, 13.9% preferred Chinese, and 11.1% preferred another language. After adjusting for age and acuity, Spanish language- and Chinese language-preferred patients were at 16% and 14% higher odds of admission, respectively (odds ratio [OR] 1.16, 95% confidence interval [CI] 1.10-1.23 and OR 1.14, CI 1.02-1.27 respectively), compared to ELP patients. NELP patients waited an average 5.4 minutes longer to be roomed (95% CI 4.46-6.29) and 15.6 minutes longer until disposition (95% CI 12.62-18.54, $P<0.05$). This discrepancy was greater for patients triaged at lower acuities, with ESI 5 Spanish language- and Chinese language-preferred patients waiting an average of 50.3 and 90.6 minutes longer than ELP patients until disposition (95% CI 17.67-83.57; and 95% CI 24.31-81.57 respectively).

Conclusion: After adjusting for acuity level and age, non-English language preferred patients were at higher odds of admission and experienced disparate wait times, especially at lower acuity levels. Further investigation is needed to understand the causes of these differences and mitigate these health inequities. [West J Emerg Med. 2025;26(3)415–424.]

INTRODUCTION

Communication between patients and physicians is an essential aspect of acute care in the emergency department (ED). Patients who prefer to communicate in a language other than English—non-English language preferred (NELP)—are vulnerable to the effects of medical communication barriers.[1,2] In the United States, 21% of the population speaks a language other than English at home, with 9% of the population reporting that they speak English less than "very well."[3] These persons often belong to communities that have historically faced health disparities including lower triage priorities and greater mortality rates in the hospital.[4] For many NELP patients, these issues manifest in the ED. Due to concerns related to factors such as cost of treatment, immigration status, and lack of consistent primary care,[5,6] the ED is often NELP patients' main point of entry into the healthcare system.[7,8] Patients' NELP status has been associated with increased admission and readmission rates for certain language groups,[4,9,10] as well as increased likelihood to have an unplanned ED return visit within 72 hours,[11] which results in additional costs to the healthcare system and potential inefficiencies in care.

In situations where patients and physicians cannot directly communicate in the same language, professional interpreters serve an important role. Interpreters increase accessibility and delivery of care for patients, and they provide superior patient education compared to language-discordant interactions.[12,13] When professional interpreters are underused in the ED, there are lower levels of patient satisfaction, fewer diagnostic procedures ordered, and increased miscommunication of discharge information.[2,14,15] Even when professional interpreters are used, miscommunication may persist.[16,17] Given the fast-paced, acute care setting of the ED, emergency physicians face resource constraints and workload strains that force quick decisions with limited information.[18] This combination of real and perceived time pressures may lead to bias, especially when added to the challenges of language-discordant care, defined as when a patient's primary spoken language differs from the primary language of the clinician.[14]

While many studies have shown racial and ethnic disparities in ED care,[4,19] there is limited research on operational differences in care between NELP patients and English language preferred (ELP) patients. Previous literature has shown that people of color experience longer mean wait times than White patients.[20,21] However, these studies do not assess language proficiency as a barrier to timely care within these diverse groups. At the same time, admission rate differences between NELP and ELP patients remain unclear, with mixed results based on acuity[22] or with a limited focus on Spanish-speaking patients.[23] In this study, we investigate differences in care between NELP and ELP patients across three operational categories: hospital admission rate; time from arrival to treatment room; and time from arrival to disposition.

Population Health Research Capsule

What do we already know about this issue?
Non-English language preferred (NELP) status is associated with increased admission, readmission rates, and likelihood of unplanned Emergency Department (ED) return visits within 72 hours.

What was the research question?
Are there operational differences in ED care for NELP patients?

What was the major finding of the study?
Spanish- and Chinese language[1]patients had 16% and 14% higher odds of admission, respectively, compared to ELP patients. At Emergency Severity Index 5 (ESI 5), NELP patients waited 52.9 minutes longer for disposition than English patients ($P<0.05$).

How does this improve population health?
With an increasing proportion of NELP patients presenting to EDs, more must be done to address disparities in wait times and admission rates.

METHODS

This retrospective cohort study uses race, ethnicity, and language (REAL) data captured from Zuckerberg San Francisco General Hospital and Trauma Center's electronic health records (EHR) (Epic Systems Corporation, Verona, WI).[24] The policy for the collection of REAL data is outlined in San Francisco Department of Public Health guidelines.[25,26] We used a report to extract parameters of interest from the EHR in bulk. The study design was reviewed and approved by University of California San Francisco Institutional Review Board (IRB). The applicable criteria of health records identified, sampling method, missing-data management plan, and IRB approval, suggested by Worster and Bledsoe,[27] were upheld in reviewing health records.

Setting

We conducted this study at an urban, Level I trauma center between January–December 2020.

Language Data Collection

Per institutional policy, ED patients are asked by ED staff during check-in about their language preference for the encounter. This preference can be changed by the patient at any time during the encounter.

Patients who reported English as their preferred language used in communicating with clinicians were marked as ELP.

Patients who chose any other language were considered NELP. We grouped the NELP languages into three categories: Spanish; Chinese (Mandarin, Cantonese, Taishanese, Taiwanese, and Zhongshan-Chinese dialect); and other (all other remaining languages). Spanish and Chinese categories reflect the largest ethnic groups treated at this site and the most common languages spoken at this center.

Healthcare encounters at this center were interpreted by certified bilingual clinicians and contracted interpretation services by qualified interpreters delivered through phone or video tablet. In-person interpretation services by qualified non-clinical staff were much more limited in both languages and hours available compared to the 24/7 remote contracted service. The frequency of use of each modality was not recorded.

Variables

Data extracted from the EHR included age, sex, race, ethnicity, language preference, chief complaint, primary diagnosis, ED discharge disposition, and Emergency Severity Index Score (ESI), which was used as a proxy for acuity. Sex, race, ethnicity, and language preference were self-reported. We also extracted times, including length of stay, time from arrival to treatment room, room to clinician, and clinician to disposition.

The primary outcome was hospital admission rate. Secondary outcomes included time from patient arrival to placement in the treatment room and time from patient arrival to disposition. We defined hospital admission rate as the rate of admission to the in-patient hospital or transfer to an acute care facility. Arrival to room was defined as the time from patient registration in the ED to when they were brought to their assigned ED room. Lastly, arrival to disposition was defined as the time from registration to disposition or discharge order.

Exclusion Criteria

Patient records that were missing an ESI score or time stamps related to time from arrival to room or arrival to disposition were not included in the analysis. We also excluded observations with any missing variables for the specific model from that model's analysis. The number of missing records for each variable are included in Appendix A.

Statistical Methods

All analyses were performed using R v4.3.3 (R Foundation for Statistical Computing, Vienna, Austria) and RStudio v2023.12.1+402 (RStudio PBC, Boston, MA). We used chi-square tests and Student's t-tests to compare the demographic characteristics of NELP and ELP patients. Chi-square tests were also used to compare the percentages of ELP vs. Spanish language preference patients who were assigned as low acuity (4-5). To examine differences between NELP and ELP patients in the hospital admission outcome, we used unadjusted and adjusted logistic regression models to estimate odds ratios (OR) with 95% confidence intervals (CI). For the two continuous time-based outcomes (arrival to room and arrival to disposition), we fitted adjusted linear regression models. All analyses used single ED encounters as the unit of observation, and all adjusted analyses controlled for patient age (<18, 40-64, 65-74, 85+ vs. 19-39), language preference (Spanish, Chinese, other vs. English), and ESI/Acuity level (2-5 vs. 1).

RESULTS

Of the 58,079 unique ED encounters in the study period, 26.4% were NELP patients (Table 1). The NELP patients were more likely to be female (47.6% vs 33.4%, $P<0.05$), slightly older (mean age 45.9 vs 45.1, $P<0.05$), and identify as non-White (81.2% vs 70.5%, $P<0.05$). Within NELP patient encounters, 75.0% preferred Spanish, 13.9% preferred Chinese, and 11.1% preferred another language (Table 1). In total, 20.7% of patients were admitted from the ED. In the unadjusted chi-square analysis, more NELP patients were admitted from the ED overall at 22.6% vs 20.0% of ELP patients admitted (Table 2) ($P<0.05$).In the unadjusted regression using language preference as the single variable (Table 3, Model 1), Spanish-language preference had lower odds of admission compared to ELP patients (odds ratio [OR] 0.91, 95% confidence interval [CI] 0.86-0.96). In contrast, patients who identified Chinese or other as their preferred language had higher odds of admission compared to ELP patients (OR 2.61, 95% CI 2.39-2.59 and OR 1.72, CI 1.55-1.91, respectively).

In the multivariate model that adjusted for age and acuity level (Table 3, Model 2), NELP patients overall had greater odds of admission. However, after adjusting for age and acuity level, Spanish language- and Chinese language-preferred patients showed increased odds of admission (OR 1.16, 95% CI 1.10-1.23 and OR 1.14, CI 1.02-1.27, respectively) compared to ELP patients ($P<0.05$). Admission rate was not significantly different from ELP patients for patients who chose another language. In the chi-square analysis, there was no statistically significant difference between the proportion of English language- vs Spanish-language preferred patients who were assigned as low acuity 4-5 ($P=0.37$).

Patients who visited the ED waited an average of 23 minutes from arrival until they were roomed. Compared to ELP patients, NELP patients waited an average 5.4 minutes longer to be roomed ($P<0.05$). By category, patients who prefer Spanish, Chinese, or other languages experienced an average increased time to arrival to room of 5.9, 3.8, and 3.4 minutes (Table 3, Model 3), respectively, compared to ELP patients ($P<0.05$).

Patients who visited the ED waited an average of 218 minutes from arrival until they received disposition. As a whole, NELP patients waited 15.6 minutes longer until disposition ($P<0.05$). Time to disposition for patients with indicated language preferences of Spanish, Chinese, and other averaged 17.2, 9.9, and 11.5 minutes longer, respectively,

Table 1. Sample characteristics by non-English language preferred (NELP) and English language preferred patients (ELP). (Total of 58,079 Encounters)

Variable	NELP	ELP	*P*-value*
	n=15,307 (26.4%)	n=42,682 (73.6%)	
Sex			<0.05
Female	47.6%	33.4%	
Male	52.4%	66.5%	
Age Category			<0.05
0-18	13.1%	4.2%	
19-39	31.2%	38.8%	
40-64	36.3%	45.3%	
65-74	9.5%	8.0%	
75-84	5.2%	2.2%	
85+	4.1%	1.3%	
Race/Ethnicity			<0.05
American Indian or Alaska Native	0.05%	1.0%	
Asian	18.4%	7.5%	
Black Or African American	0.5%	32.1%	
Native Hawaiian or Other Pacific Islander	0.3%	2.0%	
Other	3.5%	5.6%	
White	2.1%	29.5%	
Yes - Hispanic, Latino/A, Or Spanish Origin	72.3%	19.2%	
Blank	2.8%	2.5%	
Decline To Answer	0.1%	0.4%	
Language Preference			
English	-	100%	
Spanish	75.0%	-	
Chinese	13.9%	-	
Other	11.1%	-	
Emergency Severity Index/Acuity			<0.05
1	5.5%	7.1%	
2	20.3%	25.5%	
3	54.7%	46.1%	
4	18.3%	18.6%	
5	1.2%	2.8%	

P<0.05 indicates differences between ELP and NELP patients within the subgroup.
NELP, non-English language preferred; *ELP*, English language preferred.

(Table 3, Model 3) than ELP patients ($P<0.05$; $P<0.05$, $P<0.05$). The difference in time to disposition between NELP and ELP groups was wider at lower acuity levels (3, 4, and 5) (Figure 1). At these levels, the overall average time spent was 236, 148, and 94 minutes, respectively. However, at ESI 4, Spanish language- and Chinese language-preferred patients waited an additional 30.8 and 47.6 minutes of time, respectively, to disposition compared to ELP patients ($P<0.05$). At the lowest acuity ESI 5, Spanish language preferred- and Chinese language preferred-patients waited for an average of 50.3 and 90.6 minutes more than ELP patients ($P<0.05$). Other language-preferred patients' arrival to disposition times were not significant at ESIs 4-5.

DISCUSSION

In this retrospective study of the association between a patient's language preference and operational outcomes, NELP patients showed different odds of admission and treatment times compared to ELP patients. Adjusting for age and acuity level, NELP patients, as a whole, as well as those who selected Spanish and Chinese, experienced higher overall admission rates compared to ELP patients. While our findings

Table 2. Admissions data of English language preferred patients (ELP) and non-English language preferred patients (NELP) overall and by language preference (Spanish, Chinese, and Other).

Category	Percentage Admission	*P*-value*
Total	20.7%	-
English Language Preferred	20.0%	-
Non-English Language Preferred	22.6%	<0.05
Spanish (as % of all Spanish Language patients)	18.5%	<0.05
Chinese (as % of all Chinese Language patients)	39.5%	<0.05
Other (as % of all Other Language patients)	30.1%	<0.05

**P*<0.05 indicates differences between ELP compared to NELP overall and the NELP subgroups.
ELP, English language preferred; *NELP,* non-English language preferred.

were largely consistent, there was notable variation specific to the models.

The unadjusted regression that included language preference as the sole variable showed that Spanish language-preferred patients had lower odds of admission compared to ELP patients. When the variables of age and acuity level were accounted for in the multivariate model, Spanish language-preferred patients were at higher odds of admission compared to ELP patients. This trend seems to align with Schulson et al's finding that patients with limited English proficiency were more likely to be admitted to the hospital than English-proficient patients for any admission.[23] Both of our regression models showed increased odds of admission for NELP patients as a whole compared to ELP patients.

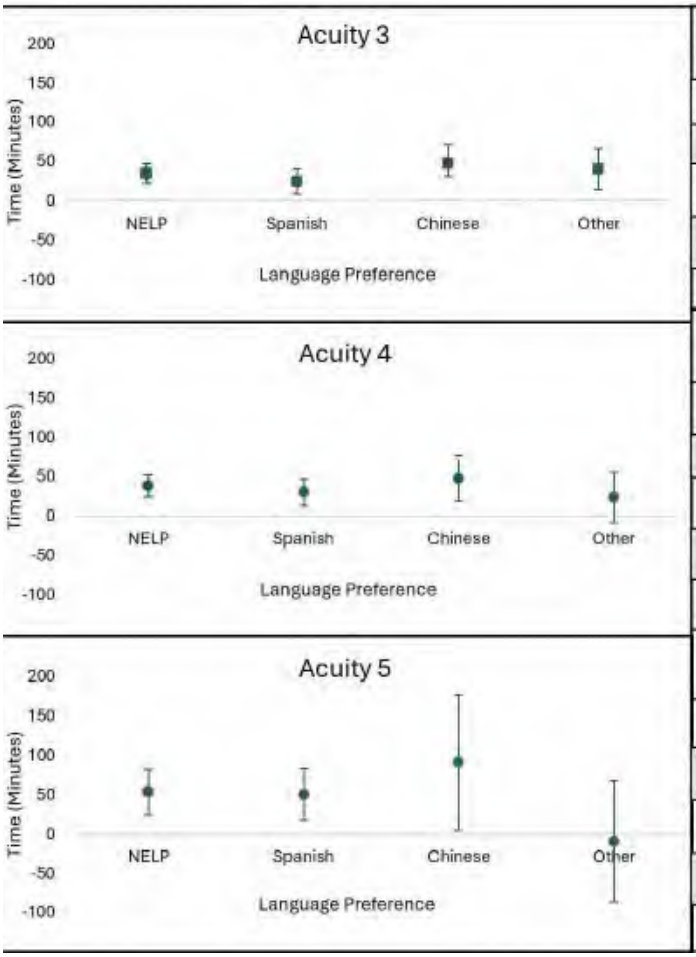
Admission decisions in the ED are informed both by the patient's clinical condition and non-medical factors. Hunter et al examined the non-medical factors that influenced clinician disposition decisions for non-critically ill patients. They found that almost half of the admission decisions for patients in their study were influenced by factors including lack of information about the patient's baseline condition, need for diagnostic testing, recent ED visits, and perceived inability to follow-up in a primary care setting.[28] All these issues affect NELP patients. Previous studies have reported that non-English speakers, even within the same racial/ethnic group, have poorer access to preventative care and insurance coverage.[7,29,30] Additionally, communication barriers that result from clinician-patient language discordance are well documented in the literature and can contribute to diagnostic uncertainty.[1,17,31]

As a percentage of its language population, Spanish language-preferred patients were admitted at a lower rate than ELP patients. One possible explanation could reflect this center's comfort in managing Spanish-speaking patients. Spanish is the most common non-English language in this community, with both in-person and phone interpretation options available. Although this study lacks the ability to track

Table 3. Differences in likelihood of hospital admission and average times for arrival to room and arrival to disposition for patients with non-English vs. English language preference, overall and by NELP category.

	Likelihood of Hospital Admission: Model 1*		Likelihood of Hospital Admission: Model 2‡	
Language	Odds Ratio	95% CI	Odds Ratio	95% CI
NELP	**1.17**	**(1.12, 1.23)**	**1.15**	**(1.093, 1.213)**
Spanish	**0.90**	**(0.859, 0.955)**	**1.16**	**(1.095, 1.233)**
Chinese	**2.61**	**(2.386, 2.857)**	**1.14**	(1.023, 1.271)
Other	**1.72**	**(1.548, 1.914)**	1.11	(0.981, 1.257)
	Time from Arrival to Room: Model 3Φ		Time from Arrival to Disposition: Model 3Φ	
Language	Coefficient (Minutes)	95% CI	Coefficient (Minutes)	
NELP	**5.38**	**(4.464-6.288)**	**15.58**	**(12.62-18.54)**
Spanish	**5.93**	**(4.916-6.950)**	**17.21**	**(13.91-20.52)**
Chinese	**3.88**	**(1.732-6.021)**	**9.90**	**(2.941-16.85)**
Other	**3.46**	**(1.113-5.802)**	**11.55**	**(3.942-19.15)**

Bold indicates statistically significant at a level of $P < 0.05$.
*Model 1 compares NELP patients, overall and by NELP category to ELP patients, unadjusted for covariates.
‡Model 2 compares NELP patients overall and by language category to ELP patients after adjusting for age and ESI/acuity level.
ΦModel 3 compares NELP patients overall and by NELP category to ELP patients after adjusting for age and ESI/acuity level.
CI, confidence interval; *NELP*, non-English language preferred; *ELP*, English language preferred.



Arrival to Disposition: Acuity 3		
Language Preference	Coefficient (Minutes)	Adjusted 95% CI
NELP*	34.80	(22.75, 46.85)
Spanish*	24.49	(8.60, 40.38)
Chinese*	47.62	(30.76, 71.81)
Other*	40.31	(13.86, 66.75)

Arrival to Disposition: Acuity 4		
Language Preference	Coefficient (Minutes)	Adjusted 95% CI
NELP*	37.98	(24.50, 51. 45)
Spanish*	30.80	(13.70, 47.91)
Chinese*	47.62	(18.38, 76.87)
Other	23.19	(-8.92, 55.31)

Arrival to Disposition: Acuity 5		
Language Preference	Coefficient (Minutes)	Adjusted 95% CI
NELP*	52.94	(24.31, 81.57)
Spanish*	50.35	(17.67, 83.57)
Chinese*	90.62	(4.80, 176.44)
Other	-10.19	(-86.98, 66.61)

Figure 1. Distributions and tables of adjusted arrival to disposition times for emergency department visits of acuity levels 3, 4, and 5 of non-English-language vs English language-preferred patients, overall and by language preference.
*Indicates statistically significant at a level of $P < .05$.
Model adjusted for age and interaction variable created between language preference and ESI/acuity levels 1-5; reference level for language preference is ELP, ESI/acuity level is 1, and age is 19-39.
CI, confidence interval; *NELP*, non-English language preferred; *ELP*, English language preferred.

the Spanish-speaking proficiency and certification level of all patient-facing ED staff members, given the area it serves, there are likely more Spanish-speaking clinicians in the ED than for any other non-English language. This increased availability of Spanish-speaking clinicians to conduct language-concordant encounters with Spanish-speaking patients likely reduces diagnostic uncertainty and allows for more discharges, as reflected by the lower patient admission rate.

For Spanish-speaking Hispanic populations, specifically, language-concordant interactions between physicians and patients have been associated with improved patient participation in treatment plans[32] and improved glycemic control.[1] Although interpreters are not direct substitutes for language concordant care,[13] when professional interpreters are used, patients receive more health education[13] and there is a lower likelihood of communication errors.[33]

Although there is a tendency to aggregate NELP patients as a monolithic group, patients with different language preferences are made up of different races and ethnicities with unique cultural attitudes, beliefs, and interactions with the healthcare system. Use of the ED by Spanish-speaking patients may be different compared to other language groups. Parast et al noted that Hispanic patients reported higher ED utilization and a more profound lack of access to primary care compared to White patients.[6] Recent national utilization trends add to this finding: ED visits among Hispanic persons <65 years of age with Medicaid increased the most compared to other races/ethnicities, from 46.3% in 2011 to 62.7% in 2021.[34] Hispanic patients who prefer Spanish may be using the ED for less severe complaints to compensate for a lack of primary care access, resulting in a lower rate of admission.

However, it is also possible that clinicians and institutions are underestimating this group's illness severity and inappropriately

discharging patients who should be admitted. A recent study by Rojas et al found that children accompanied by caregivers preferring languages other than English are more likely to be triaged as non-urgent in their pediatric ED.[35] At the race and ethnicity level, a multistate study found that severely injured Black and Hispanic trauma patients were more likely to be undertriaged than White patients.[36] Joseph et al found similar trends in the undertriage of patients and suggested that language barriers may be an underlying contributor to this disparity due to incomplete information gathering on time-pressured triage nurses.[37] However, in our study we found no significant difference between English language- and Spanish language-preferred patients who were assigned acuities 4-5 (non-urgent). This may again be due to institutional comfort with this patient population, fewer pressures on triage nurses at this center, or more conservative triage designation policies.

In contrast, Chinese and other language-preferred patients were admitted more frequently in their relative populations compared to ELP patients (39.48%, $P<0.05$ and 30.10%, $P<0.05$, respectively). At this center, these NELP languages are less common than Spanish. Fewer resources or less familiarity may encourage risk-averse physicians to conservatively admit the patient, which is supported by the consistent trend in literature of NELP patients' increased admission rates or readmissions within 30 days.[9–11,38,39] Specific linguistic and cultural differences with Chinese language-preferred patients may also help explain this admissions trend compared to Spanish language-preferred patients. Asian Americans, especially those who speak a different language than English, face similar issues to Hispanic patients in lack of access to healthcare and inconsistent medical care.[5] However, Asians as an ethnic group represent more than 100 languages/dialects compared to 99% of Hispanics with limited English proficiency who speak Spanish.[40] This linguistic diversity is an additional source of complication for physicians and interpreter services.

Chinese language-preferred patients may also rely on alternative treatments or be more conservative in seeking Western healthcare until they are ill enough to warrant admission. Clough et al noted that Asian immigrants may hold adversarial beliefs about Eastern vs Western medicine, carry social stigma around certain diseases,[41] and have attitudes that any form of healthcare (even preventative) should be withheld until symptoms are present.[42] If the presenting clinical conditions of these patients are sicker than other groups, it is understandable that they are more frequently admitted.

The odds of admission were not the only difference between ELP and NELP patients, with significant increases in the times of arrival to treatment room and arrival to disposition observed within each NELP language category. Compared to differences in rooming time, NELP patients waited much longer than ELP patients to receive disposition. This suggests discrepancies in treatment time or disposition planning for NELP patients compared to ELP patients. Inadequate capture of diagnostic information during the initial exam may force uncertain physicians to rely on additional imaging[37] and labs, thereby increasing post-room waiting times. A previous study found that Spanish-speaking and American Sign Language patients were more likely to receive imaging studies.[43] In the literature, NELP patients have been subject to increased use of radiographs, ultrasounds,[23] and even three times as much computed tomography for abdominal pain compared to English-proficient patients.[38]

These discrepancies were greatest at ESI 5 levels for Spanish-language and Chinese-language preferred patients. One reason for these disparities could be due to the nature of emergency medicine. In the ED, high-acuity and life-threatening presentations are evaluated urgently with resource-intensive algorithmic treatments.[44] In contrast, low-acuity complaints are less time-sensitive but may require extensive interviewing or other time-consuming resources. Although some of the increased length of stay could be warranted from additional time spent interviewing patients with interpreters or waiting for an interpreter to become available to provide the best care, it is unlikely that the additional 30-90 minutes that these lower acuity NELP patients waited prior to disposition could be explained entirely by ideal interpreter use. It is also possible that low-acuity patients may experience the worst versions of both physician interactions and waiting times in the ED. Saunders noted that patients in his study assigned the lowest acuities experienced the longest times simply moving through the ED yet also had brief evaluations and treatments.[44] These logistical differences could affect clinical outcomes.

Guttman et al findings show that a longer mean length of stay is associated with an increased risk of admission or short-term mortality in low-acuity patients.[45] As a result, the time disparities for low-acuity NELP patients represent not only an equity and satisfaction issue but also a potential hazard for non-urgent and emergent patients, with Luo et al contending that the resources required to treat low-acuity patients are not negligible and even may delay care for higher acuity patients.[46] These results reflect stark differences in patient experience that could become clinically significant or, at the very least, negatively affect patient satisfaction.[47,48]

In caring for NELP patients, clinicians face additional time-related challenges including obtaining the appropriate translator and waiting for them to interpret through the history-taking and counseling their patients. Ramirez et al reported that these perceived increased physician time requirements even serve as a barrier to interpreter usage in the first place.[14] However, when non-English speaking patients received inadequate counseling, they misunderstood discharge instructions, including how to manage their condition, take their medications, recognize symptoms that should prompt a return to care, and know when to follow up.[49,50]

To an extent, clinicians may be justified in their concerns, as Fagan et al found that compared to patients not requiring an interpreter, patients using a telephone interpreter had significantly longer mean clinician times.[51] However, this

difference was not appreciated with in-person interpreter services,[51] which suggests a possible solution to help mitigate this health inequity is to expand the availability of in-person services or improve existing telephone-facilitated encounters. At this study's site, telephone interpretation was by far the most common option and may be a contributor to the time disparities in disposition for NELP patients. Thus, due to real and perceived concerns over additional effort and time costs, clinicians may have been more reluctant to see low-acuity NELP patients or take longer to determine patient disposition.

LIMITATIONS

Limitations of this study include its single-center design, with institutional resources and practices potentially limiting the generalizability of the results. Lower-resourced centers, centers with less familiarity with NELP populations, or centers with more clinician-patient language concordance, would be expected to have different results. In addition, the modality of interpretation services used for these encounters (in-person clinician, non-clinician, remote contracted service) was not recorded. There is a possibility that extremes in length of stay could be due to one particular modality. We also did not control for sex, leaving it as a potential confounder. Future research should control for this variable or explore whether there are intragroup differences between sexes in NELP populations in their experiences of care.

While the most common NELP languages at this ED were grouped into Spanish and Chinese, other sites may have a different demographic makeup and feature different non-English patient languages with unique challenges and results. For statistical purposes, this study's categorization of Chinese as a language preference was the combination of many dialects. Dialects like Mandarin and Cantonese are more popular globally and, thus, interpretation services are more readily available for these dialects than one such as Taoshinese, potentially influencing physician comfort and time-based outcomes. Furthermore, inappropriate designations of NELP or ELP status, specifically inaccuracies in the EHR or inaccurate self-reporting would likely over- or underestimate the number of NELP encounters. For example, a patient may be more proficient in a non-English language but still choose English as the preferred language of their encounter. Lastly, the observational nature of this study did not lend to identifying the causes of the discussed disparities. Further studies are needed to investigate possible solutions to this health inequity.

CONCLUSION

Emergency Department patients who preferred to communicate in a language other than English were at higher odds of admission and had disparities in wait times that were especially pronounced at lower acuity levels. To improve the efficiency of ED operations and promote health equity, further investigation is needed to identify the causes of these differences, evaluate existing language interpretation options, and encourage centers to review practices that may impact the care of NELP patients. Centers should begin this investigation with the collection of accurate language interpretation data. These metrics are necessary to assess ED throughput and gauge responsiveness to the specific communities that are served.

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Validation of a Methodology to Investigate Care Inequities for Transgender Patients

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Introduction: Pain is a common chief complaint in the emergency department (ED), and there are known disparities in the management of pain among racial/ethnic minorities, women, and older adults. Transgender and gender diverse (TGD) individuals comprise another under-represented patient population in emergency medicine and are also at risk of disparities in care. To measure and evaluate the magnitude of care inequities among TGD individuals, first we need to be able to accurately identify the right cohort and comparison groups. The primary objective of this study was to establish an accurate and generalizable process for identifying TGD patients through the electronic health record (EHR). Secondary objectives included creating and validating a method for matching and comparing of TGD patients to cisgender patients.

Methods: This was a retrospective, observational cohort study that included patients presenting to Mayo Clinic EDs with a chief complaint of abdominal pain across four states (MN, WI, AZ, FL) between July 1, 2018–November 15, 2022. Patients ≥12 years of age were included. Patients' sex assigned at birth and gender identity was extracted from the EHR via patient-provided registration fields. Two independent investigators independently reviewed each medical record of the identified TGD patient to validate the accuracy of pulled gender identity. Discrepancies were resolved by a third reviewer. Each transgender patient was matched to cisgender GBQ males (gay, bisexual, queer), cisgender LBQ (lesbian, bisexual, queer) females, cisgender heterosexual males, and cisgender heterosexual females using propensity score (PS) matching. We calculated the PS values using a multivariable logistic regression model where being transgender was the outcome, and covariates in the model included age, site, mental health history, and gastrointestinal history.

Results: We initially identified 300 patients as TGD based on electronic data pull. An additional 1,000 patients were also included in the cohort for matching purposes. The agreement between electronic and manual review was 99.9%, and the kappa was 0.998 (95% confidence interval 0.994-1.000). We were able to match patients except for GBQ males due to low numbers. There is a significant difference in age between groups (P <0.001) with GBQ males being older than other groups.

Conclusion: The methodology for identifying transgender and gender diverse patients in the EHR was accurate compared to manual review of gender identity. The TGD patients were able to be well matched, except to GBQ males. This provides a validated method to identify TGD patients in the EHR and further study disparities they may receive in care. [West J Emerg Med. 2025;26(3)425–430.]

INTRODUCTION

Lesbian, gay, bisexual, transgender and queer (LGBTQ) individuals are estimated to make up between 2.3-8.0% of the North American population.[1] This group includes transgender and gender diverse (TGD) people, who account for 0.6% of the population, with higher prevalence among adolescents (1.2-4.1%).[2]

These TGD patients have greater chronic illness burden related to several domains of the social determinants of health, including societal marginalization and poverty; lack of access to healthcare, employment, and housing; and higher rates of mental illness, depression and substance use.[1] The emergency department (ED) is a health resource for vulnerable underserved populations; however, a qualitative study demonstrated that TGD patients avoid ED care due to past negative experiences.[3-7]

To measure and evaluate the magnitude of care inequities among TGD, first we need to be able to accurately identify the right cohort and comparison groups. Currently, there is no established method for identifying and statistically comparing TGD patients to a relevant comparison cohort. Previous studies involving TGD patients had significant variability in their methods. Often matching was based on different combinations of gender identity, age, sex assigned at birth, and sociodemographic factors.[8-12] Our objectives in this study were to establish an accurate and generalizable process for identifying TGD patients through the electronic health record (EHR) and create and validate methods for matching and comparing of TGD patients to cisgender, LGB, and heterosexual patients.

We focused on patients presenting with abdominal pain, a very frequent chief complaint in the ED and one that is difficult to diagnose and treat and may, therefore, be associated with care inequities. It is a condition of particular relevance to transgender people, as abdominal pain may be associated with gender-affirming surgery and gender-affirming hormone therapy.[3] Pain is the most common chief complaint in the ED, comprising over 50% of all visits and representing 80% of all referrals from clinicians.[3,13] Despite the well-documented disparities in pain management in the ED among other minority populations, there is a lack of published literature describing pain management among TGD patients.

Our objective was to establish an accurate and generalizable process for identifying TGD patients through the EHR. A secondary objective was creating and validating a method for matching and comparing of TGD patients to cisgender, LGB, and heterosexual patients.

Population Health Research Capsule

What do we already know about this issue?
Transgender and gender diverse (TGD) patients have greater chronic illness burden but avoid ED care due to past negative experiences.

What was the research question?
We sought to create an accurate and generalizable process for identifying TGD patients through the electronic health record (EHR).

What was the major finding of the study?
The agreement between electronic and manual review to identify TGD patients was 99.9%, and the kappa was 0.998 (95% CI 0.994-1.000).

How does this improve population health?
The EHR accurately identifies TGD patients, a first step in evaluating the magnitude of care inequities.

METHODS

Study Design

A protocol was written prior to study start. Content experts from gastroenterology, psychology, and endocrinology reviewed and provided feedback on this proposal. This was a retrospective, observational cohort study including patients ≥12 years of age presenting to the ED with a chief complaint of abdominal pain between May 5, 2018–November 15, 2022. The study adheres to the Strengthening of the Reporting of Observational studies in Epidemiology (STROBE) guideline.[14] The following elements of optimal retrospective chart review were followed: abstractor training; case selection criteria; variable definition; performance monitored; inter-rater reliability mentioned and tested; and medical record identified. We used sampling methods and received institutional review board approval for this research.

Setting and Participants

We included patients who presented to Mayo Clinic EDs in Minnesota, Florida, Arizona, and Mayo Clinic Health System: a total of 21 academic and community EDs. Patients who declined research authorization for medical record review were excluded. An electronic report was pulled from the EHR to identify patients who presented to the ED with abdominal pain as their chief complaint.

Variables

We identified TGD patients in the EHR (Epic Systems Corporation, Verona, WI) using patient-provided registration data and information provided by surveys sent to patients before visits. In the patient registration data patients provide

their gender (female/male/non-binary/choose not to disclose), and their sex at birth (female/male/uncertain/choose not to disclose). Based on this data, patients who reported their gender as non-binary and those whose reported sex at birth was male and gender was female (or vice-versa) were flagged as TGD patients. From the surveys sent to patients prior to visits we focused on the gender identity question, where patients are asked to select their gender identity from the following options: male, female, nonbinary or genderqueer, transgender male/female-to-male, transgender female/male-to-female, other, or choose not to disclose. Responding genderqueer, transgender male/female-to-male, or transgender female/male-to-female to this question also flagged TGD patients. Among the non-TGD/cisgender patients, we also used the sexual orientation question from the patient surveys to classify patients. Response options to this question were as follows: straight (not lesbian or gay); bisexual; lesbian or gay; pansexual; something else; or choose not to disclose. Cisgender patients were considered heterosexual if they responded "straight (not lesbian or gay)", and cisgender lesbian, gay, bisexual, queer patients were identified if their sexual orientation was listed as bisexual, lesbian, or gay.

We electronically retrieved data on sex at birth, gender identity, age, mental health, and gastrointestinal (GI) disease history. History of mental health disorder was defined as having a diagnosis of anxiety, depression or schizophrenia, and GI disorder was defined as having a diagnosis of inflammatory bowel disease based on International Classification of Diseases 10th Revision (ICD-10) codes (Supplemental Table 1).

Measurements

Two independent investigators, blinded to each other's responses, reviewed each medical record of the identified TGD patients to validate the accuracy of pulled gender identity (SS, KC, GJ). Data was verified by looking at patient demographic information and verifying that gender identity and sexual orientation matched the electronic extract. If there was no information available in the patient's demographic information the patient's problem list, medical history and surgical history were reviewed to identify gender-affirming surgeries or hormone therapy. If there was no information available, the chart was reviewed to identify any notes with endocrinology or the Transgender and Intersex Specialty Care Clinic. Lastly, if gender identity was still not identified, we used the search function within the EHR to search for "gender identity, transgender, sexual orientation, sex assigned at birth" (Figure 1). Investigators all underwent the same training for methods to manually identify gender identity. Discrepancies were reviewed by a third reviewer (KE) and resolved by consensus.

All other data variables were electronically extracted from the medical record, and 10% of the data was manually validated by an investigator (SS, KE, KC, GJ).

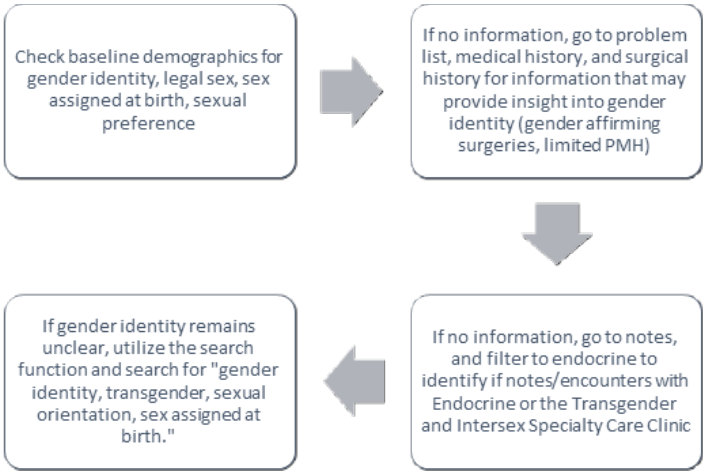

Figure 1. Gender and sexual identity verification method in electronic health record.
PMH, past medical history.

Statistical Analysis

We summarized data using counts and percentages for categorical data, and medians and interquartile ranges for continuous data. Data were compared between the five groups using chi-square tests for categorical data and Kruskal-Wallis tests for continuous data. We calculated the percentage agreement and Kappa statistic to assess the agreement in identifying transgender patients using the electronic pull compared to manual chart review.

Each transgender patient was matched 1:1 matching where possible (one cohort did not have enough eligible visits to match all TGD patients) to cisgender male (gay, bisexual, queer) GBQ patients, cisgender female LBQ (lesbian, bisexual, queer) patients, cisgender heterosexual male patients, and cisgender heterosexual female patients using propensity score (PS) matching. We calculated a PS using a multivariable logistic regression model, where being transgender was the outcome and covariates in the model were age, site, mental health history, and GI history identified based on the diagnosis list of each patient (ICD-10). Patients were matched +/- 0.2 of the standard deviation of the logit of the PS.

RESULTS

There were 43,191 patients with an ED encounter for abdominal pain during the study time frame, 25,527 of whom had provided information on sexual orientation and gender identity. A total of 300 identified as TGD. An additional 1,000 patients were also included in the cohort for matching purposes. Note that we matched a lower ratio of GBQ males due to small numbers of ED visits for abdominal pain in that group. A summary of the matching characteristics is shown in Table 1. There was a significant difference in age between groups (P <0.001) with GBQ males being older than other

Table 1. Summary of matching patients.

	LGBQ Female (n=300)	LGBQ Male (n=100)	Heterosexual Female (n=300)	Heterosexual Male (n=300)	Transgender (n=300)	Total (N=1,300)	*P*-value
Age, Median (IQR)	24 (21, 31)	34 (27, 42)	24 (20, 31)	25 (20, 31)	24 (20, 31)	25 (20, 32)	<0.001
Site							0.11
ARZ	13 (4.3%)	9 (9.0%)	20 (6.7%)	30 (10.0%)	22 (7.3%)	94 (7.2%)	
FLA	15 (5.0%)	11 (11.0%)	19 (6.3%)	21 (7.0%)	18 (6.0%)	84 (6.5%)	
MCHS	195 (65.0%)	52 (52.0%)	179 (59.7%)	157 (52.3%)	173 (57.7%)	756 (58.2%)	
RST	77 (25.7%)	28 (28.0%)	82 (27.3%)	92 (30.7%)	87 (29.0%)	366 (28.2%)	
History of anxiety	203 (67.7%)	64 (64.0%)	200 (66.7%)	184 (61.3%)	197 (65.7%)	848 (65.2%)	0.53
History of depression/bipolar	214 (71.3%)	64 (64.0%)	212 (70.7%)	188 (62.7%)	207 (69.0%)	885 (68.1%)	0.12
History of schizophrenia	9 (3.0%)	4 (4.0%)	10 (3.3%)	13 (4.3%)	8 (2.7%)	44 (3.4%)	0.82
History of somatic symptoms	7 (2.3%)	3 (3.0%)	11 (3.7%)	7 (2.3%)	9 (3.0%)	37 (2.8%)	0.86
History of IBD	8 (2.7%)	7 (7.0%)	10 (3.3%)	9 (3.0%)	12 (4.0%)	46 (3.5%)	0.32

LGB, lesbian, gay, bi-sexual; *HS*, heterosexual; *ARZ*, Arizona; *FLA*, Florida; *MCHS*, Mayo Clinic Health System; *RST*, Rochester; *IBD*, inflammatory bowel disease.

groups. Groups were otherwise able to be well matched based on hospital site, psychiatric history, and GI history. Upon manual review only one patient was found to have been incorrectly identified as TGD, this error occurred due to human error with demographic information entry in the EHR (Table 2). The agreement between electronic and manual review was 99.9%, and the kappa was 0.998 (95% CI 0.994-1.000). In the matching cohort an additional 302 patients had missing sexual orientation information. Despite missing sexual orientation information, the documented gender identity (LGBQ, heterosexual) information for these patients was sufficient to correctly categorize them for matching purposes. This information was added through verification of information from provider notes in the EHR, most being notes filed by primary care physicians (Figure 1).

DISCUSSION

We sought to validate a method to identify TGD patients via an electronic data pull within our health system. Given the disparities in care received by TGD patients there is a growing need for study in this patient population to improve care and outcomes.[1] Previously published retrospective literature varies on identification of TGD individuals. In their study Boyer and colleagues identified transgender individuals via ICD-10 codes.[10] Another study by Abramovich et al identified transgender patients in the Canadian healthcare system via self-defined gender identify in the EHR.[15]

A study identifying thrombotic events in transgender patients receiving hormone therapy identified patients by including those whose sex was assigned as male at birth and receiving "feminizing drugs" and those whose sex was assigned female at birth receiving "masculinizing drugs." Hormone treatment was determined through prescription data using national drug codes.[16] However, none of these methods were manually validated to ensure the accuracy of identification of transgender individuals. Another method used to study TGD individuals is the Behavioral Risk Factor Surveillance System from the US Centers for Disease Control and Prevention.[17,18] This survey collects data from United States residents regarding health-related risk behaviors, chronic health conditions, and use of preventative care. The results of this survey are limited to reported information and responses from individuals.

We found that an electronic data pull was accurate at identifying TGD patients in the EHR. Our results support the use of data extraction from the EHR for future TGD studies within our system to further identify disparities in the TGD population.

There have also been a variety of matching methods used in TGD studies. In a study by Pharr et al transgender patients were matched to cisgender patients 1:1 based on age, race, gender, income, education, and marital status; however, there were significant differences between the two groups.[8] Another

Table 2. Validation of gender identify.

		Manual Review	
		Transgender	Other
Electronically Identified	Transgender	299	1
	Other	0	1000

Agreement: 99.9%
Kappa: 0.998 (95% CI 0.994-1.000)

study by Boyer and colleagues matched transgender individuals to cisgender individuals by age and county.[10] With our matching strategy we were able to match TGD patients with LBQ females, and heterosexual males and females, but we were only able to match 100 GBQ males in this cohort. There was also a significant difference in age with the GBQ males. Our matching strategy took into consideration the numerous sexual identities within a population and matched on baseline past medical history.

There are inherent limitations to retrospective studies. We found that the electronic data pull was accurate when compared to manual review of the gender identity in the EHR. However, we were unable to confirm with the patients themselves whether the documented gender identity and sexual orientation was accurate. Gender identity and sexual orientation are self-reported by patients and may lead to reporting bias with possible under-reporting. We were only able to match 100 GBQ males, compared to 300 in the LBQ females and heterosexual males and females. The GBQ male group was also older compared to our other four groups. It is likely secondary to lower rates of abdominal pain in this group. Lastly, accuracy of an electronic data pull may be variable based on different EHRs and documentation of gender identity.

CONCLUSION

It is possible to accurately identify transgender and gender diverse patients using health records electronic data extraction tools. Continued research on the disparities TGD patients face is necessary so we can continue to improve the care of this patient population.

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A Systematic Review of Guidelines for Emergency Department Care of Sexual Minorities: Implementable Actions to Improve Care

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Introduction: Sexual minorities, including lesbian, gay, bisexual, asexual, pansexual, and others make up 4.0-5.4% of the North American population. Stigmatization and minority stress can lead to poorer health status in sexual minorities, and a previous scoping review showed gaps in the emergency medicine (EM) literature for care of sexual minorities. In this review we sought to examine existing guidelines for the care of sexual minorities that made recommendations relevant to care in the emergency department (ED).

Methods: Using the PRISMA criteria, we performed a systematic search of OVID Medline, EMBASE, CINAHL, and the grey literature for clinical practice guidelines (CPG) and best practice statements (BPS) published until July 31, 2022. Articles were included if they were in English, included medical care of sexual minority populations of any age, in any setting, region, or nation, and were of national or international scope. Exclusion criteria included primary research studies, systematic or narrative reviews or otherwise non-CPG or BPS statements, editorials or letters to the editor, articles of regional or individual hospital scope, non-medical articles, or if a more recent version of the CPG or BPS existed. We identified, recorded, and assessed for quality all recommendations relevant to using the AGREE-II and AGREE-REX tools. Inter-rater reliability was assessed using the interclass correlation coefficient. We coded recommendations for the relevant point of care while in the ED (triage, registration, rooming, investigations, etc).

Results: We excluded 2,413 of 2,534 unique articles. Only nine articles contributed 11 ED-relevant recommendations. Seven of the nine articles were found to be of moderate to high quality; 6 of 11 recommendations were identified as high quality and adaptable. They included recommendations for screening, testing, and care of HIV+ sexual minority populations, and general or trauma care for men who have sex with men and sexual minority populations in general.

Conclusion: This is the most comprehensive review of guidance documents for care of sexual minority populations to date. It identifies 11 actionable recommendations for the ED and identifies opportunities for community-led development of comprehensive clinical practice guidelines for care of sexual minority populations in the ED. [West J Emerg Med. 2025;26(3)431–440.]

INTRODUCTION

Gay, lesbian, bisexual, and other identities that comprise sexual minorities[1] represent between 4.0-7.6% of the North American population, with the majority identifying as bisexual.[2,3] This has been increasing over time, and led by "Generation Z," born between 1997–2002, 16% of whom report a non-heterosexual identity.[3]

In jurisdictions that lack universal health care and/or have restrictive marriage laws, a sexual minority person will have reduced access to health insurance.[4] Sexual minorities may experience social marginalization, and there are fewer culturally competent healthcare clinicians to foster safe environments for care for sexual minorities. As a result, there is still a reluctance to disclose this identity to clinicians.[4–6] Further, sexual minorities have poorer overall health compared to their heterosexual counterparts as a result of prejudice, marginalization, and minority stress,[7–9] contributing to increased risk for suicidal ideation[10,11] and substance use disorders,[13,14] and more risk factors for cardiovascular disease.[15] They are also at increased risk for breast and anal cancer in lesbians and gay men, respectively, as a result of decreased screening and environmental and lifestyle differences, compared to heterosexual populations.[12] These barriers to healthcare and greater disease risks mean that sexual minorities may rely more heavily on the emergency department (ED) for their primary care, and/or may delay seeking care until their health becomes poor enough that they need emergency care.[4] It is imperative that these barriers are not reinforced in the ED.

Clinical practice guidelines (CPG) are collaborative, structured guidance documents described by the US Institute of Medicine as "statements that include recommendations intended to optimize patient care that are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options."[16] Best practice statements (BPS), which are more difficult to define, can include a practice advisory or consensus statement from professional societies or leaders in front-line care.[17] Both documents represent standardized approaches to evidence-based care and are often adapted to meet the more focused needs of front-line clinicians in the form of clinical manuals. While there have been reviews of guidelines for care of sexual minorities, none focus on ED-relevant recommendations.[18,19]

Previous work has shown there is a limited amount of research relevant to the care of sexual minorities in the ED.[20] This article is the second of three systematic reviews and quality assessments of guidelines for the care of sexual and gender minorities in the ED and focuses on ED-relevant recommendations for care of sexual minorities. The first review[21] focused on transgender populations, and the third will focus on intersex populations.

METHODS

This study followed the PRISMA guidelines for systematic reviews, using the AGREE-II (Appraisal of Guidelines for Research and Evaluation-II) and AGREE-REX (Recommendations Excellence) tools for evaluation of quality and clinical applicability (available at www.agreetrust.org). This trial was registered at the Open Science Foundation before commencement and can be found at https://doi.org/10.17605/OSF.IO/ZPMEK. A comprehensive search of Medline, EMBASE, and CINAHL, performed in collaboration with a medical librarian, included any article published up until July 31, 2022, using keywords relating to the sexual minority population and guidelines (Appendix C). We combined a grey literature search using Google Scholar with a search of relevant societies and clinical groups for clinically focused statements and guidelines to support the automated search.

Articles were included if they were a CPG, BPS (Box A), consensus document, or other formalized guidance for clinical care of sexual minorities of any age (eg, lesbian, gay, bisexual, asexual, or pansexual populations), in English, in any practice setting, and were of regional, national, or international scope. Articles were excluded if they were replaced by a later version of the guideline, were a systematic or narrative review, offered unstructured or non-medical guidance, or if they were local, municipal, or single institution in scope.

Two of four reviewers independently screened every title/abstract and then included full-text articles (MK, SKP, GN,

Clinical Practice Guidelines are statements that include recommendations intended to optimize patient care that are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options and contain the following features:

Essential Features:

- Broad stakeholder involvement of all relevant parties
- Explicit conflict of interest statements presented
- Clear questions to specifically guide clinical practic
- Thorough, transparent retrieval and assessment of evidence; may have an accompanying systematic review/meta-analysis to inform recommendations
- Structured grading of evidence and framing of recommendations using accepted framework (eg, GRADE)
- External review by relevant bodies
- Key recommendations highlighted in document
- Updating timelines presented
- Reporting using AGREE-II framework

Desirable Features:

- Implementation protocols/pathways provided for end-users
- Outcome measurement tools provided; audit and feedback processes recommended

Best Practice Statements are consensus statements, practice advisories, position statements, position papers, or frontline clinical manuals usually from professional societies or specialist groups that have the following features:

- Current important topic for practice
- Attempt to seek and evaluate evidence
- Practical recommendations to guide practice
- High level of certainty that recommendations will improve patient care

Box A. Key features of a clinical practice guideline and best practice statement.[22–24]
AGREE-II, Appraisal of Guidelines for Research and Evaluation II; *GRADE,* Grading of Recommendations Assessment, Development, and Evaluation.

JS) using Covidence (covidence.org). Conflicts were resolved by a group consensus meeting, with ties broken by senior reviewer MK. Included studies were abstracted and analyzed for ED-relevant recommendations using a keyword search for the term "emergency." The ED-relevant recommendations were coded as a CPG or BPS, by their country or region of origin, and by their domain(s) of relevance to the ED: decision to come to ED; prehospital care; registration; triage; waiting room experience; rooming/initial nursing care; history and physical exam; investigations; diagnoses; treatment; and disposition/discharge planning and/or follow-up care. This was done by two of four independent researchers (MK, SKP, GN, JS), and conflicts were resolved by a group consensus meeting, with ties broken by senior reviewer MK.

The methodological quality of the guidelines included was assessed using the AGREE-II instrument (four reviewers: MK, SKP, GN, JS), and of the included recommendations using the AGREE-REX instrument. Raters received training in the use of the instruments through both an online tutorial available at McMaster University,[25] and from senior researchers on the project. We calculated rating scores using the online AGREE-II calculator (downloaded for free from the AGREE Trust website above) and with Microsoft Excel (Microsoft Corp, Redmond, WA) for the AGREE-REX instrument. Comparators were by individual raters, rather than by consensus, and were reported in the percent total score of each domain (Appendix A, Figures C and D). More specifically, the score is calculated by first summing all the appraisers' scores in one item or sub-domain, then adding all the summed sub-domain scores together and scaling that number as a percentage of the maximum possible score in the domain (Appendix A, Figure 2). As per the AGREE-II and AGREE-REX instruments,[26,27] we gave overall scores of >70% a high-quality rating, a score of ≥ 30 and ≤ 70% a moderate-quality rating, and a score of < 30% a low-quality rating. We assessed inter-rater reliability using the intraclass correlation coefficient (ICC) statistic in SPSS Statistics for Windows v28 (IBM Corporation, Armonk, NY). An ICC score of <0.50 was considered poor, from 0.50 to <0.75 moderate, from 0.75 to <0.9 good, and > 0.90 excellent.[28]

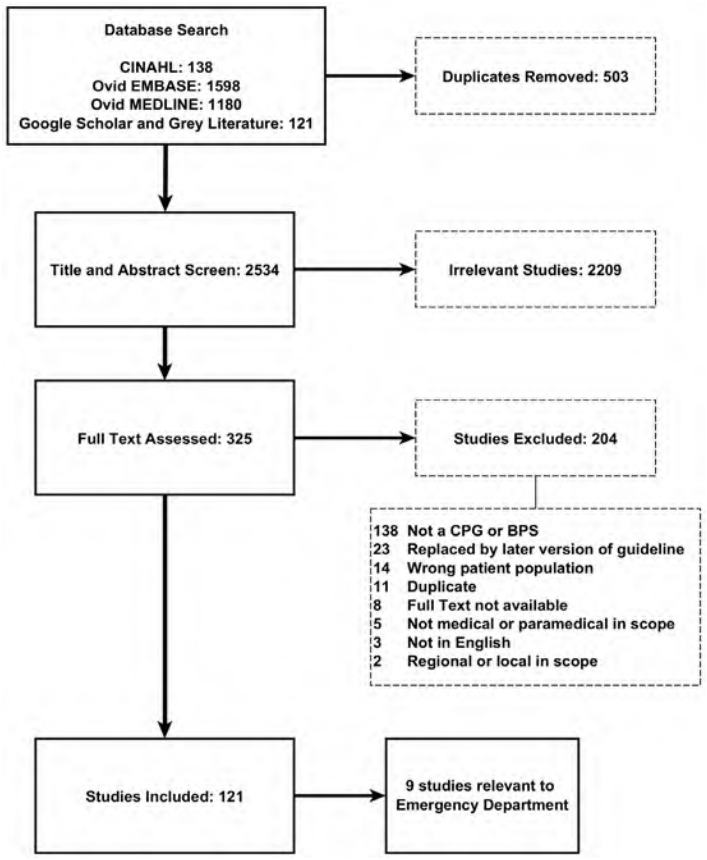

Figure 1. PRISM diagram.
CPG, clinical practice guideline; *BPS*, best practice statement; *PRISM*, Practical, Robust Implementation and Sustainability Model.

RESULTS

Our search yielded a total of 3,037 studies. After we removed 503 duplicates, we screened the titles and abstracts of 2,534 studies and included 325 for full text review. Of these, we excluded 204 studies, and 121 studies underwent keyword search and abstraction (Figure 1, see Appendix B for complete list). Nine[29–37] of the included studies (Appendix A Table 1) yielded the 11 ED-related recommendations (Box B), and these were evaluated for quality and clinical applicability using the AGREE-II and AGREE-REX instruments, respectively.

Five of the nine articles were classified as BPS,[29,31,34,36,37] and four as CPG.[30,32,33,35] Four of the articles concerned screening, diagnosis, and care of HIV+ populations,[30,32,36] while two covered general medical and/or trauma care for sexual and gender minority populations.[34,37] One BPS examined the health inequalities of American Indian and Alaska Native [*sic*] children and included sexual minority populations as a subgroup,[29] as did a guideline on sexual counselling for people with cardiovascular disease and their partners.[35] Finally, there was a CPG on caring for the sexual health in general of men who have sex with men[34] and a UK guideline on intimate partner violence (IPV) in sexual and gender minority populations.[32] Domains of care in the ED covered by these recommendations include the decision to come to the ED, triage and rooming, investigations and treatments, and disposition and follow-up care, with the majority focusing on investigations and treatments.

The overall quality of the documents and recommendations are to be found in Appendix A and Box B in Appendix A. Most guidance documents scored moderate or high in quality rating, and two BPS[29,31] scored low, due to poor rigor of development and applicability. The AGREE-REX

HIV Care

1. Emergency clinicians should use rapid testing technology to ensure STI diagnoses and ensure that post-test counselling reaches men who have sex with men (MSM) clients. (Ad Hoc Expert Working Group for CDC 2012).
2. Education for ED staff and local protocols are required to ensure appropriate advice and baseline HIV testing for MSM requesting post-exposure prophylaxis (PEP) following HIV exposure. (Clutterbuck et al 2018).
3. MSM should be routinely offered testing for HIV in the ED in areas of high prevalence whether they are undergoing venipuncture for another indication or not (Palfreeman et al 2020).
4. Medications for non-occupational PEP should be readily available in the ED if they are needed urgently (Tan et al 2017).

Visitation Policies

5. All medical facilities should allow patients to determine who may visit and act on their behalf, regardless of sexual orientation (Daniel et al 2015).

Prehospital Care

6. Reduce the proportion of LGB persons who delay or have difficulty in getting emergency medical care. (GLMA 2010).
7. Increase the proportion of LGB persons who have access to prehospital emergency services (GLMA 2010).
8. Increase the districts with trauma systems that maximize, prevention, survival, and functional outcomes of LGB trauma patients (GLMA 2010).

Interpersonal Violence

9. Medical centres and clinicians ought to be prepared to help LGB people find support when they are survivors of intimate partner violence. (National LGBTQIA+ Health Education Centre 2019).

Not Otherwise Categorized

10. Create a culturally sensitive medical home and referral pathway for sexual minority people who use the ED for primary care (Bell et al 2021).
11. During sexual counselling, LGB patients should be advised to seek emergency care should they experience angina during sex that does not resolve spontaneously in 15 minutes or 5 mins after nitrate use and call 9-1-1 should they not be able to use nitrates. (Steinke et al 2013).

Box B. Summary of recommendations.[29–37]
Gay and Lesbian Medical Association (GLMA), Health Professionals Advancing LGBTQ+ Equality; *LGB*, lesbian, gay, bisexual; STI, sexually transmitted infection.

scoring found that all the recommendations were of moderate to high quality, but only nine of the 12 recommendations could be adopted (1-6, 9, 11), while the remaining three (7, 8, 10) could not find a consensus. Inter-rater reliability using interclass correlation coefficient (ICC) for the AGREE-II ratings (Appendix, Tables 3 and 4) showed good or excellent correlation between raters for most domains, with only scope and purpose showing poor correlation. The ICC for the AGREE-REX domains were good to moderate for clinical applicability, values, and preferences, and the total score, but implementability had poor correlation.

DISCUSSION

This is the largest and most comprehensive review of guidance for care of sexual minorities in the ED to date, identifying 122 international CPG or BPS, while prior reviews found only 11-17.[18,19] We found 11 moderate-to-high quality recommendations that could be implemented now in most EDs.

HIV Care

Recommendations for care of sexually transmitted infection/HIV+ and at-risk sexual minorities are the focus of over one third of the recommendations (1-4). The HIV crisis continues among sexual minority communities, with MSM at greatest risk.[38,39] In the US, it was estimated that in 2023, 156,000 HIV+ people were not diagnosed or engaged in care.[40] In Canada, this number is estimated to be 16,969[39] with a large percentage of those in the US (67%) and Canadian (50.3%) populations being MSM.[39-40] Black and Latinx MSM are at particular risk in the US and have an increased disease burden and a decreased opportunity of being tested or diagnosed.[41] This represents an opportunity to identify new HIV+ MSM and connect them to services to extend life, reduce long-term healthcare costs, and prevent the spread of HIV.

It is recommended to target MSM populations for HIV screening in high prevalence areas. However, non-targeted screening, also called universal screening, for all sexually active people ages 13-65 is currently recommended by multiple North American agencies.[42–44] This allows detection before symptoms develop, with infected people gaining years of life and showing economic benefit.[45] The recommendations in our review focus on MSM populations and suggest that they may need to be specifically targeted for screening, treatment and referral. However, risk-based assessment may increase stigma and is dependent on patients self-reporting risk, the likelihood of which is dependent on the trust of the local system.[46-47]

The guidance for universal screening does not offer a standard approach to the development of HIV screening programs.[46] There have been both experimental and government-mandated ED-based HIV testing programs in large urban areas in Canada, the United Kingdom (UK), and the US that show such programs can increase the testing yield and be cost effective,[48] especially if they are opt-out programs.[45] One facilitator of HIV testing in the ED would be access to rapid testing, as per Recommendation 1. In a New York-based study, adolescent patients were much more likely to seek HIV testing in the ED if there was a rapid test available,[49] and a recent commentary that outlined the barriers and facilitators of point-of-care rapid testing in the ED declared it a reasonable and realistic goal.[50]

There are alternatives to universal or targeted screening to HIV in the ED. Anonymous testing for HIV is available in many jurisdictions, but its successes are mixed and dependent on local factors.[51] This would also require new ED information technology infrastructure and creative solutions to patient communication that maintain privacy. Alternatively, effective HIV self-testing kits are currently available in the US and Canada.[52] While home-based self-testing for those who do not want to disclose their MSM status in the ED can help, it raises the risk of losing direct linkage to support and treatment because it would be up to the individual to self-refer and they may need more support and counselling to do so.[54,55] Finally, testing for HIV when people present with indicator conditions that are more associated with HIV infection, such as syphilis and gonorrhea, may increase the testing uptake.[53] Both universal HIV screening and these alternatives require creative solutions to linkage to care, and it is not clear whether one is superior to the other.

Improving access to non-occupational post-exposure prophylaxis (nPEP) is needed; it is under-prescribed in the

ED. Barriers to prescribing nPEP from the ED include lack of clinician time for assessment and counselling, difficulty in connecting patients to follow-up, and cost of the medication for the patient.[56] The implementation of nPEP programs is not standardized, with different recommendations for timing of initiation, regimens, and referral for nPEP adherence and completion.[57] Despite this, nPEP programs do exist in several jurisdictions, usually in the context of sexual assault.[58] A national standard for nPEP with robust referral pathways is sorely needed, along with education to increase awareness of nPEP among patients and clinicians.

Initiation of pre-exposure prophylaxis (PrEP) in the ED is also recommended. Several barriers to eligibility screening, such as lack of clinician training, lack of effective and equitable screening tools to identify higher risk individuals, and proven clinical models for provision, lead to uneven distribution, with one study showing 67% of new prescriptions in Ontario from 2015-2018 were filled in Toronto.[59,60] There is a similar trend in the US, with the southeastern states responsible for over one half of new HIV diagnoses but only one quarter of PrEP-providing clinics.[61]Black and Latinx populations are also underserved.[62] Universal HIV screening offers an opportunity to offer referral to PrEP clinics for at-risk people, and a recent review showed that rapid or same-day referral to PrEP clinics increased uptake.[63]

The implementation of rapid HIV testing would also facilitate PrEP prescribing, as a reliable rapid test would allow the initiation of PrEP in HIV- individuals directly from the ED. As of yet, reviews of the economic feasibility have focused on the HIV positivity rate but have not factored in the benefits of starting PrEP earlier, thereby avoiding HIV infection altogether.[47,64] Future studies should include the benefits of prevention when studying rapid testing, which may tip the balance to offering this as a standard in all EDs and support PrEP programs in the ED in both the US and Canada.

With the growing crises of lack of access to primary care,[65,66] it is important to build robust pathways to referrals for sexual minorities who test positive for HIV in the ED or present to the ED HIV+ and undertreated. The continuity of improved ED-based care is attenuated if appropriate post-ED follow-up care is not available after discharge. A 2016 review found 37 linkage-to-care (LTC) programs in the US and included various strategies, such as physically escorting the patient to HIV clinics and referrals to outside clinics, with the former demonstrating improved LTC with a rate greater than 85%, compared to the average of 74%.[67] One of the limitations of LTC programs is that they require a lot of infrastructure and multidisciplinary teams and are often integrated into larger HIV screening, counselling, rapid treatment, and referral programs that need systematic changes to be successful.[53] To implement this widely there would need to be a systematic approach at the state, provincial, or national level to develop, fund, implement and monitor the success of such programs. Given the large number of undiagnosed HIV+ people in the US and Canada, this is a necessary next step.

In sum, the HIV recommendations speak to the need in every ED for a robust, well-supported HIV testing program that offers universal rapid testing in the ED while at the same time increasing the safety for disclosure of sexual minority status. This will decrease stigma, increase uptake of pre- and post-exposure HIV prophylaxis, and improve connections to treatment clinics and counselling to support new or undertreated HIV diagnoses.

Visitation Policies

Recommendation 5 identifies different family structures that sexual minorities develop to build community and share their lives and that will be involved in their healthcare. While same-gender marriages are recognized in all jurisdictions in the US and Canada, some sexual minority people may not pursue marriage and, as they age, they may be relying on informal care networks like those established during the AIDS crises in the 1980s and 90s.[68,69] Equal visitation polices are mandated for facilities funded by the US Centers for Medicare & Medicaid, and 99% of hospitals participating in the Healthcare Equity Index survey document such policies.[70,71] Visitation policies that reflect all types of families and caregivers should be implemented to support sexual minorities presenting to the ED.

Prehospital Care

Recommendations 6-8 focus on prehospital care: first responders are the bridge between community and hospital care. Since the publication of the Health People Companion Document for LGBT Health in 2010, recommendations for sexual and gender minorities have been added to the main Health People document, but they do not include any statements about prehospital care.[37,72] There is no evidence that prehospital barriers to care for sexual minorities have lessened since 2010; thus, when developing systems to remove barriers in the ED, emergency medical services should be included in these systems.

Interpersonal Violence

Recommendation 9 addresses the bias sexual minorities face when seeking care for IPV and others forms of violence. Emergency departments need to include screening for IPV in all demographics when patient present to the ED so that we have a greater chance of identifying these invisible populations. Gay men are subject to higher rates of IPV than heterosexual men and women, with rates as high as 26-33%. The risk was higher if they were also a person of color, HIV+, and were younger. About 13-40% of lesbians and bisexual women report physical violence, and 11-14% report sexual violence within same-sex relationships.[73] It is important to recognize that the stigma that sexual minority populations face

along with barriers to care may decrease reporting of IPV in the ED. Harland et al reported a less than expected reporting of IPV among sexual minorities in the ED than heterosexual counterparts This may have been due to the lack of access to care, fear of disclosure of sexual minority relationships, discrimination upon disclosure, and a focus in screening for IPV in heterosexual relationships.[74]

As well, referrals for care when IPV is identified need to be appropriate for the sexual minority and may differ from heterosexual populations. There are significant barriers in seeking shelter for gay, lesbian, and bisexual people in a same-gender relationship. A 2016[75] review of barriers to care in US sexual and gender minority (SOGI) populations found that 61.6% of SOGI IPV survivors were turned away from shelters when seeking assistance, and none of the 1,500 domestic violence (DV) shelters in the US are dedicated to lesbian IPV survivors. Among the reasons lesbian IPV survivors gave regarding their fear of seeking help in DV shelters was that their abusive partners would be able to find them and seek access at the same shelters. This is an opportunity for EDs to work with IPV referral partners to make sexual minority training mandatory to ensure a safe and appropriate space for sexual minority IPV survivors to seek shelter.

Not Otherwise Categorized

Referrals to primary care are a challenge from the ED, given the limitations of access as described previously in this paper. Building relationships with culturally humble clinicians in the community and with the community itself can build trust and remove barriers for care in the ED, but this remains an aspirational goal with all the other pressures on referrals from the ED. As to the recommendation for angina counselling, this can be considered when discharging a sexual minority person at risk for cardiovascular disease, although it is dependent upon creating an environment that is felt permissible for disclosure of sexual minority status. Also, this is good advice for any person, sexual minority or not, who is at risk for cardiovascular disease.

LIMITATIONS

This systematic review of guidelines is limited by exclusion of recommendations not directly related to care in the ED; there may be guidelines and recommendations that are focused on other aspects of community or hospital care that can inform care in the ED. Indeed, the included studies were focused on primary or specialist care, and not the ED, and we did not analyze the indirect applicability of the other guidelines in the documents. Counter to this, because the recommendations were not developed on primary ED populations they may not be applicable in the ED. This is the focus of future work in the development of ED guidelines for the care of sexual minorities. Only English articles were included. Despite a grey literature search, we may have missed relevant BPS that are typically not part of searchable databases. Finally, the age of some of the recommendations may preclude their use in the current ED environment as social and legislative changes may result in different approaches if the same recommendations were to be developed today.

The AGREE-REX findings may be less reliable because we used four independent raters, while the tool was validated using five. Also, while the AGREE-II and AGREE-REX tools do include a risk of bias assessment (see section 9)[26] they do not capture this more subtle source of bias in guideline development.[76]

While the recommendations touched on most elements of the domains of care, they do not represent a comprehensive pathway of experience through an ED visit and leave out crucial experiences that may reinforce barriers to care, including sexual orientation screening at registration and training of front-line staff other than clinical staff. This also highlights a more general limitation of the lack of ED-focused recommendations in general. As identified in our previous scoping review there are still many gaps in the literature pertaining to care of sexual minority populations in the ED.[20] The recommendations this review identified do not speak to the collection of gender, sex, or sexual identity demographics at registration or triage, identify any disease-specific recommendations other than HIV, and they did not include sexual minority populations as stakeholders in the design and implementation of any of the guidance documents.

Inter-rater reliability (ICC) was poor for the implementability of these recommendations, according to the AGREE-REX evaluation. This is most likely due to the varied stages of medical training for the evaluators, which included medical students, residents, and staff physicians. It is likely that due to the different experience levels, there was uncertainty about whether these recommendations could be implemented in the clinical context of the individual rater. With raters of more closely matched clinical experience, we would expect the ICC to be better.

Next Steps

These 11 recommendations are actionable. They can serve as a basis for development of CPG for care of sexual minorities in the ED and spark reflection and innovation. Our review highlights important gaps in the literature that may inform a future research agenda for care of sexual minorities in the ED.

An essential step in the adoption and implementation of these recommendations is the involvement of the sexual minority community in the development of any research questions, clinical trials, and guideline development. While there were advisory boards of community members participating in some of the guideline development process, they have not participated in the development of the research

questions and priority setting for the guideline development group. In fact, due to past and ongoing discrimination of sexual minorities in medicine in general,[77] the disconnect between the community and the evidence base for care is built into the knowledge creation system.[20] We have engaged sexual minority members of the medical community in the production of this manuscript, but to re-design the entire guideline development process to be more equitable, our group is developing a Delphi-type[78] process to engage the community in the identification of research priorities and study design. Our hope is this will broaden our CPG to serve the community it focuses on, rather than just the researchers or system it works within.

CONCLUSION

This is the most comprehensive review of clinical practice guidelines and best practice statements for sexual minority populations to date and identifies 11 actionable recommendations for care of sexual minorities in the ED. It also reveals an opportunity for community-led implementation of these recommendations in an equitable manner to ensure that HIV testing, treatment, and referral pathways exist and do not reinforce barriers to care. There is a clear need for focused EM-relevant practice guidance for sexual minority patients in ED settings, ideally co-created with emergency clinicians and sexual minority community members.

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Moving Beyond "Check A Box": Shifting Physician Perceptions and Culture with an Antiracism and Equity Curriculum

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Objectives: The purpose of this study was to evaluate the impact of the Discussing Anti-Racism and Equity (DARE) curriculum on individual physician knowledge and practice, as well as on perceptions of group culture.

Methods: DARE was a longitudinal multimodal curriculum targeted at pediatric and adult emergency medicine (EM) trainees and faculty, made up of 12 lectures/workshops, three simulations, five book clubs, and two movie screenings. We used a multiphase, parallel convergent mixed-methods approach. Focus groups before and after DARE explored prior education, antiracism attitudes and behaviors, perceived impact of intervention curriculum, and perceptions of departmental medical culture. We elucidated themes using thematic analysis. Surveys of trainees and attendings evaluated individual attitudes and practices related to equity and antiracism.

Results: We held nine focus groups with a total of 52 participants. Half of participants were EM residents (26), and half were faculty (12 pediatric EM and 14 general EM). Four major themes emerged around antiracism education and DARE. Both trainees and faculty reported a lack of standardized or effective prior education, although trainees are beginning to report increased exposure in medical school. Participants reported an overall positive impact of DARE on individual knowledge and practice, with continued room for improvement. Focus groups particularly highlighted a perceived shift in departmental antiracist culture post-DARE. Finally, future curricular aims were elucidated. A total of 56 surveys showed significant improvement in all realms of antiracism medical- practice questions when posed as retrospective pre-post questions ($P < 0.01$).

Conclusion: The DARE curriculum increased individual antiracism awareness and cultivated culture shift among the targeted clinician group. Focus groups provided clear next steps for ongoing and expanded education. [West J Emerg Med. 2025;26(3)441–451.]

BACKGROUND

Health inequities stemming from systemic, interpersonal, and internalized racism have plagued our medical system for as long as it has existed.[1] The medical community at large, from physicians to hospitals to journal editors, has issued calls to address health inequity and structural racism in medicine.[2-4] A recent review of the emergency medicine (EM) literature showed the persistence of racial inequity in our field, including in pain treatment, stroke management, timely or appropriate antibiotic therapy, rates of physical restraint, and survival rates following out-of-hospital arrest, to name just a few.[5] Racism does not skip over children either; racial disparities impacting pediatric emergency department (ED) care include pain treatment,[6] physical or pharmacological restraint use,[7,8] sepsis morality rates,[9] and evaluations for child abuse.[10] Our field needs a multipronged approach to create an

antiracist practice of medicine and alter inequity.[11-13] Impactful education will be one key driver in that change.[14,15]

A variety of educational interventions have been proposed to address racism in medicine, including many one-time workshops and some longer curricula (typically single format).[16-18] However, it remains unclear how to best impact individual racism/implicit bias, and few interventions have assessed educational impact on a broader shared culture of medicine. Considering this, we piloted a curriculum called Discussing Anti-Racism and Equity (DARE) for emergency and pediatric emergency clinicians. This comprehensive year-long educational intervention was designed to increase antiracist attitudes and behaviors among emergency clinicians, with a broader goal of improving patient care and shifting departmental culture. The DARE curriculum consisted of a variety of educational modalities including book clubs, simulation sessions and workshops, lectures, movie screenings, and targeted clinical cases during morbidity and mortality conferences. We used a mixed-methods assessment to evaluate the impact of the intervention, focusing on antiracist attitudes and behaviors as well as impressions of departmental culture.

OBJECTIVES

The objective of the DARE curriculum, broadly, was to encourage anti-racist attitudes and behaviors among emergency clinicians. Specifically, participants would be able to do the following:

1. Assess implicit bias and the effects of racism on their individual practice of medicine.
2. Identify the legacy and impact of structural racism on medicine.
3. Use practices that challenge the subtle impacts of individual racism/bias in their clinical work and interpersonal interactions.
4. Take actions or create feasible goals toward an actively anti-racist practice of medicine.
5. Participate effectively in an actively anti-racist departmental culture.

The curriculum had an additional objective to develop a core group of participants committed to developing and demonstrating an anti-racist ethic in our ED.

CURRICULAR DESIGN

We recognized the need for an anti-racism and equity-focused curriculum as there was little to no formal training in these topics at our institution. Both our faculty and trainee group were majority White, as was our nursing staff. The population our hospitals served was more diverse. The curriculum and its evaluation included physicians (attendings, fellows or residents) from three hospitals, comprising one pediatric ED and three general EDs. Our largest hospital, including a pediatric and adult ED, averaged seeing at least one-third Hispanic- or Black-identifying patients.

We were aware from our own experiences (as a Black female emergency attending and White queer female pediatric EM fellow) as well as those shared with us by others that examples of microaggressions and potentially biased patient care were common. Contextually, the DARE curriculum started in the fall of 2020, directly following the murder of George Floyd and the subsequent growth in general anti-racist awareness as well as political backlash. This meant that many in our faculty group were more invested in the idea of the DARE curriculum and perhaps were primed to embrace a cultural shift. However, for a politically divided ED staff, it also meant significant new obstacles in engaging nursing and hospital staff, as well as an urgent need to help our trainees navigate and have support around potentially fraught interactions within the ED.

In building the DARE curriculum, we used the levels of racism as outlined by Camara Jones,[19] as well as Bloom's taxonomy,[20] to ensure that it was of appropriate scope and depth (Table 1).

To encourage knowledge retention and skill growth, sessions occurred longitudinally and built on each other, as well as allowed participants to practice previously learned skills. To target our learning objectives within our specific hospital and departmental context, initial sessions focused on White identity and privilege, microaggressions and implicit bias, as well as introduction to racism and medical racism. After introductory sessions we integrated skill-building practice, with three simulation sessions and a case-based workshop scattered through the year. Ongoing lectures continued to grow participant knowledge base. All of these sessions were held during scheduled, protected conference time, allowing a majority of trainees to attend; faculty were strongly encouraged to attend. We additionally worked with our department to fold antiracism content into other available learning opportunities. Notable examples include a morbidity and mortality session focused on racism in real patient cases, run by EM chief residents, and requesting that the grand rounds committee invite a topical speaker.

To address different learning styles and allow for more in-depth learning, we also used a book club model (with books provided) and movie screening with discussion. Due to time constraints, these sessions were held outside educational conference time and had correspondingly lower attendance. However, they allowed participants time for more robust conversation and relationship-building and assisted in our final curriculum goal of growing out a core of participants who could be counted upon to be more active ambassadors and advocates in our department. The first year of the curriculum had a total of 12 conference sessions, three simulation scenarios,[21] five book clubs, and two movie screenings with discussions (Table 2).

IMPACT/EFFECTIVENESS

Methods

We evaluated the curriculum using a multiphase, mixed-methods study with a parallel convergent approach. In the

Table 1. Objectives, framework and assessment map of the Discussing Anti-Racism and Equity curriculum.

Objective	Bloom's Taxonomy Level	Level of racism	Assessment[a]
Assess implicit bias and the effects of racism on individual practice	Analyze	Personally mediated racism	Survey Item 1-2 + focus group individual practice theme
Identify the legacy and impact of structural racism in medicine	Understand	Institutional racism	Survey Item 5
Use practices that challenge the subtle impacts of individual racism	Apply	Personally mediated racism	Survey Item 3-4 + focus group individual practice theme
Take feasible actions or create goals for an antiracist medical practice	Create	Intuitional, personally mediated, internalized racism	Survey Item 6-9 + focus group individual practice theme
Participate in an actively antiracist department culture	Evaluate	Institution and personally mediated racism	Survey Item 7-9 + focus group culture theme
Develop a core group of participants committed to an anti-racist ethos	Create	Institutional racism	Not formally assessed. Further encouraged with creation of a DEI committee open to new members with a variety of projects, as well as ongoing encouragement of integration of equity topics into education

[a]Further detail on survey items in Table 5; further detail on focus group themes in Table 3.
DARE, Discussing Anti-Racism and Equity; *DEI,* diversity, equity, and inclusion.

initial phase, focus groups at the start of the curriculum focused on an educational needs assessment and baseline understandings of ED culture around race and racism. In the second phase, focus groups held mid- and post-curriculum focused on an assessment of the curriculum, including any perceived changes to group understandings of culture. Focus groups were chosen for this methodology to examine shared social meanings and meaning-making in how race and racial bias are viewed by emergency physicians, and how this coalesces into a broader local medical culture. Interactive consensus was important to such a process. The quantitative portion was a web-based anonymous survey given post-curriculum. The survey collected information on demographics and anti-racist attitudes and behaviors. The study was deemed exempt by the Lifespan Institutional Review Board. This curriculum and study received funding via the Emergency Medicine Department of Equity Initiatives discretionary funding for faculty and resident development.

Qualitative Approach

We created separate focus groups for residents, EM attendings, and pediatric EM attendings. We considered dividing groups further by race/ethnicity; however, given the small number of non-White physicians in our department this was not feasible. To recruit as wide a sample as possible for the focus groups by making attendance easy, we held multiple resident focus-group sessions concurrently at the end of resident conference time. A simple, anonymous opt-out mechanism was in place to ensure no trainees felt pressured into participation. For attendings, we recruited for focus groups via email to all eligible participants. Groups had 4-9 participants each, with multiple focus groups recruited within each subgroup. Given the timing of focus groups during the COVID-19 pandemic, all focus groups were held over Zoom (Zoom Video Communications, Inc, San Jose, CA). Participants received a $50 gift card after completion of the group.

Two curriculum leads (HBD, TW) developed the interview guide, based on medical implicit bias and medical education literature. Focus-group questions focused on how race and racism were discussed and perceived in the ED, to elicit the departmental culture. Other questions focused on prior education related to race and racism in medicine, and relative effectiveness of varying learning techniques. Finally, questions during and after the DARE curriculum elicited feedback on those sessions and reflections on how personal practice, patient care, and/or departmental culture may have shifted during the training sessions.

The majority of the focus groups were facilitated by a creator of the DARE curriculum. This facilitator was a White pediatric EM fellow, with a background in equity and bias-focused medical education and prior experience facilitating conversations about race and racism among medical professionals. Two additional facilitators were recruited who had prior experience in facilitation and bias work, who were both White and EM attendings. Focus groups were audio recorded via Zoom and a back-up device. Recordings were transcribed verbatim and de-identified prior to analysis.

Table 2. Sessions of the Discussing Anti-Racism and Equity curriculum (DARE),

Lecture/ workshop session	Topics covered
PEM/PICU joint conference: Who Me? Bringing awareness of racial bias and an anti-racist ethic to our everyday practice.	Implicit bias, impact of racist implicit bias on patient care and communication, introduction to microaggressions with small-group discussion, upstander skills review and practice/role play
Discussing Antiracism and Equity: Breaking our Allegiance to Whiteness (guest speaker)	Introduction to privilege, conceptions of White identity, small-group discussion around personal racial identity
Antiracism Policies and Practices for our Organization	Institutional policies that relate to antiracism, local related research work, educational impacts, mutual accountability and collective responsibility
Grand Rounds: Injury, Equity and Racism (guest speaker)	Injury prevention, inequities in injury burden, identifying inequity causes and solutions
Microaggressions and Implicit Bias Case-Based Workshop	Introduction to microaggressions, upstander skills review, small-group case review and practice/role play
Systemic Racism and Health (guest speaker)	Discussion of systemic racism, impact of structural factors on medicine and health, opportunities for collective action
Racism-focused M&M	Case evaluation with racism focus
Race-based Research	Race-based biases in clinical research, practical strategies to identify and mitigate bias in research, intersectionality
PEM: Use of race in pediatric algorithms	Discussion of use of race in pediatric algorithms, specific example--debate of UTI algorithm
Medical Apartheid: History of racism in medical research and impact on current practices	Racism in medical research throughout US history, including voices of dissent; impact on informed consent and current emergency medicine practices; influence of historical abuses on current practices and patient perspectives
Institutional Antiracism Updates	Intermittent (roughly biannual) brief updates reviewing departmental and institutional antiracism actions
EM Intern Orientation: Introduction to Racism and Microaggressions[a]	Racism and levels of racism, upstander skills and practice
Simulation Cases	
Interrupting Overt Racism in the Workplace	Addressing overt racism, options when patients make racist statements, protective institutional policies and resources
Interprofessional Microaggressions	Recognizing and interrupting interprofessional microaggressions, microaggressions where power differentials are in play
Implicit Bias and Patient Care: Mitigating Bias, Preventing Harms	Identifying interactions where racial implicit bias is impacting patient care, practicing taking action, racism in child abuse evaluation
Movies	
Juneteenth discussion: Movie screening and discussion of the Netflix movie 13th	
A Baldwin Kind of Mood: Movie screening and discussion of interview with James Baldwin	
Book Club	
How to Be an Antiracist	
Talking to Strangers	
Caste	
White Fragility	
Medical Apartheid	

[a]Implemented for new interns after the prior academic year of the DARE curriculum had run.
M&M, morbidity and mortality; *PEM,* pediatric emergency medicine; *PICU,* pediatric intensive care unit; *UTI,* urinary tract infection.

Transcripts were organized using NVivo v12.6 (QSR International, Burlington, MA). Data were inductively coded without a priori codes to meet an exploratory goal of describing ED culture and educational preferences. A number of transcripts were double-coded until a final codebook was established. Codes were then clustered into descriptive themes using thematic analysis. Once final themes were identified, representative quotes were selected.

Quantitative Approach

An anonymous survey was emailed to all eligible participants six months after the one-year curriculum completed. The survey included questions focused on the learning objectives of the curriculum (see Table 1), using retrospective pre/post questions referred to here as Anti-Racism Medical Practice (Appendix A). This retrospective pre/post approach was chosen as learning related to racism and implicit bias is potentially susceptible to response-shift bias.[22] That is, participants may overestimate their understanding of issues of racism and bias, and/or underestimate their own bias, prior to educational interventions. Participants selected scaled responses that mimicked a stages-of-change model, with increasing numbers of 1 to 5 indicating increased engagement with the queried skill: 1) I am not interested in this practice; 2) I would like to do this but have not considered how; 3) I have been thinking about how to do this; 4) I sometimes do this; 5) I often or always do this. This scale was chosen based on the experience of the antiracism educators as well as findings in early focus groups that participants tended to reflect on their individual journeys in roughly such a fashion (data not reported here). Of the nine questions in this series, the first six were tabulated into a score for analysis. As the surveys were collected anonymously, survey results were not individually linked to qualitative data.

We conducted statistical analysis using SAS v 9.4 (SAS Institute, Inc, Cary, NC). Independent sample *t*-tests were conducted to compare changes in the Anti-Racism Medical Practice scores over time by several characteristics. We conducted repeated measure analysis of variance to assess the change in Anti-Racism Medical Practice scores over time by sex and race.

Qualitative Results

Focus groups were held until we reached thematic saturation, ie, until no new major themes emerged. In total, this required nine focus groups with 52 participants. This included 12 pediatric EM attendings, 14 general EM attendings, and 26 EM residents. A variety of themes emerged in analysis, which were consistent across the adult and pediatric groups. Here, we focus on four overarching themes: incomplete prior antiracism/equity education; impact of DARE on individual knowledge and practice; departmental culture before and after DARE; and desires for the future. Each of these four overarching themes had corresponding subthemes, discussed further below and summarized in Table 3.

Needs Assessment: Prior Experiences and Expectations of Anti-Racist Education

Residents as well as attendings who reflected on medical school found their prior education to be inadequate or "bad." Cultural competency content ranged from information about traditional health remedies to "ridiculous" and "bizarre" charts characterizing different ethnic groups. Some participants noted they received education about health disparities "maybe one day a week for a few weeks…at a really basic level. Pretty painful to sit through." "Anything related to race and healthcare was kinda couched in health disparities." However, it never "discussed how race is not biological and it did not unpack the concept of racism; it just talked about how racial minorities are more at risk for health disparities." All participants noted any formal medical school education that touched on race or diverse populations seemed more to "check

Table 3. Focus group themes.

Themes	Sub-themes
Non-standardized prior education	Limited/inadequate prior learning
	Influence of silent curriculum
	Self-directed learning
Impact of DARE on individual attitudes and practice	Increased bias awareness (self and others)
	Specific knowledge points or skills
	Eagerness to brainstorm new directions and push the department as a whole
	Room for improvement in individual practices
Departmental culture before and after DARE	Pre-DARE antiracism resistance or blind spot
	Increased group-level awareness after DARE
	Perceived acceptance of antiracism initiatives, empowerment post-DARE
	Departmental or hospital-level disconnect from anti-racism awareness
Future desires	Ongoing curriculum with new topics
	Strong impact of personal stories and narratives
	Equity-focused patient care metrics
	Multidisciplinary outreach to all EM staff

DARE, Discussing Anti-Racism and Equity; *EM,* emergency medicine.

a box;" something that "we had to go through, and then we moved on."

For some residents, experiences such as hospital rotations were more impactful than formal curricula.

> Just every single patient interaction, I genuinely feel like every attending, every resident, every social worker, every interpreter, community health worker, [was a] patient advocate. It was just like the system just was different - a public hospital, that was for-the-people-by-the-people feeling. So while we didn't get a formal education, I felt like we were taught so much every day.

Another resident noted negative lessons that could come from this non-formal learning. At her school,

> the patient population is majority African-American … but we didn't get a lot of teaching about it. And that being said … it's kinda a joke within the school that every single chair of every department is an old white male.

Attending groups also noted the absence of structured racism-related education in prior training, recalling "things like social determinants of health" and "a social medicine focus … not in a formal way, but it was something that was out there and the mission of emergency medicine." Or participants noted a complete absence: "I don't remember having any conversations about race." In this void, non-formal learning often came up as formative. Like the residents, for some this was positive.

Other attendings recalled more stereotyped experiences as trainees, such as witnessing an attending discounting the complaints of a Spanish-speaking patient with "'That's just status Hispanicus.' It didn't even register to me … that was woven into the fabric of training." Many attendings pointed to learning outside the medical environment as their main exposure to learning about racism and related topics, in undergraduate or postgraduate programs, through experiences living in diverse areas or having cross-racial friendships or family members (for White participants), or via self-directed learning.

A final subtheme noted in the attending groups around education was the process of unlearning.

> I think about all the things that we have to unlearn that we've been taught throughout time, throughout all of our individual lives, that you have to unlearn and unpack in a high-speed, high-octane situation like the emergency department. It's really a lot.

Similarly:

> How do you unfinetune some of those biases that are hurtful or harmful? We act on all of those assumptions, and it's really hard to … recognize them when you've spent your whole career internalizing and acting on them.

Of note, among post-DARE groups with newer residents, the reflection on medical school content had begun to shift. Some residents specifically noted the use of taking implicit association tests (IAT) in medical school. One resident, on discovering their implicit racial bias, found it to be "a really shocking thing … a really eye-opening moment." Another found their IAT results to be "really painful to hear" but "a really good tool." Others commented on the changing landscape in medical schools, explaining that "especially younger physicians, I feel like bias training has been part of my educational process since the very beginning."

Impact of DARE on the Individual

A major theme post-DARE was changing awareness and knowledge. Participants across stages of training noted their "recognition" that their thinking had "evolved," or that they were "not as oblivious as I once was." Some also referenced specific areas of learning, such as around medical mistrust, pain treatment, restraint use, microaggressions, and how bias can manifest in medical care communication. Attendings in particular reflected on teaching and leadership, finding that DARE "made me think I oversee so many learners … what I say and how I say it and how I act is really impacting the upbringing and the future careers of the people I'm around." Attendings noticed changes in how they educated trainees and addressed team members. Some voiced new concerns in committee meetings or considered reshaping curricula.

Regarding direct patient care, many noted general awareness, whether it's "just sitting in the back of your mind" in a variety of scenarios, or "a continual reminder of…you have to check yourself." Some participants noted it made them change practice, such as considering race as a factor when noticing a "discrepancy" in patient care, or pausing to consider for an agitated patient "if this person was a different color … would we be sedating 'em now? Or would we be verbally deescalating now? Would we be calling family?" The ability to confront biased language was a frequently cited skill, particularly after opportunities to practice and discuss this skill in simulation. A small number had difficulty pinpointing any changes in their practice, or more commonly, reflected on their room for improvement, feeling "I'm still not 100 percent prepared," or noting a change in thought process but "is it translating into actions yet? I'm not sure, but I'm hoping that it will."

Impact of DARE on Departmental Culture

Pre-DARE residents had a negative reflection on departmental-level culture. They reflected on their inability to alter departmental practices, and brought up examples of how residents who had attempted to create change either met or worried about leadership resistance:

> Just reflecting on some of the social movement events that were happening earlier this year. A lot of our mentality was like, 'I hope we don't get in trouble by the system.' Not like, 'I hope the system organizes this event so that we can all participate in it.' It's like, 'No, the residents are planning, and just hopefully we don't get in trouble.' And … obviously it shows the culture of non-support and definitely not leadership.

They did note a tendency to receive verbally expressed support; however, there was concern that this was not followed through with actions or spending.

> Diversity is espoused as important, and it's Tweeted out, and it's a goal, but in practical terms, it's an inconvenience.
> It's become very fashionable to be part of Black Lives Matter and to say, 'I'm against racism,' but I haven't seen that really translate into very much change within our department.

Attendings used less condemning language but also noted a previous culture where racism was a "blind spot" or not frequently discussed or prioritized.

Post-DARE, participants felt physician group-level antiracism awareness had increased. Even focus groups held while DARE was ongoing noted that conversations about equity had become "semi-normalized … people are at least cognizant of the issues, whereas before it was a big blind spot." Even being "willing to have that conversation… is a huge step forward." Post-DARE resident groups found that with these increasing conversations and awareness, they felt "safe" and "comfortable" discussing antiracism on shift, because the DARE curriculum made them feel it was "explicit" and "salient." They described antiracism and equity as "in the waters more," "in the ether," "a common footprint" and "a shared understanding." They found that with this, "the ability to make change is there." Across training levels, participants noted an increased emphasis on equity work, finding "something that I've really enjoyed seeing was that it seems to be at least a priority now." Some noted a sense of empowerment in their ability to embrace this work:

> I have felt more empowered to talk about these issues and also feel like this is okay to have this as a priority, and that this is a focus of being an academic faculty person, whereas I think in the past it was like this is a side interest … I think it's become more of an interest for other people, and I think that's been something beneficial.

Future Curricular Aims

Post-DARE, participants often described a pull between a changing physician culture and the rest of the ED staff. Most frequently, participants cited a desire for multidisciplinary outreach to all EM staff to incite greater culture change, reporting "I don't think that we're going to make big progress on culture until everybody is on the same page and intentional." There was particular interest in including nurses in antiracism education "given [nurses] are the folks who are at the bedside for the majority of the time with patients."

Other key areas for future intervention included continuing to have longitudinal learning "sprinkled in throughout the academic year" and incorporating advanced topics that were more intersectional. Participants particularly noted the strong impact that personal stories and narrative had on their understanding. Participants were universally interested in seeing internal care metrics broken down by race as a tool for learning and improvement. A few had concerns about backlash and the need for the appropriate framing of such data.

Quantitative Results

Fifty-six clinicians (26 attendings, 22 residents, three fellows, and one advanced practice practitioner) were included in the survey data (Table 4).

Table 4. Demographics of survey respondents.

	n (%) (N=56)
Gender	
Male	27 (48.21%)
Female	29 (51.79%)
Work Role	
Physician	55 (98.21%)
Advanced practice practitioner	1 (1.79%)
Physician role[a]	
Attending	26 (47.27%)
Fellow	3 (5.45%)
Resident	22 (40.00%)
Attending who completed residency in 2021	4 (7.27%)
Race	
White	48 (85.71%)
Asian	4 (7.14%)
Black	2 (3.57%)
Hispanic/Latinx	2 (3.57%)
Post-training	
0-5 years	5 (19.23%)
6-10 years	4 (15.38%)
11-15 years	4 (15.38%)
16-20 years	6 (23.08%)
21-30 years	6 (23.08%)
>30 years	1 (3.85%)

[a]Frequencies are among clinicians who indicate "physician" as their work role.

As DARE sessions were attended variably, it was difficult to estimate the survey response rate. Among total physicians in our trainee and faculty group, this was a survey response rate of 34%, which is an underestimate given that not all faculty attended DARE sessions. The majority of clinicians (48, 85.71%) identified as White, mirroring a majority White faculty and trainee group, and about half were female. The change in retrospective pre/post responses for anti-racism medical practice behaviors for post-intervention survey respondents can be found in Table 5.

Respondents' assessment of their engagement with anti-racist medical practice behaviors significantly increased from pre- to post-intervention, from an average composite score of 19.27 to 23.23 ($P < .001$). These behaviors included reflecting on how racial bias could impact their practice of medicine, taking steps to mitigate bias in patient care, addressing microaggressions, reporting issues of racism, identifying how structural racism impacts patient care, and voicing concerns or ideas for change around racism to their leadership or community. There were also significant increases in the non-composite items (not included in total score due to not an applicable option for some respondents). Among clinicians who conduct lectures, the integration of health equity, racism, or bias issues into lectures significantly increased from 2.77 to 3.85 ($P < .001$). Among clinicians conducting research, the integration of health equity, racism, or bias issues into their research improved from 3.05 to 3.78 ($P < .001$). Among clinicians in leadership roles, the integration of health equity, racism, or bias issues into their role improved from 3.12 to 3.95 ($P < .001$). Repeated measure analysis of variance findings comparing anti-racism medical practice changes over time by sex and ethnicity can be seen in Appendix B. There were no significant differences over time by sex and ethnicity.

DISCUSSION

This study demonstrates the potential of an antiracism and equity curriculum to develop an antiracist practice of medicine and encourage an antiracist culture in hospitals. Focus groups revealed the curriculum was overall acceptable to trainees and faculty alike, with some individual sessions favored over others. Opportunities for practicing skills, such as in simulation, were particularly appreciated.

Focus groups suggested that faculty had variable prior exposure to antiracism- or equity-focused education, much of it from individuals seeking it outside their medical training. A subtheme included the actively poor education and hidden curriculum faculty had been presented within their training. This suggests the integral importance of including faculty in antiracism- and equity-focused education. As a participant had reflected after DARE, they were the ones "impacting the upbringing and future careers" of trainees, suggesting the need for them to learn themselves to be better informed leaders and educators. Residents also expressed a need for improved antiracism and equity training, although newer

Table 5. Retrospective anti-racism medical practice score (N=56).

	Pre mean (SD)	Post mean (SD)	t (df) *P*-value
Overall score	19.27 (5.57)	23.23 (3.54)	t (55) = - 6.28, P < .001
Item 1. I reflect on how my racial bias might impact my practice of medicine.	3.86 (0.98)	4.39 (0.62)	t (55) = -3.98, P < .001
Item 2. I take steps to mitigate my own racial biases in patient care.	3.66 (1.10)	4.36 (0.59)	t (55) = -5.08, P < .001
Item 3. I address microaggressions or biased statements with a colleague or patient.	3.11 (1.12)	3.57 (0.97)	t (55) = -3.33, P < .01
Item 4. I report issues of individual racism when unable to confront it myself.	2.82 (1.10)	3.46 (1.04)	t (55) = -5.00, P < .001
Item 5. I learn and identify how structural racism may impact patient care.	3.18 (1.22)	4.18 (0.81)	t (55) = -6.63, P < .001
Item 6. I propose changes or bring up concerns to improve structural racism in my hospital/ department/community.	2.64 (1.18)	3.27 (1.12)	t (55) = -4.85, P < .001
Additional items on the integration of health equity, racism and/or bias			
Item 7. I integrate issues of health equity, racism, or bias into lectures that I give.	2.77 (1.24)	3.85 (1.14)	t (45) = -6.01, P < .001
Item 8. I integrate issues of health equity, racism, or bias into the research that I do.	3.05 (1.39)	3.78 (1.29)	t (32) = -4.42, P < .001
Item 9. I integrate issues of health equity, racism, or bias into the leadership position I hold.	3.12 (1.14)	3.95 (1.13)	t (39) = - 5.24, P < .001

residents reflected they had at least some bias-focused training in medical school. Antiracism and equity training may remain a moving target for trainees as medical schools take on more education in these realms. Regardless, in graduate medical education trainees will continue to need to learn how to apply broad concepts of antiracism and equity to their specific setting. Programs implementing antiracist and equity education should assess the baseline knowledge and skills of their trainees to help inform how much and what type of education is needed.

Assessment of the curriculum in focus groups suggest that it was impactful, further supported by survey responses. Trainees and attendings alike noted a changing knowledge base and overall attitude in the focus groups. Participants noticed differences in how they approached patient interactions, taught learners, and interacted with medical team members. They also noted strides in their abilities to deliver antiracist care while acknowledging the need for further individual growth. This was mirrored in survey questions with significant changes in reflection on and mitigation of personal racial biases, addressing microaggressions, identifying the impact of structural racism on patient care, and proposing changes or bringing up concerns related to local structural racism in care.

A qualitative theme particular to attendings was change to their teaching and leadership after DARE. This was also a significant change in the survey data; for those who had educational, research or leadership positions, they indicated an increase in integration of antiracism and equity in those realms. This does rely on self-report but is bolstered in part by our focus group participants' focus on culture change: their observation that the colleagues around them were more aware of and invested in antiracism and equity. These findings are encouraging in their suggestion that a curriculum can begin to alter personal *and* group-level attitudes and practices.

For those hoping to initiate an antiracism curriculum, there are now numerous published workshops, simulation scenarios, and lectures that programs can use as building blocks.[23-27] We posit based on our results that the longitudinal, interactive, multimodal, and embedded nature of our curriculum were some of the most important aspects that should be included in future antiracism curricula across the board. We addressed learners at different points in their training and practice, who reported differing, nonlinear educational experiences in this area. This underlines the importance of targeting all levels of learners for antiracism training. Our qualitative themes emphasized the impact of medical culture in learning—whether it be the silent curriculum in medical school learned from clinical rotations, or a faculty member's perception of what is considered a "priority" by their institution—making medical culture a key target for change.

We would also emphasize the importance of local context, which influenced our approach and certainly should be considered for any institution. For example, our trainees and faculty were both grand majority White, which is why we chose to include a major workshop session focused on privilege and whiteness. Additionally, as confirmed in our initial focus groups, our department was starting from a place without a clear culture or support of antiracism. Our curriculum was initially supposed to include a nursing arm (see Appendix C, Proposal of Nursing DARE Curriculum), to more thoroughly impact departmental culture and practice. However, we ran into such vocal dissent at this idea that it was mandated by the hospital to be put on hold for over a year, and ultimately it fell apart due to lack of support and staff availability. This made clear the underlying objection to antiracism among, at a minimum, a vocal minority of our nursing staff, as well as the antipathy of our hospital. For systems like ours, any curriculum aimed at trainees should also include faculty, and as many other EM/PEM staff as possible, to better encourage a true shift in patient care and allow projects on a systemic scale. As noted in our focus groups, prior to the curriculum residents had faced significant hurdles, as well as fear, around taking an active systemic stance advocating for their patients. After, although we had not yet been able to reach our ideal of including nursing, more trainees and faculty felt that antiracism and racism were concepts that were in the water, and an appropriate focus for a career.

LIMITATIONS AND NEXT STEPS

We conducted this curriculum and study at a single institution, so this must be considered in its particular context. We were reliant on self-report of knowledge and skills in both our focus group and survey data. While this is common in the assessment of educational interventions,[24,28,29] as we look forward to the impact of curricula on patient care and outcomes, more direct measures will be useful in future studies. Notably, our theme of culture change was not an individual self-report but a group reflection on the department as a whole.

Our survey response rate was difficult to calculate and is potentially lower than ideal, opening up the possibility of a positive response bias in the data. Additionally, survey results were partially reliant on retrospective report of attitudes and skills prior to the curriculum. While this was purposeful given the topics taught, there is also potential bias in recall. However, our quantitative data strongly mirrors the themes of our robust qualitative data, suggesting likely validity. In future iterations we would hope to capture a higher proportion of participants via quantitative data.

It is key to note that education is only one arm in improving antiracist care and culture. For example, our focus was not on recruitment and retention, altering hospital policies, or engendering hospital-level culture change. Such interventions are also necessary to fully embrace antiracist medicine at both the individual and institutional level.[30-33] This broader lens will also necessarily begin overlapping with an educational focus. For example, one qualitative subtheme was individual room for improvement in the clinical practice

of EM. This will remain an important next step in curriculum development while also requiring creative systemic approaches, such as integrating electronic health dashboards that give racial disparity data or including faculty and trainees in racism-focused quality improvement.[34-36] Finally, a key next step for our institution is providing antiracism education for all team members,[37,38] encouraging a broader culture shift.

CONCLUSION

Overall, a longitudinal, multimodal antiracism and equity curriculum targeted at both trainees and faculty was effective in creating increased anti-racist attitudes and self-reported behaviors and improved antiracist/equity-focused physician culture. Future directions include expanding the curriculum in new directions, engaging multidisciplinary staff, and targeting internal patient metrics toward equitable care.

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Images in Black and White: Disparities in Utilization of Computed Tomography and Ultrasound for Older Adults with Abdominal Pain

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Introduction: Abdominal pain is the leading emergency department (ED) chief complaint in older (≥65 years of age) adults, accounting for 1.4 million ED visits annually. Ultrasound and computed tomography (CT) are high-yield tests that offer rapid and accurate diagnosis for the most clinically significant causes of abdominal pain. In this study we used nationally representative data to examine racial/ethnic differences in cross-sectional imaging for older adults presenting to the ED with abdominal pain.

Methods: We performed a retrospective, cross-sectional analysis using data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) to assess differences in the rate of imaging between White and Black older adults presenting to the ED for abdominal pain. Our primary outcome was the receipt of abdominal CT and/or ultrasound imaging.

Results: Across 1,656 older adult ED visits for abdominal pain, White patients were 26.8% (relatively, 14.2% absolute) more likely to receive abdominal CT and/or ultrasound than Black patients: 802 of 1,197 (67.0%) White patients were 26.8% (relatively, 14.2% absolute) more likely to receive abdominal computed tomography and/ or ultrasound than Black patients (P=0.01).

Conclusion: This study revealed that Black older adults presenting to the ED with abdominal pain receive significantly lower levels of cross-sectional imaging (CT/ultrasound) than White patients. Our findings highlight the need for further investigations into causes of disparities while initiating quality improvement processes to assess and address site- and clinician-specific patterns of care. [West J Emerg Med. 2025;26(3)452–457.]

INTRODUCTION

Abdominal pain is the leading emergency department (ED) chief complaint in older (≥65) adults, accounting for 1.4 million ED visits annually.[1] Abdominal pain in older adults has a broad differential diagnosis and morbidity and mortality equal to or greater than that of ST-elevation myocardial

infarction.[2] Timely diagnosis and treatment are crucial for optimal outcomes. Although questions remain about the optimal level of testing, ultrasound and computed tomography (CT) (collectively referred to as cross-sectional imaging) offer rapid, accurate diagnosis of most clinically significant, treatable causes of abdominal pain.[3,4] However, 40% of older adults with abdominal pain receive neither an abdominal ultrasound nor CT in EDs nationally.[5]

There are no objective signs, symptoms, standards or lab tests that can perfectly determine the need for CT.[6] In this context, individual clinical judgment and local practice patterns can determine which patients receive these tests and may engender disparate care between Black and White patients.[6,7] Prior research on the national scale provides adequate evidence suggesting minoritized populations receive significantly less imaging overall compared to their White counterparts.[8,9] Given known disparities in the assessment and treatment of pain for Black patients, there may be disparities in imaging based on a chief complaint of abdominal pain because there are no guidelines for the management of acute, geriatric abdominal pain.[6,10,11] A cohort of ED patients at a single institution provides suggestive evidence of such an effect: Black and Hispanic adults (≥18) with abdominal pain were significantly less likely to receive CT than their White counterparts.[7]

There is currently a paucity of studies assessing the racial disparities in imaging in abdominal pain in older adults. In this study we used nationally representative data to examine patterns of cross-sectional imaging for abdominal pain presentations among older adults in US EDs. We hypothesized that non-Hispanic Black (Black) patients with a chief complaint of abdominal pain would receive cross-sectional (CT and/or ultrasound) imaging at lower rates than non-Hispanic White (White) patients.

Population Health Research Capsule

What do we already know about this issue?
The decision to image older adults with abdominal pain is high stakes yet lacks guidelines. Reliance on clinical judgment could result in bias.

What was the research question?
Are there significant racial differences in ultrasound and computed tomography use in older adults presenting to the ED with abdominal pain?

What was the major finding of the study?
White patients were 26.8% more likely to receive abdominal computed tomography and/or ultrasound than Black patients (P=0.01).

How does this improve population health?
Understanding the presence of disparities in vulnerable populations is essential to rectifying biased cognitive patterns in patient care.

METHODS

Study Setting and Population

To test this hypothesis, we performed a retrospective, cross-sectional analysis using data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) to assess for differences in the rate of imaging between White, Black, and Hispanic older adults presenting to the ED for abdominal pain. We pooled data from 2013-2020. The NHAMCS is an annual, cross-sectional survey conducted by the National Center for Health Statistics (NCHS) of the US Centers for Disease Control and Prevention, which abstracts ED charts from non-federal, acute care hospitals.[12] The survey design is fully described elsewhere.[12]

We restricted our sample to older adults (≥65 years old) with an abdominal pain chief complaint. The NHAMCS uses pre-established reason-for-visit classification schemes to encode the free text recorded in the chart into one of 5,449 standardized chief complaints.[12] We defined a chief complaint of abdominal pain as the patient's report of pain-like symptoms of either the abdomen or of any abdominal internal organ as the primary reason for visit. Most diagnoses came from the code "Abdominal pain, cramps, or spasms not otherwise specified." Additional methodology for selecting abdominal pain chief complaints in this dataset have been previously described.[5] (Supplemental Table 1)

Outcomes and Primary Comparison

Our primary, dichotomous outcome was the receipt of abdominal CT, ultrasound, or combined CT and/or ultrasound imaging among older adults presenting with abdominal pain during their visit. We excluded magnetic resonance imaging as it was not a standard for rapid diagnosis and was used in <5 ED visits.

Independent Variables

Independent variables included racial and ethnic groups (hereby defined as race/ethnicity), sociodemographics, and hospital characteristics. We categorized patients according to NHAMCS racial and ethnic categories as abstracted from ED charts: non-Hispanic White; non-Hispanic Black; and Hispanic. We dropped American Indian and Alaska Native groups due to insufficient sample size (<30). The primary comparison was between Black and White patients for two reasons. First, prior studies have demonstrated that the widest and most consistent disparities across a variety of health

outcomes exist between Black and White patients, one being a minority group subject to both structural and individual racism, and the other a historically privileged majority.[13,14] Second, power analyses between all racial/ethnic groups suggested the strongest power between these groups regarding combined CT/ultrasound imaging (>80% power at alpha=0.05). Similar power analyses between Hispanic and White patients did not yield adequate power (<60%).

Covariates

For each patient, we analyzed sociodemographic information: age; biological sex (gender not recorded in data); residence; insurance; and triage level. Age categories were designated as 65-74, 75-84, and ≥85 years. Residence categories included the following: homeless; nursing home; living at home; or living in a private institution. Insurance categories were Medicaid, Medicare, private insurance, self-pay, and unspecified. Triage levels were defined as Emergency Severity Index (ESI): ESI 1, immediate; ESI 2, emergent; ESI 3, urgent; ESI 4, semi-urgent; and ESI 5, non-urgent. We excluded ESI 1 from analysis primarily because this category had an insufficient sample size in the preliminary data (<30). In addition, prior literature has demonstrated that abdominal pain is a rare chief complaint of ESI 1 or similar high-acuity category presentations.[13,15,16] Research indicates that the highest acuity patients frequently either lack the time or capability to reliably report their chief complaint as they require acute and immediate care.[5] The NCHS re-scales EDs that use a different triage system to the 5-level ESI scale using a validated methodology.[12]

Statistical Analysis

We used standard descriptive statistics (counts and percentages of binary and categorical variables) to report the characteristics of each visit and chi-square tests to compare study variables across racial/ethnic groups, computed with Stata version 15.1 (StataCorp, College Station, TX). Individual chi-square tests were run per imaging modality. All statistical analyses and estimates were done using NHAMCS four-level, probability-based survey weights to estimate nationally representative statistics, including 95% confidence intervals and hypothesis tests. These weights were adjusted for non-response by time of year, geographic region, urbanicity, and hospital ownership. All hypothesis tests were two-sided with alpha = 0.05. We omitted or combined cells with fewer than 30 observations. Missingness was <2% and addressed with row-wise deletion. The Penn Institutional Review Board exempted this de-identified analysis from review.

RESULTS

Patient and Hospital Characteristics

Our sample included 1,656 abdominal pain ED visits from older adults from 2013-2020 (Table). Based on survey weights, these sampled visits represent an estimated eight-year incidence of 12,553,136 older adult abdominal pain ED visits. Visits from White patients comprised much of the sample (1,197, or 72.3% after applying survey weights). Black (234, 14.1%) and Hispanic (153, 9.2%) patient visits were also common (Table 1). Across all races and ethnicities, the average patient was 76.1 years old. The majority of visits were from patients who were women (1,013, 61.2%), those living in their own homes (1,529, 92.4%), those living in urban areas (1,373, 82.9%), and patients with Medicare insurance (1,322, 79.8%).

Administration of Cross-sectional Imaging

Across all older adult (≥65 years of age) ED visits for abdominal pain, cross-sectional imaging (CT and/or ultrasound) was used in 1,073 (64.7%) visits (Figure), with significant differences between racial and ethnic groups (P= 0.03). White patients were 26.8% more likely to receive abdominal CT and/or ultrasound than Black patients; 802 of 1,197 (67.0%) White

Table. Patient demographic, geographic, and insurance characteristics; and hospital geography by race/ethnicity and overall.

	Patients, Number (%)					
Total estimated number of ED visits over 8-year period (Survey data for ED visits over 8-year period)	Total 12,553,136 (N=1,656)	White 9,028,252 (n=1,197)	Black 1,834,456 (n=234)	Hispanic 1,258,346 (n=153)	Other 432,082 (n=72)	P-value
Patient characteristics						
Age						<0.01
65-74 years	818 (49.7%) [46.1-53.3%]	563 (47.0) [43.4-50.8]	141 (60.2) [50.8-68.9]	93 (60.8) [51.0-69.8]	21 (28.8) [18.5-41.8]	
75-84 years	556 (33.3) [30.5-36.3]	414 (34.6) [31.3-38.0]	64 (27.5) [19.9-36.7]	42 (27.2) [19.0-37.2]	36 (50.0) [34.5-65.6]	
≥85 years	282 (17.0) [14.0-20.4]	220 (18.4) [15.1-22.2]	29 (12.3) [8.2-18.1]	18 (12.0) [6.8-20.6]	15 (21.2) [9.3-41.5]	

(Source: NHAMCS, 2013-2020, authors' calculations using nationally representative survey weights for percentages and total estimated ED visits). *ED,* emergency department.

Table. Patient demographic, geographic, and insurance characteristics; and hospital geography by race/ethnicity and overall, *continued*

	Patients, Number (%)					
Total estimated number of ED visits over 8-year period (Survey data for ED visits over 8-year period)	Total 12,553,136 (N=1,656)	White 9,028,252 (n=1,197)	Black 1,834,456 (n=234)	Hispanic 1,258,346 (n=153)	Other 432,082 (n=72)	P-value
Sex						0.19
Female	1,013 (61.1)	733 (61.2)	129 (55.3)	99 (64.9)	52 (72.8)	
	[57.7-64.4]	[57.3-64.9]	[47.0-63.2]	[53.6-74.7]	[58.8-83.5]	
Male	643 (38.9)	464 (38.8)	105 (44.7)	54 (35.1)	20 (27.2)	
	[35.6-42.3]	[35.1-42.7]	[36.8-53.0]	[25.3-46.5]	[16.6-41.2]	
Residence						0.60
Homeless	1 (0.1)	1 (0.1)	0 (0.1)	0 (0)	0 (0)	
	[0.0-0.3]	[0.0-0.5]	[0.0-1.2]	[0.0-0.0]	[0.0-0.0]	
Nursing	64 (3.8)	55 (4.6)	5 (2.2)	2 (1.0)	2 (3.1)	
	[2.6-5.4]	[3.02-6.8]	[0.6-7.6]	[0.3-4.3]	[0.8-11.4]	
Living at home/private	1529 (92.4)	1094 (91.4)	219 (93.7)	147 (96.1)	69 (95.4)	
	[89.9-94.3]	[88.0-94.0]	[88.5-96.6]	[90.3-98.5]	[86.7-98.5]	
Unspecified/other	62 (3.7)	47 (3.9)	10 (4.0)	4 (2.9)	1 (1.5)	
	[2.5-5.7]	[2.3-6.6]	[2.0-7.8]	[0.9-8.9]	[0.2-10.1]	
Insurance						<0.01
Medicaid/CHIP	89 (5.2)	34 (2.8)	22 (9.4)	19 (12.1)	14 (18.9)	
	[3.8-7.2]	[1.6-4.9]	[5.3-16.3]	[7.1-19.8]	[7.3-40.8]	
Medicare	1,322 (79.8)	991 (82.8)	173 (73.8)	109 (71.3)	49 (67.7)	
	[75.8-83.3]	[77.9-86.8]	[66.0-80.4]	[62.4-78.8]	[49.5-81.8]	
Private	109 (6.6)	71 (5.9)	18 (7.8)	15 (10.1)	5 (7.3)	
	[5.5-8.0]	[4.6-7.6]	[5.1-11.7]	[6.03-16.4]	[3.15-15.9]	
Self-Pay	16 (1.0)	14 (1.2)	0 (0.1)	2 (1.0)	0 (0.7)	
	[0.5-2.0]	[0.5-2.6]	[0.0-0.5]	[0.3-3.2]	[0.0-4.8]	
Unspecified/other	120 (7.4)	87 (7.3)	21 (8.9)	8 (5.5)	4 (5.4)	
	[5.0-10.7]	[4.5-11.9]	[5.02-15.3]	[2.4-12.6]	[2.1-13.2]	
Hospital geography						0.03
Urban	1,373 (82.9)	950 (79.4)	207 (88.6)	145 (94.9)	71 (98.5)	
	[72.5-90.0]	[67.0-88.0]	[69.7-96.4]	[85.8-98.3]	[89.9-99.8]	
Non-urban	283 (17.1)	247 (20.6)	27 (11.4)	8 (5.1)	1 (1.5)	
	[10.0-27.6]	[12.0-33.1]	[3.7-30.3]	[1.7-14.2]	[0.2-10.1]	
Triage level						0.16
Emergent	119 (7.2)	78 (6.5)	32 (13.5)	5 (3.0)	4 (5.8)	
	[5.4-9.5]	[5.0-8.7]	[8.6-20.7]	[0.7-11.2]	[2.1-15.0]	
Urgent	971 (58.6)	712 (59.5)	120 (51.2)	94 (61.8)	45 (62.0)	
	[53.4-63.6]	[53.7-65.0]	[42.4-60.0]	[47.8-74.0]	[43.7-77.4]	
Semi-urgent	105 (6.4)	72 (6.0)	16 (7.0)	14 (9.2)	3 (4.3)	
	[4.3-9.4]	[4.1-8.7]	[3.1-15.4]	[3.7-21.0]	[1.6-11.1]	
Non-urgent	18 (1.1)	12 (1.0)	5 (2.3)	0 (0)	1 (0.8)	
	[0.6-1.9]	[0.5-2.0]	[0.8-6.3]	[0.0-0.0]	[0.1-5.2]	
Unspecified/other	443 (26.7)	323 (27.0)	61 (26.0)	40 (26.0)	19 (27.1)	
	[21.6-32.6]	[21.5-33.2]	[17.4-37.0]	[17.0-37.9]	[14.1-45.9]	

(Source: NHAMCS, 2013-2020, authors' calculations using nationally representative survey weights for percentages and total estimated ED visits)

CHIP, Children's Health Insurance Program*; ED,* emergency department; *NHMACS*, National Hospital Medical Ambulatory Care Survey; *n,* number of observations in dataset before survey weighting.

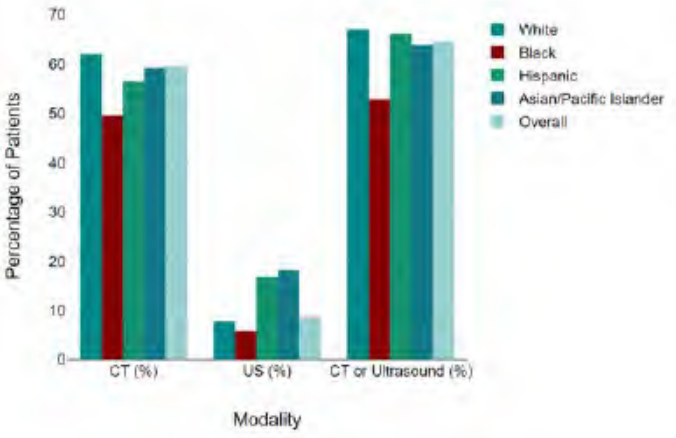
patients received cross-sectional imaging compared to 124 of 234 (52.8%) Black patients ($P = 0.01$). Analyzed separately, White patients received more CT imaging alone than their Black counterparts (62.0% vs 49.6%), but the difference was not significant ($P = 0.06$). White patients also received significantly more ultrasound imaging than their Black counterparts (7.7% vs 5.8%, $P = 0.02$).

DISCUSSION

In nationally representative ED data from 2013-2020, of over 12 million visits we found older Black patients with a chief complaint of abdominal pain were significantly less likely to receive definitive diagnostic imaging compared to White patients. We identified an absolute 14.2 percentage-point difference in cross-sectional imaging between Black and White patients. Our study builds on prior work demonstrating a racial disparity in abdominal imaging utilization in a single hospital's ED for abdominal pain.[5,7] It also adds to a greater body of evidence identifying racial disparities in imaging in the ED, specifically among older adults. There are no other national studies that focus on this specific age group with abdominal pain.[8,9]

The differential rate of imaging has at least two potential explanations. First, Black and White patients may present to the ED with a different distribution of underlying pathologies. While this cross-sectional study cannot exclude this possibility, for this to be the entire explanation, the demonstrated 26.8% greater imaging rate for White patients would need to be matched by a similarly elevated rate of severe, CT-diagnosable pathology among White compared to Black patients. The elevated rates of morbidity and mortality among Black older adults in US EDs and in admitted patients with emergency

Figure. Diagnostic imaging by race and ethnicity. Percentages represent weighted percentages based on NHAMCS* national survey weights.



CT, computed tomography *US,* ultrasound.
(Source: *National Hospital Ambulatory Medical Care Survey, 2013-2020; authors' calculations using nationally representative survey weights for percentages and total estimated emergency department visits)

general surgical conditions belie this explanation.[17,18] Second, White patients could be over-tested relative to their level of risk and, likewise, Black patients under-tested relative to their level of risk. In this case, the rates of CT utilization for Black patients described in this study could represent a clinically appropriate level of testing, or under-testing. Notably, in a single-ED study cohort that imaged at a similar rate to White patients in our data, two of five CTs obtained demonstrated acute findings.[7] In either case, these differences in CT imaging reflect disparate levels of resource utilization, where greater resources in the form of CT scanner time are spent on White patients. To differentiate between these cases, a cohort that obtains imaging on all patients or follows patients past their discharge from the ED is required.

There is already a substantial body of literature that suggests the pain of Black patients in the ED may be minimized compared to the pain of White ED patients.[13,14,19,20] These differences in the assessment of pain levels can also translate into disparate assessment and diagnosis. Therefore, given known disparities in the assessment and treatment of pain for Black patients, there may be disparities in imaging based on a chief complaint of abdominal pain.[11] Biased cognitive patterns are particularly influential in abdominal pain because there are no objective signs, symptoms, standards, or lab tests that can perfectly determine the need for a CT, nor are there guidelines for the management of acute, geriatric abdominal pain.[6,11,21] A cohort of ED patients at a single institution provides suggestive evidence of such an effect: Black and Hispanic adults (≥18) with abdominal pain were significantly less likely to receive CT than their White counterparts.[7]

Our work adds to the growing body of evidence highlighting disparate levels of testing for racially minoritized groups across various conditions. The actual mechanisms by which the health system produces biased care are multifactorial and require further attention.

LIMITATIONS

This study has several limitations. It is possible that older Black patients are more likely to use the ED for lower acuity presentations, leading to appropriately lower rates of imaging. Similarly, we cannot rule out differential patient refusal of CT when offered by clinicians, for instance, due to differences in insurance or physician trust. Second, since the NHAMCS captures data from electronic health records, there is the possibility for level of measurement error based on self-reporting of race. The NHAMCS is also underpowered to assess differences in non-Black racial and ethnic groups. Additionally, the NHAMCS does not have the ability to ascertain clinician race/ethnicity, which may influence clinical bias. Third, the NHAMCS cannot differentiate between abdominal ultrasound and other ultrasounds. However, it is likely that most of these imaging modalities for a chief complaint of abdominal pain would be localized to the abdomen while a patient with a non-abdominal secondary reason for visit might receive an

ultrasound, and any measurement error is unlikely to be systematic by race/ethnicity.

CONCLUSION

This study revealed that Black older adults presenting to the ED with a chief complaint of abdominal pain receive significantly lower levels of cross-sectional imaging (CT and/or ultrasound) than White patients. Our findings highlight the need for further investigations into the causes of these disparities given the high rates of morbidity and mortality associated with abdominal pain ED presentations in older adults.

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Emergency Medical Service Responders' Perspectives on Transgender, Intersexual, and Non-Binary Patients in Germany

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Introduction: Gender minorities, including transgender, intersexual and non-binary (TIN) individuals, are at risk of receiving suboptimal care in emergency departments due to clinicians' limited knowledge and formal training in TIN-specific needs. Little evidence is available regarding emergency medical service (EMS) responders, including paramedics (EMT-P), emergency medical technicians (EMT) ,and prehospital emergency physicians (EP). Therefore, in this study we aimed to explore the experiences and knowledge, attitudes, and education/training needs of EMS professionals in Germany regarding the care of TIN patients.

Methods: In April 2023, we electronically surveyed EMTs, EMT-Ps and prehospital EPs from ambulance stations across Germany. Participants completed a questionnaire consisting of 15 closed-ended items assessing their experience and knowledge, attitudes, and education/training needs regarding the care of TIN patients. We used standard descriptive statistics and tested for group differences using the chi-square test.

Results: Of the 2,925 potential respondents, 906 completed the survey and were eligible for further analysis (response rate: 31%). Of these, 218 (24%) were prehospital EPs and 688 (76%) were EMTs and EMT-Ps, the latter two being significantly younger and less experienced. Almost half of the respondents reported having experience in caring for TIN patients as EMS responders (45% of EMTs/EMT-Ps vs 40% of prehospital EPs) but demonstrated significant gaps in non-medical and medical knowledge. Attitudes toward TIN patients were generally positive, but there were discrepancies between perceived comfort and actual communication behavior, with up to 25% of respondents overall avoiding questions they would ask non-TIN patients. Most respondents had no formal training in the appropriate management of TIN patients: only 7% of EMTs/EMT-Ps and 5% of prehospital EPs indicated having received such training during their professional or medical training. Our survey showed that 63% of EMTs/EMT-Ps and 62% of prehospital EPs agreed that there is an urgent need to increase awareness for TIN patients among EMS responders.

Conclusion: Despite generally positive attitudes toward transexual, intersexual and non-binary patients, EMS responders in Germany demonstrated deficits in knowledge and clinical preparedness to care for this vulnerable patient population, indicating that the care of TIN patients has not yet become routine in EMS and highlighting a strong need for improved education and training. [West J Emerg Med. 2025;26(3)458–464.]

INTRODUCTION

The provision of prehospital emergency medical care requires healthcare professionals to address a wide range of medical needs in time-sensitive and often challenging situations and environments.[1] Among the patient populations encountered in prehospital settings are individuals who identify as transgender, intersexual or non-binary (TIN).[2] These individuals often face significant barriers when accessing healthcare due to discrimination, social stigma, and inadequate training of healthcare professionals.[3,4] These barriers contribute to pronounced health disparities worldwide, with TIN patients at increased risk of mental health disorders, substance use disorders, and chronic health conditions.[5,6] In both the United States (US) and Germany, TIN individuals represent approximately 0.6% of the adult population and up to 4.1% of adolescents, highlighting the need to address health disparities in this unique and growing population.[7,8]

Prehospital emergency medical services (EMS) or emergency departments (ED) are often the first point of contact between TIN patients and the healthcare system in emergencies.[9] However, for many TIN individuals, this interaction is often accompanied by challenges, mainly due to the limited understanding of their specific healthcare needs by healthcare professionals.[10] This deficit may lead to delays in care, misdiagnosis, and, in some cases, avoidance of emergency services by TIN patients altogether. Studies in the US and Germany/Europe show that nearly half of TIN individuals delay or avoid seeking emergency medical care because of concerns about mistreatment or previous negative experiences with healthcare professionals.[11,12] There are multiple barriers to effective emergency medical care for TIN individuals, with the lack of education and training of emergency care professionals on gender diversity and the appropriate management of TIN patients being the key challenge.[13] Surveys of emergency physicians (EP) and nurses working in EDs in Germany and the US show that although the majority have encountered TIN patients, most had significant knowledge gaps and reported feeling unprepared to provide competent care. Less than 30% of respondents stated they had received formal training in TIN care.[14,15]

Despite increasing awareness of these challenges, there remains a significant gap in the literature regarding the specific needs of TIN patients, particularly in the prehospital emergency care setting, as outlined in the 2024 Position Statement on Care for Transgender and Gender Diverse Prehospital Patients by the National Association of EMS Physicians (NAEMSP) in the US as well as in a recent scoping review on this topic by Farcas et al.[9,16] Existing research has predominantly focused on hospital-based emergency care in the ED, with limited attention paid to EMS responders in prehospital settings.[2] A recent survey of EPs and paramedics (EMT-Ps) in the US found that 94% of respondents expressed a willingness to include LGBTQ+ (lesbian, gay, bisexual, transgender, questioning/queer)-related content in their training programs, but few training institutions currently offer such training.[17] Furthermore, there is a lack of data concerning the specific prehospital management of TIN patients in both the US and Europe. This gap is particularly concerning because the initial phase of emergency care is critical due to patients' heightened vulnerability and anxiety, which are associated with uncertainty about the medical interventions to come.[9]

Population Health Research Capsule

What do we already know about this issue?
Transgender, intersexual and non-binary (TIN) individuals experience significant health disparities and encounter barriers to care, including in emergency situations.

What was the research question?
We sought to explore the knowledge and attitudes of emergency medical services (EMS) responders in Germany regarding the care of TIN patients.

What was the major finding of the study?
EMS providers showed large gaps in knowledge about TIN care, but a strong desire to improve these findings.

How does this improve population health?
Recognizing the need for improved education and training of EMS responders in the management of TIN patients may promote more equitable emergency care.

In this context, our goal in the present study was to explore the perspectives of EMS responders in Germany, including prehospital EPs, emergency medical technicians (EMT) and paramedics (EMT-P), regarding the care of TIN patients. While the involvement of prehospital EPs is specific to the Franco-German EMS system, EMTs and EMT-Ps are present in most EMS systems worldwide.[18]

METHODS

Study Design and Study Population

We conducted a cross-sectional study of EMS professionals in Germany including prehospital EPs (Notarzt), paramedics (Notfallsanitaeter), and EMTs (Rettungssanitaeter) using a web-based survey platform (SoSci Survey GmbH, Munich, Germany).[19] Compared to the US EMS system, which relies primarily on EMTs and EMT-Ps to provide prehospital care, the German EMS system follows the Franco-German model, which involves a greater degree of physician involvement in prehospital care and emphasizes advanced medical interventions in the field rather than rapid transport to hospitals.[18] To qualify as

a prehospital EP, subspecialty training in prehospital emergency care and at least two years of clinical experience after medical school are required.[20]

The survey was distributed to 100 of approximately 1,000 randomly selected ambulance stations staffed with prehospital EPS across Germany, of which 65 agreed to distribute the survey to their EMS clinicians and responders. All active members of the prehospital EMS were considered eligible to participate. We estimated the number of prehospital EPs active as freelancers in the 65 ambulance stations to be approximately 975 and the number of EMTs and EMT-Ps to be 1,950, based on ambulance station staffing data. The Ethics Committee of Hannover Medical School approved the study (No. 10706_B0_K_2023).

Survey Development

Survey development and administration is described in a prior publication.[14] The survey instrument, which was developed by an interdisciplinary group of experts in questionnaire development and members of the TIN community in Germany, comprised 15 closed-ended items designed to assess participants' experiences, attitudes, and education/training needs related to the care of TIN patients. These items were evenly distributed across three thematic categories: 1) five items related to experiences and knowledge; 2) five focused on respondents' attitudes and 3) five on education/training needs. Response options were either single-choice or presented on a 4-point Likert scale (strongly agree – somewhat agree – somewhat disagree – strongly disagree). The survey instrument was already used in a previous study on EPs and nurses working in EDs in Germany.[14] During the initial survey development, all survey items were tested for clarity with six EPs, five nurses, and eight EMS responders. To ensure the comparability of the two study samples for potential subsequent analysis, no adjustments were made to the ED staff survey. We collected the demographic parameters of the study participants and their informed consent for study participation and data use.

Survey Administration

Participants had the opportunity to complete the anonymous, self-administered online survey during a four-week period in April 2023. Invitations were sent via e-mail to the medical directors of the ambulance stations with the request to distribute the survey link to their active staff members, including prehospital EPs, EMTs, and EMT-Ps. A reminder was sent after two weeks. All participants who met the inclusion criteria and completed at least the demographic parameters and the content category on experience were included in the final analysis.

Primary Data Analysis

We extracted raw data from SoSci Survey into SPSS v 27 (SPSS Statistics, IBM Corp, Armonk, NY) and calculated standard descriptive statistics, including frequencies. The chi-square test was applied for group comparison. We considered $P < 0.05$ to be significant. The effect size Cramer`s V is interpreted as high (V=0.5), moderate (V=0.3) and low (V=0.1).

RESULTS

During the study period, 958 surveys were returned, of which 906 were eligible for further analysis. Fifty-two participants did not complete at least the demographic parameters and the content category on experience and had to be excluded. Ninety-three percent of respondents completed all 15 items. The overall response rate was 31%, with approximately 975 prehospital EPs and 1,950 EMTs/EMT-Ps contacted by their respective ambulance station medical directors to participate in the study. Of the respondents, 218 (24%) were prehospital EPs and 688 (76%) were EMTs/EMT-Ps. There were significant intergroup differences in all demographic variables analysed (age, size of city of workplace, years of work experience) except for gender. In particular, EMTs/EMT-Ps were significantly younger (59% of EMTs/EMT-Ps ≤ 30y vs 8% of prehospital EPs ≤ 30y, $P<0.001$; V=0.441) and had fewer years of work experience than the EPs (69% of EMTs/EMT-Ps < 10 years vs 41% of prehospital EPs, $P<0.001$; V=0.277). Table 1 summarizes the characteristics of the respondents.

Table 1. Demographics and descriptive characteristics of prehospital emergency medical service professionals.

	Prehospital EP		EMT/EMT-P	
Demographics	N	%	N	%
Total	218	24.1	688	75.9
Gender				
Male	139	63.8	456	66.3
Female	76	34.9	221	32.1
Diverse	1	0.5	7	1.0
No answer	2	0.9	4	0.6
Age group (years)				
≤ 20	0	0.0	41	6.0
21 – 30	17	7.8	362	52.6
31 – 40	104	47.7	161	23.4
41 – 50	52	23.9	79	11.5
> 50	45	20.6	45	6.5
Size of city of workplace (thousands)				
< 20,000	35	16.1	175	25.4
20,000 – 100,000	74	33.9	252	36.6
> 100,000 – < 1,000,000	82	37.6	203	29.5
≥ 1,000,000	27	12.4	58	8.4
Working experience (years)				
In training	0	0.0	51	7.4
< 5	27	12.4	196	28.5
5 – 10	63	28.9	230	33.4
> 10	128	58.7	211	30.7

EP, emergency physician; *EMT/EMT-P,* emergency medical technician or paramedic.

Experience and Knowledge

Almost half of respondents reported having cared for transgender and gender non-conforming patients as prehospital EMS professionals over the prior two years (Figure 1).

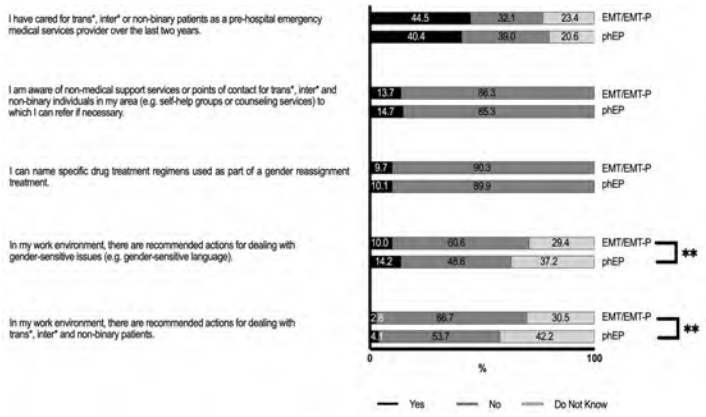

Figure 1. Experience and knowledge of pre-hospital emergency medical service providers in caring for transgender, intersexual and non-binary patients.
** = p <0.01
phEP, pre-hospital emergency physician; *EMT/EMT-P,* emergency medical technician or paramedic.

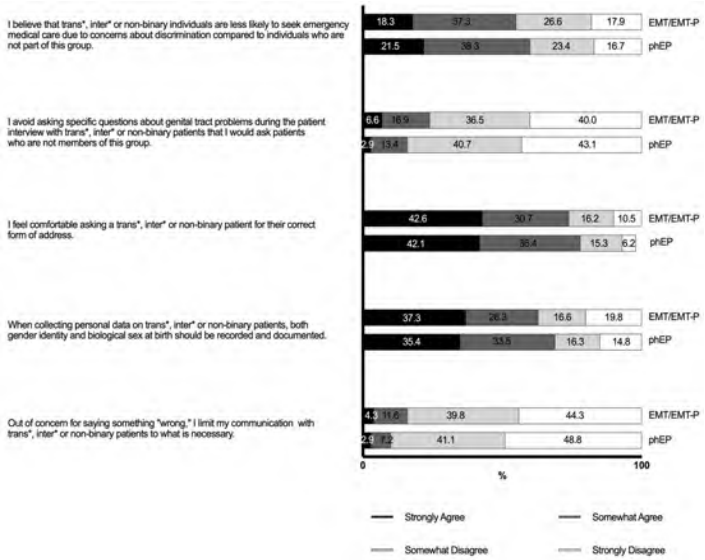

Figure 2. Attitudes of pre-hospital emergency medical service providers regarding transgender, intersexual, and non-binary patients.
phEP, pre-hospital emergency physician; *EMT/EMT-P,* emergency medical technician or paramedic.

However, both prehospital EPs and EMTs/EMT-Ps demonstrated a lack of medical knowledge and awareness of non-medical support services for TIN individuals. Only 15% of prehospital EPs and 14% of EMTs/EMT-Ps reported being aware of non-medical support services or referral points for TIN people in their region, and only 10% of the respondents of both groups were able to name specific medication regimens associated with gender-affirming treatments. In addition, most prehospital EPs (96%) and EMTs/EMT-Ps (97%) reported that no official guidelines existed, and they were not aware of any recommendations for the management of TIN patients in the prehospital EMS setting.

Attitudes

Most respondents in both groups agreed that both gender identity and biological sex at birth should be documented when collecting personal information in the prehospital EMS setting (69% of prehospital EPs and 64% of EMTs/EMT-Ps) (Figure 2).

Seventy-nine percent of prehospital EPs and 74% of EMTs/EMT-Ps felt comfortable asking TIN patients for their correct form of address. Most also reported that they would not avoid asking questions about genital tract problems that they would usually ask non-TIN patients, nor would they limit their communication with TIN patients to what was necessary out of concern for saying something wrong. In terms of perceptions of oppression, around 60% of both participant groups agreed that they believed TIN individuals were less likely to seek emergency medical care than non-TIN individuals because of concerns about discrimination (60% of prehospital EPs and 58% of EMTs/EMT-Ps).

Education and Training Needs

Most respondents reported not having received any formal training in the appropriate management of TIN patients (61% of prehospital EPs and 55% of EMTs/EMT-Ps). Specifically, only 5% of the EPs and 7% of EMTs/EMT-Ps reported having received such training during their professional or medical education, including undergraduate, postgraduate, residency or fellowship programs. Thirty-four percent of prehospital EPs and 38% of EMTs/EMT-Ps reported learning about this topic on their own (Figure 3).

A significant proportion of both groups, prehospital EPs (62%) and EMTs/EMT-Ps (63%), agreed with the statement that there is a need to raise awareness among EMS professionals regarding the care of TIN patients. In addition, 75% of prehospital EPs and 66% of EMTs/EMT-Ps felt that this should be included in medical education and professional training. Accordingly, more than 60% of participants in both groups expressed the belief that continuing medical education (CME) on the appropriate management of TIN patients would be valuable (67% of prehospital EPs and 65% of EMTs/EMT-Ps) and that they would participate in such CME if offered (93% of the EPs and 96% of EMTs/EMT-Ps) (Figure 4).

DISCUSSION

In this cross-sectional survey, we found that although most EMS professionals in Germany felt comfortable communicating

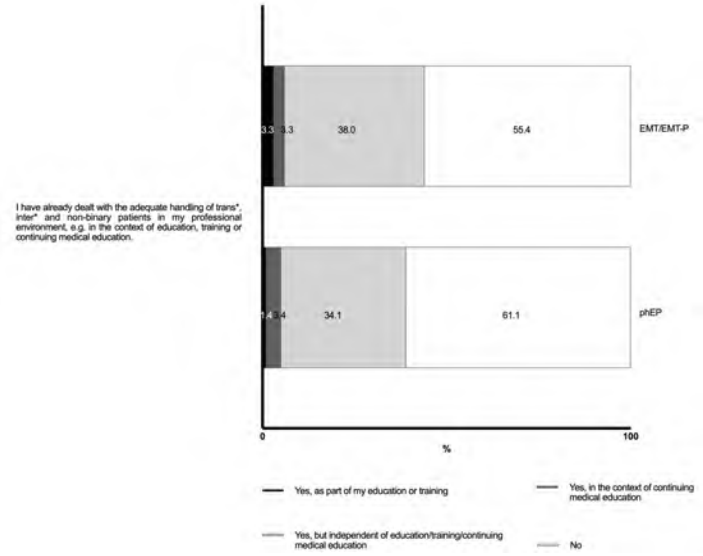

Figure 3. Education and training of pre-hospital emergency medical service providers regarding the care for transgender, intersexual and non-binary patients.
phEP, pre-hospital emergency physician; *EMT/EMT-P,* emergency medical technician or paramedic.

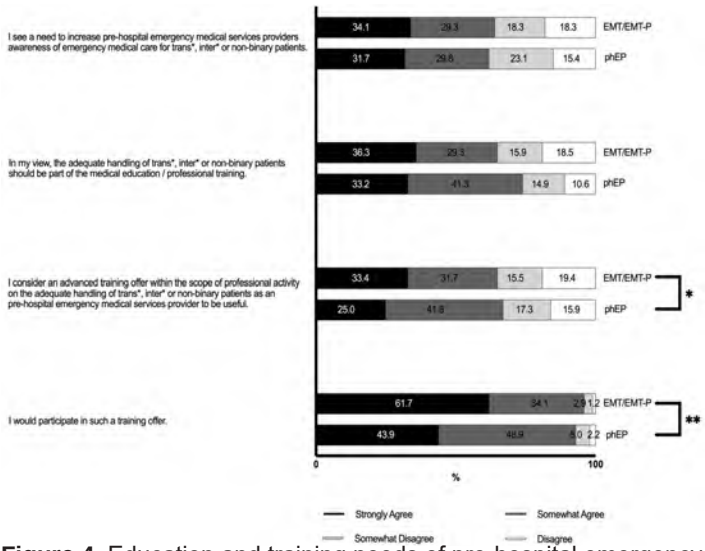

Figure 4. Education and training needs of pre-hospital emergency medical service providers regarding the care for transgender, intersexual and non-binary patients.
* P < 0.05, ** P <0.01,
phEP, pre-hospital emergency physician; *EMT/EMT-P,* emergency medical technician or paramedic.

with TIN patients at first glance, there were still large gaps in knowledge about key aspects of emergency care for this underserved patient population and a strong desire for improved education and training to address these findings.

Although almost half of respondents in both groups reported encounters with TIN patients as prehospital EMS professionals in the prior 24 months, almost 90% demonstrated knowledge gaps in terms of lack of awareness of non-medical support services to which TIN patients can be referred, or specific medical regimens related to gender transition used by TIN patients. These findings are consistent with data from Chisolm, Straker et al and our group showing that both EPs and ENs working in EDs in the US and Germany had inaccurate knowledge about the care of TIN patients.[14,15] With regard to EMTs and EMT-Ps, the lack of explicit educational content on LGBTQ care in EMS training programs, as recently shown by Jalali et al, and the lack of official guidelines for addressing gender-related issues, is likely to have contributed to these gaps and may result in inadequate or delayed care, exacerbating the inequalities faced by these individuals in emergency situations.[21,22]

Given its role as a pivotal entry point into the health care system for this vulnerable population, it is imperative to strengthen the capacity of EMS professionals to address the needs of these patients, who find themselves in a particularly precarious situation. In this regard, the NAEMSP has recently published a position statement on Care for Transgender and Gender Diverse Prehospital Patients in the US, which explicitly underscores the significance of gender-affirming care within the prehospital context. This statement clearly outlines the steps necessary to provide optimal care for these patients in emergency situations and has the potential to serve as a model for Europe.[9]

It is also plausible that affected individuals may perceive this lack of knowledge as insensitivity. Supporting this, several studies examining the experiences of transgender and gender non-conforming patients in ED settings have shown that more than half of these individuals avoid EDs primarily due to a perceived lack of clinician sensitivity and anticipated discrimination.[11,23] There is no published data focusing on the experiences of TIN patients in the prehospital emergency care setting. Turning the tables and examining the attitudes of EPs and ENs toward the care of TIN patients in the ED, it was demonstrated that, contrary to published patient experiences, most ED staff felt comfortable communicating with TIN patients.[14,15] Similar to these findings, the majority of respondents in this study of prehospital EMS professionals felt comfortable asking TIN patients for the correct form of address and agreed that both gender identity and biological sex should be documented. Nevertheless, up to 15% of respondents reported limiting communication with TIN patients out of concern for saying something wrong, and up to 25% of respondents avoided asking questions about genital tract problems that they would ask non-TIN patients. This discrepancy between perceived comfort and actual communication behaviours suggests a need for targeted training to improve competence and communication skills among EMS professionalvs.

Previous research suggests that TIN individuals often experience misgendering or questioning of their identity during emergency care encounters, leading to feelings of disrespect

and mistrust toward healthcare professionals.[10,12] Greater focus on communication skills, particularly the correct use of gender-sensitive language and respectful communication practices, therefore, seems necessary. Raising awareness of the oppression of TIN patients in emergency care seems equally important, as almost 40% of respondents in this study were unaware that TIN individuals are less likely to seek emergency medical care than non-TIN individuals due to concerns about discrimination. This awareness seems critical to removing barriers to healthcare access for TIN individuals.[24]

A key result of this study is the lack of formal training in TIN care among EMS professionals, which is likely to have contributed to the above findings. This is consistent with previous research, both in the US and Europe, indicating that training on sexual and gender minorities is often inadequate or absent in healthcare education.[25,26,27] Notably, most participants agreed with the need to raise awareness of the care of TIN patients among EMS professionals and supported the inclusion of TIN-specific content in medical education and training. Such training should include both clinical knowledge, such as recognising the unique health risks of TIN individuals, and non-clinical aspects including respectful communication.

For EMT-Ps, Kruse et al developed a 70-90 minute mandatory, asynchronous, online training module on sexual and gender minority health in the prehospital setting, which led to a significant increase in allyship among cisgender, heterosexual-identified frontline paramedics in Canada.[28] Although not specifically tailored to EMS professionals, the InTraHealth self-learning platform for healthcare professionals in Germany provides guidance on addressing and preventing discrimination against TIN people in healthcare settings.[29] In addition, the development of standardised protocols, informed by both healthcare professionals and members of the TIN community, could improve the consistency and quality of care provided to TIN patients in emergency situations. Involving the TIN community in the development of these protocols could also ensure that the protocols are sensitive and meet the real needs of the TIN patient population.[30]

LIMITATIONS

This study used an unvalidated survey instrument that relied on self-reported data from prehospital EPs and EMTs/EMT-Ps, which may have been subject to response bias, including social desirability bias. A positive selection bias cannot be excluded, as EMS medical directors, prehospital EPs or EMTs/EMT-Ps with a greater interest in this topic may have been more likely to participate in the study. Also, no information was available on non-respondents. Only eight participants identified as gender-diverse. Therefore, we cannot comment on their specific experiences and attitudes, which may differ from other EMS personnel and have not been explored in the literature. Finally, the relatively low estimated response rate of 31% and the limitation of the sample to prehospital EPs and EMTs/EMT-Ps in Germany may limit the generalisability of our findings to other countries or healthcare systems, although EMTs and EMT-Ps can be found in many EMS systems worldwide.

CONCLUSION

This study provides evidence that there are significant gaps in the knowledge and clinical preparedness of EMS professionals to care for TIN patients in the prehospital emergency care setting. While attitudes toward TIN patients were generally positive, educational and structural barriers remain. Addressing these challenges through the integration of TIN healthcare topics, including gender-sensitive and respectful communication, into undergraduate and further training programs for healthcare professionals seems crucial to ensure that all patients, regardless of their gender identity, receive equitable, respectful, and competent care.

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Simulation-based Training Changes Attitudes of Emergency Physicians Toward Transesophageal Echocardiography

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Objective: The American College of Emergency Physicians recommends that transesophageal echocardiography (TEE) be used to "maintain the standard of ultrasound-informed resuscitation" in cardiac arrest. To date, no standards exist on how to train emergency physicians (EP) on TEE use in the emergency department (ED). We propose a novel educational paradigm using simulation to train EPs on the use of TEE in cardiac arrest.

Methods: A total of 63 EPs at a single-center academic teaching hospital participated in a 90-minute simulation-based education session to summarize the use of TEE in cardiac resuscitation and practice related procedural skills. The session consisted of a simulated cardiac arrest scenario using both transthoracic echocardiography (TTE) and TEE and hands-on practice on a high-fidelity TEE task trainer. Participants filled out anonymous surveys before and after the training session, which evaluated their subjective attitudes toward TEE, knowledge of its role in cardiac arrest, and perceived efficacy of the curriculum in introducing the modality.

Results: Survey results indicated fewer perceived barriers to performing TEE in resuscitation after completion of the course, with statistically significant decreases in the following: not understanding image acquisition (85.5% pre vs 27.4% post; $P<0.001$), interpretation (66.1% pre vs 25.8% post; $P<0.001$), indications (29.0% pre vs 0.0% post; $P<0.001$), contraindications (35.5% pre vs. 3.2% post; $P<0.001$), and the potential benefit for the patient (24.2% pre vs 3.2% post; $P<0.001$). Finally, 68% of EPs stated they were "extremely likely" to use TEE in cardiac arrest with the availability of assistance from a credentialed attending.

Conclusion: The survey responses suggest that a short, simulation-based course can generate interest in the incorporation of TEE in cardiac resuscitation as well as overcome many of the perceived barriers regarding TEE. Moreover, they suggest that the participating academic EPs would be interested in using TEE in critical patients in the future when available. [West J Emerg Med. 2025;26(3)465–468.]

BACKGROUND

The American College of Emergency Physicians (ACEP) recommended in 2017 that transesophageal echocardiography (TEE) be used to "maintain the standard of ultrasound-informed resuscitation in the scenario of cardiac arrest."[1] Whereas traditionally transthoracic echocardiography (TTE) has been

employed by emergency physicians (EP) in resuscitation scenarios, its utility is limited by potentially poor image quality due to suboptimal windows. Additionally, studies have shown that the use of TTE during cardiac arrest increases pulse check duration.[2,3] In comparison, TEE has been demonstrated to decrease compression pauses and improve visualization of cardiac structures for reversible causes of cardiac arrest.[4] Studies in animal models also suggest that TEE can be used to guide cardiac compressions for maximal cardiac output, potentially improving mortality outcomes.[5] Current evidence shows TEE is a safe procedure with the risk of perforation limited to 0.01% and an overall mortality rate of 0.0098%.[6,7]

Despite TEE being identified as potentially useful during resuscitation, there are many logistical challenges to establishing TEE at an institution, including equipment availability, sterilization protocols, training, and credentialing. Even within departments with established TEE programs, however, its use varies widely. This may be due to a lack of evidence-based standards on how to train EPs on TEE use, as well as other perceived barriers that have not yet been identified. Prior studies on TEE education have involved small groups of learners, primarily trainees; moreover, they have focused on learners with prior advanced ultrasound training.[8] Furthermore, the understanding of TEE in the larger emergency medicine (EM) community is limited, with no current studies identifying perceptions and gaps in knowledge of TEE in the general EP population. Adoption of TEE by emergency departments (ED) has been hindered by a multitude of factors, many of which may not be fully recognized.

Compared to traditional educational modalities, the use of simulation allows learners to expose underlying practice patterns and decision-making frameworks, while also establishing a formal mechanism to de-bias error-prone behaviors via structured debriefing.[9] This allows participants to conceptualize new ideas to be implemented in practice.[10] Currently, there is little literature on how to incorporate simulation into TEE education for practicing and non-ultrasound-trained EPs. Our objective in this study was to employ a simulation-based education course to train a large and diverse group of EPs at an academic ED, including non-ultrasound fellowship-trained EPs, to study the prevailing barriers to adoption of TEE and the effect of simulation to bridge those barriers.

METHODS

Study Design, Setting, and Participants

This was a prospective, single-center, cross-sectional study conducted in a tertiary-care teaching hospital with an EM residency, clinical simulation fellowship, and emergency ultrasound fellowship. We created a simulation-based course to introduce attending EPs to the use of TEE in cardiac resuscitation. Study subjects were a convenience sample of all employed attending EPs in the institution. Subjects participated in a 90-minute course consisting of a simulation case, debriefing, and hands-on practice using a TEE simulator. Excluded were faculty of the emergency ultrasound and clinical simulation divisions with knowledge of the study objectives. Pre- and post-course surveys were used to evaluate changes in physician attitudes toward TEE. The local institutional review board classified this study as "exempt."

COURSE DESIGN

The course was implemented January 2019–July 2020 with groups of two to three learners per session. Sessions were facilitated by at least one ultrasound fellowship-trained faculty and one simulation fellowship-trained faculty with experience in TEE and clinical debriefing, respectively. Prior to the training module, all participants completed one hour of asynchronous TEE education consisting of either video podcasts or continuing medical education from prior conferences.

The course began with a simulated cardiac arrest scenario using the high-fidelity simulator CAE Apollo (Global Technologies, Ltd, Parsippany, NJ). The scenario was designed to reproduce the limitations and pitfalls of TTE in cardiac arrest (eg, poor views and prolonged interruptions in compressions) and highlight several advantages of TEE in guiding resuscitation (eg, continuous compressions with a specific prompt to change hand placement to avoid obstructing the aortic outflow tract and demonstration of organized cardiac activity unseen on TTE). Debriefing focused on linking the participants' simulated challenges using TTE to similar real-world patient experiences, while specifically documenting the duration of prolonged pauses in compressions during the scenario. The framework was explicitly structured to promote critical reflection with regard to methods of decreasing pulse check duration (eg, Cardiac Arrest Sonographic Assessment protocol[11]) and introduce TEE as a safe, approachable tool to improve practice.

The final phase of the course was to provide individualized hands-on instruction with image acquisition and interpretation on a high-fidelity task trainer Ultrasound Mentor (Surgical Science Sweden AB, Göteborg, Sweden). This skills session was led by an ultrasound fellowship-trained EP credentialed to perform TEE based on ACEP standards for competency. Participants engaged in deliberate practice guided by a procedural checklist to obtain and interpret mid-esophageal four-chamber, mid-esophageal long-axis, bicaval, and transgastric mid-papillary short-axis views.[10] Clinical contexts incorporated reversible causes such as cardiac tamponade, pulmonary embolism, aortic dissection, and fine ventricular fibrillation.

Variables

Participants filled out anonymous surveys immediately before and immediately after the training session, evaluating their subjective attitudes toward TEE, knowledge of its potential role in cardiac arrest, and perceived efficacy of the curriculum in introducing the modality.

DATA ANALYSIS

Surveys were de-identified, kept confidential, and reviewed only by members of the research team. We summarized the data using descriptive statistics (percentages for categorical variables and means with standard deviations for continuous variables). Since we did not record participant identifiers, our analysis assumed independence; a chi-square test was performed to compare pre- and post-session knowledge questions. Levels of significance were tested at $P<0.05$. Analyses were conducted using SPSS v27.0 (SPSS Statistics, IBM Corp, Armonk, NY).

RESULTS

A total of 63 EPs participated in the TEE simulation course (Table 1), and 62 participants completed both pre- and post-course surveys. The strongest perceived barrier to using TEE before the module was image acquisition. There was a significant decrease in this and all other perceived barriers (image interpretation, indications, contraindications, potential benefits, potential risks) to performing TEE in resuscitation after simulation (Table 2). Participants also evaluated course effectiveness using a modified Likert scale ranging from 1 ("not at all effective") to 5 ("extremely effective)." Based on this data, participants felt the course was effective in teaching potential benefits of TEE in cardiac arrest with a mean modified Likert score of 4.73. Additionally, 68% of EPs stated they were "extremely likely" to use TEE in cardiac arrest with the availability of assistance from a credentialed attending following participation in the education.

DISCUSSION

Credentialing and training in TEE have been pursued primarily by ultrasound fellowship-trained faculty.[8] This study is unique in that it focused on introducing TEE to EPs with a broad range of ultrasound and clinical experience, rather than on training the smaller, specialized subset of ultrasound fellowship-trained physicians. A majority of our subjects (84%) did not have ultrasound fellowship training. Additionally, our study included subjects with a diverse mix of clinical experience: 46% of participants had more than five years of clinical experience. This mix of subjects suggests that even experienced clinicians with established practice patterns responded well to the simulation-based module and were interested in expanding their practice to include TEE.

Using simulation to promote active learning among our cohort allowed for a learner-centered discussion of the advantages and disadvantages of TEE, leading to natural evolution toward positive attitudes regarding the modality. Responses from participants suggest that this simulation-based module effectively eroded potential educational barriers to adopting TEE in the ED. The barrier of not understanding indications of TEE was abolished. Barriers such as technical skill in image acquisition and interpretation were allayed significantly.

Our study faces the inherent limitations of a prospective observational study: Survey results focused on the attitudes and reactions of learners following the module and did not assess participant knowledge or skill. Furthermore, all participants came from a single academic ED with well-established ultrasound and simulation divisions, limiting generalizability to the emergency medicine community at large. It also did not evaluate whether TEE is superior to TTE or compare simulation-based TEE education to other modes of education, such as lecture-based formats or asynchronous learning. However, to evaluate these outcomes it is first important to gain buy-in to the idea of TEE, which we focused on in this study.

Lastly, due to the pre- and post- nature of the study, it is difficult to determine whether this theoretical knowledge would translate to long-term changes in practice. Further directions include working toward ongoing training pathways supported by skills assessment on simulated and live patients. Other future

Table 1. Participant demographics.

Characteristic	Number (%) (N=63)
Sex	
Male	32 (51)
Female	31 (49)
Performed TEE before	
Yes	14 (22)
No	49 (78)
Attending experience	
New (<5 years)	34 (54)
Mid (5-10 years)	9 (14)
Experienced (>10 years)	20 (32)
Ultrasound experience	
Ultrasound trained	5 (8)
Current ultrasound fellow	5 (8)
No ultrasound fellowship training	53 (84)

TEE, transesophageal echocardiography.

Table 2. Perceived barriers to use of transesophageal echocardiography.

Barrier, n (%)	Pre-course 62 (100)	Post-course 62 (100)	P-value
Do not know how to acquire images	53 (85)	17 (27)	<0.001
Do not know how to interpret images	41 (66)	16 (26)	<0.001
Do not know indications	18 (29)	0 (0)	<0.001
Do not know contraindications	22 (35)	2 (3)	<0.001
Do not know potential benefit	15 (24)	2 (3)	<0.001
Causing patient harm or liability	15 (24)	6 (10)	<0.05

directions include establishing a Standardized Direct Observation Assessment Tool to measure retention and competency of TEE skills over time.

CONCLUSION

Use of transesophageal echocardiography in cardiac arrest is rapidly evolving and a subject of focus in current ultrasound and critical care literature. It is suggested that TEE may revolutionize the way emergency physicians run cardiac resuscitation by better identifying reversible causes of cardiac arrest, allowing for continuous cardiac monitoring, and optimizing high-quality compressions. Despite these potential benefits, adoption of this cutting-edge modality in the ED has been met with hesitancy, especially among practicing EPs without ultrasound fellowship training. Gaining a thorough understanding of potential educational barriers to the adoption and use of TEE is an important step in the process of implementing a TEE curriculum. This study highlighted prevalent gaps in knowledge and revealed the preconceived barriers to use of TEE in the emergency department through the use of simulation-based training.

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Trends in Studies on Transesophageal Echocardiography in Emergency Medicine: A Scoping Review

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Background: Transesophageal echocardiography (TEE) has been introduced in resuscitative scenarios in recent decades, with a growing number of emergency physicians learning, performing, and studying resuscitative TEE.

Objective: Our goal was to characterize publishing trends regarding TEE use in emergency medicine (EM) and to investigate the increasing interest in potential applications of TEE in emergency departments (ED).

Methods: We retrieved published research associated with the use of TEE in EM from the Web of Science database from inception to December 31, 2023. We analyzed trends based on the number of articles published annually. To systematically map trends related to TEE in emergency medicine (EM), we extracted data on the number of unique EM TEE practitioners, institutions performing EM TEE, study topics, and other characteristics from research articles and case reports. To better reflect research trends, we exclusively conducted subgroup analysis on the research articles. We used linear regression analysis to analyze trends and conducted checkpoints on the timelines.

Results: Of the 964 titles and abstracts screened, we included 99 eligible published articles after careful review. Articles related to EM TEE increased from one article in 1991 to 20 articles in 2023, and the rate of publication has increased rapidly since 2018 (+12.4 publications per year, 95% confidence interval [CI] 9.8-15.0, P<0.001). The number of EM TEE practitioners and EM TEE-performing institutions underwent a rapid expansion with an inflection point between 2018–2020, with a rate of +91.7 practitioners per year and +36.5 institutions per year. Subgroup analysis revealed a similar trend in the published research articles. The most common indications for EM TEE were cardiac arrest (72.7%), shock (13.1%), and procedural guidance (11.1%). The United States published the majority of EM TEE-related articles (51.5%).

Conclusion: The present study highlights that TEE-related articles in EM continue to accelerate. Among the indications for TEE, cardiac arrest remains the most frequently discussed. This scoping review provides insights into the expanding interest and applications of TEE in the field of EM. [West J Emerg Med. 2025;26(3)469–477.]

INTRODUCTION

Ultrasonography has been applied to the clinical practice of emergency medicine (EM) since 1990.[1] Emergency physicians (EP) have been trained in the use of point-of-care ultrasonography (POCUS) since 1994, when it was included in the core content of EM residency programs.[2, 3] In recent decades, POCUS has been widely implemented for diagnosis and procedures in EM.[4] According to the emergency ultrasound guidelines published by the American College of Emergency Physicians (ACEP) in 2023, POCUS has a diverse range of applications, including assessment, investigation and procedural guidance. [5]

Using the same goal-directed framework as clinical ultrasound applications, focused or resuscitative transesophageal echocardiography (TEE) has been increasingly used to evaluate critically ill patients in emergency settings. Research on TEE in EM was first published in the 1990s, with articles describing the use of TEE to diagnose aortic and cardiac diseases.[6] Since 2008, EPs started to use TEE in cardiopulmonary resuscitation, revealing its feasibility, safety, and clinical impact throughout the course of ongoing resuscitative efforts.[7] An increasing number of EPs are employing TEE as a tool in diagnosis, prognosis, therapeutic guidance, and monitoring for cardiac arrest resuscitation.[8] Since 2018, guidelines have been published to assist EPs in acquiring the equipment and skills required to successfully incorporate TEE into clinical practice.[5, 9]

Although there appears to be increased use of resuscitative TEE in EDs, little attention has been given to the expanded application of TEE in EM. Therefore, in this scoping review we aimed to systemically map the publication trends associated with TEE in EM. Additionally, we sought to describe the characteristics of published articles related to TEE.

METHODS

Study Design and Setting

In this scoping review, we investigated all the publication and citation data retrieved from the Web of Science (WoSc) database before December 31, 2023. The study protocol was approved by the Institutional Review Board of Dalin Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, Taiwan (No. B11301004). The study adheres to the Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping reviews (PRISMA-SCR) guidelines.[10] The final protocol was registered prospectively with the Open Science Framework (https://osf.io/4fsnk).

Article Selection and Assessment

Transesophageal echocardiography is defined as a specific ultrasound technology that places the ultrasound transducer inside the esophagus to acquire exceptionally detailed images of the cardiac and vascular anatomy. [6] Emergency medicine focuses on the initial evaluation and treatment of any patient requiring expeditious medical and surgical care in a hospital-based or freestanding emergency department (ED), urgent care clinic, or prehospital setting (eg, an emergency medical response vehicle or a disaster site).[11] We searched the literature published from inception through December 31, 2023, in the WoSc database using the following keywords: "transesophageal echocardiography," "TEE," and "emergency." (The search was performed March 1, 2024) We searched for keywords and linked the search terms with logical Boolean operators in titles, abstracts, and keywords according to the type of article.[12] We also extended our search to include gray literature through manual exploration. To be included in the review, studies had to explicitly demonstrate the performance of TEE in EM settings. We excluded case animal studies, studies not in English, studies in which TEE was not performed on the same day as the ED visit, and those without a clear description of the EM setting.

Two reviewers (BYT and CJY) independently screened the titles and abstracts of all articles that met the inclusion criteria in the search strategy. They subsequently discussed the results and updated a master list of studies. The full texts of potentially eligible studies were retrieved and assessed for eligibility by the same reviewers. Inter-reviewer disagreements were resolved by consensus and, if necessary, a third reviewer (TYT) was consulted. Two reviewers independently abstracted the following data from the included articles: name of the first author; year of publication; number of citations; country of origin; article categories; publishing journal name; article topic; location, type, and number of practitioners; objectives; indication for which TEE was performed; and hospital name(s). We determined country of origin based on the location of the research. Articles were classified by WoSc categories as case reports, research articles, reviews, editorials, or meeting abstracts. The topic of each article was organized into four principal domains: diagnosis; intervention (procedure guidance); education; and safety. Indications for TEE were classified as cardiac arrest, shock, procedural guidance, trauma and cardiac diseases (eg, valvular thrombi), in accordance with prior studies.[6,9]

Outcome Measurement

The primary outcome was the number of TEE-related articles published annually in EM, which we used to evaluate the trend in publication rate during the study period. The number of citations for each article was retrieved from the WoSc database. To characterize global trends in the capacity for EM TEE performance, we also conducted a systematic assessment of the annual changes in the reported numbers of EM TEE practitioners and EM TEE-performing institutions. The number of EM TEE practitioners was defined as the number of practitioners who both performed TEE and were involved in data collection, serving as an indicator of the expansion of EM TEE application worldwide. We abstracted the practitioners' numbers from original articles by using the following guidelines: 1) based on article description, if details

provided; 2) contacting the first and corresponding authors for detailed number by e-mail; and 3) if there was no reply, we estimated based on the number of TEE cases and the number of authors listed in the article. If the number of TEE cases was more than the number of authors, we considered all authors as TEE-performing physicians. If the number of TEE cases was fewer than the number of authors, we first counted the corresponding and first authors as TEE-performing physicians, followed by the second author, and so on, in that order. For authors with multiple published articles, the earliest one published was considered in the event of duplicates. We defined the TEE-performing institution as the hospital or center where TEE was performed. We applied the same calculation method to estimate the number of TEE-facilitating institutes. If more than two published studies originated from the same institution, we extracted only the earliest and removed the duplicate entries. Review articles were excluded from the data of practitioners and institutions. In addition, to reflect the current global research trends regarding the use of TEE in EM, we analyzed research articles focusing on the annual publication trends, the number of EM TEE practitioners, and EM TEE-performing institutions in the subgroup analysis. Other outcomes included the geographic distribution of papers based on country, number of citations of each article, proportion of articles published in dedicated EM journals, type of article, setting, specialty of TEE practitioners, participants, and indications for TEE. Clinical practice characteristics, such as setting, specialty of TEE practitioners, and population for TEE, were extracted only from observational studies and case reports. We conducted subgroup analysis exclusively on the research articles.

Data Analysis

As this study was a scoping review, we reported only descriptive statistics for the distribution of the number of articles and citations. To clearly present the trends in outcomes, we used the slope (β) of linear regression curves to analyze trends in the number of published studies, EM TEE practitioners, and EM TEE-performing institutions, and we calculated the 95% confidence intervals (CI) of β. Additionally, if the trends of interest did not follow a simple linear pattern, we used the "Rbeast" package to identify any inflection points.[13] A *P*-value <0.05 was considered statistically significant. We conducted all analyses using R statistical software v 4.2.3 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Search Results

An initial search of the WoSc database yielded 964 published articles. We excluded 852 articles based on screening titles and abstracts for irrelevant topics, unavailable data, and duplicate records. The remaining 112 full-text articles were retrieved and assessed for eligibility with 13 potentially relevant studies excluded after full-text review because they had "emergency" in the abstracts but did not perform TEE on the same day of an ED visit or were unrelated to an emergent presentation (Supplementary Figure S1). After careful review, 99 published articles met all the eligibility criteria (Supplementary Table S1). In total, 33 (33.3%) articles were categorized as research articles, 23 (23.3%) as case reports or series, and 18 (18.2%) as review articles (Supplementary Table S2). In the analysis of topics within TEE-related literature, 77.8% (77/99) of articles employed TEE for diagnostic purposes, 15.2% (15/99) focused on TEE training and education, 7.1% (7/99) applied TEE for procedural guidance, and 3.0% (3/99) addressed TEE safety in clinical settings. Overall, the total, average, and median numbers of citations were 1,284, 13.0, and 2, respectively.

TEE-related Publication Trends, Trends in TEE Practitioners and TEE-performing Institutions

Concerning the primary outcome, the number of TEE-related published articles on EM increased from 1 in 1991 to 20 in 2023 (Figure 1). The number of publications has been increasing steadily since 1991 with an increasing rate of publications of 1.8 per year (95% CI 1.3-2.2, $P<0.001$). The inflection point was in 2018, and the number of published articles has increased more rapidly since 2018, with an increasing rate of publication of 12.4 per year (95% CI 9.8-15.0, $P<0.001$). When focusing specifically on research articles, we observed a similar trend and inflection point in the number of articles.

We calculated trends in the number of TEE practitioners and institutions from 81 observational studies and case reports. Of these, 70 articles provided details based on descriptions within the paper, two were clarified by contacting the corresponding authors via email, and the remaining nine lacked specific details, prompting estimation based on the number of TEE cases and authors listed in the articles. The first article to calculate the number of TEE practitioners and institutions was published in 1993. The number of TEE practitioners in EM has experienced significant growth, increasing from four EM TEE practitioners described in published articles in 1993 to 559 practitioners in 2023, with a rate of increase of 8.9 practitioners per year (95% CI 5.7-12.0, $P<0.001$). Concurrently, the number of EM TEE-performing institutions in EM also demonstrated a sustained increase from two institutions in 1993 to 112 institutions in 2023, with a rate of increase of 1.6 institutions per year (95% CI 1.0-2.2, $P<0.001$). There is an inflection point between 2018–2020 where both EM TEE practitioners and EM TEE-performing institutions underwent a rapid expansion after this period (Figure 2A), with an increasing rate of 91.7 practitioners per year (after 2018) and 36.5 institutions per year (after 2020). When focusing specifically on research articles, a similar trend and inflection point were observed (Figure 2B). The number of TEE practitioners increased at a rate of 50.8 per year after

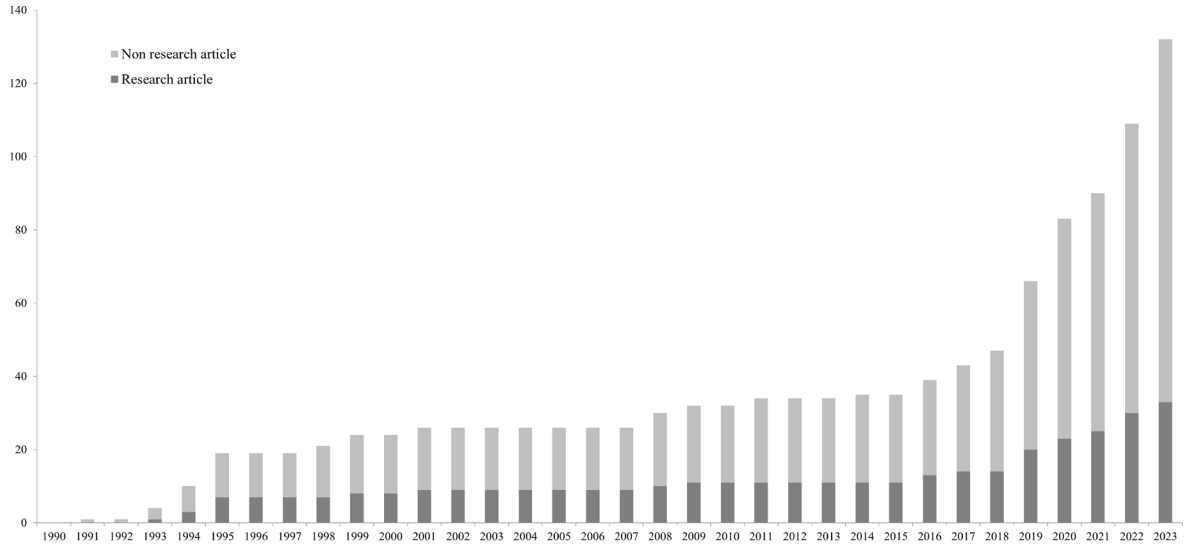

Figure 1. Cumulative number of published articles and research on transesophageal echocardiography in emergency medicine settings from 1990–2023.

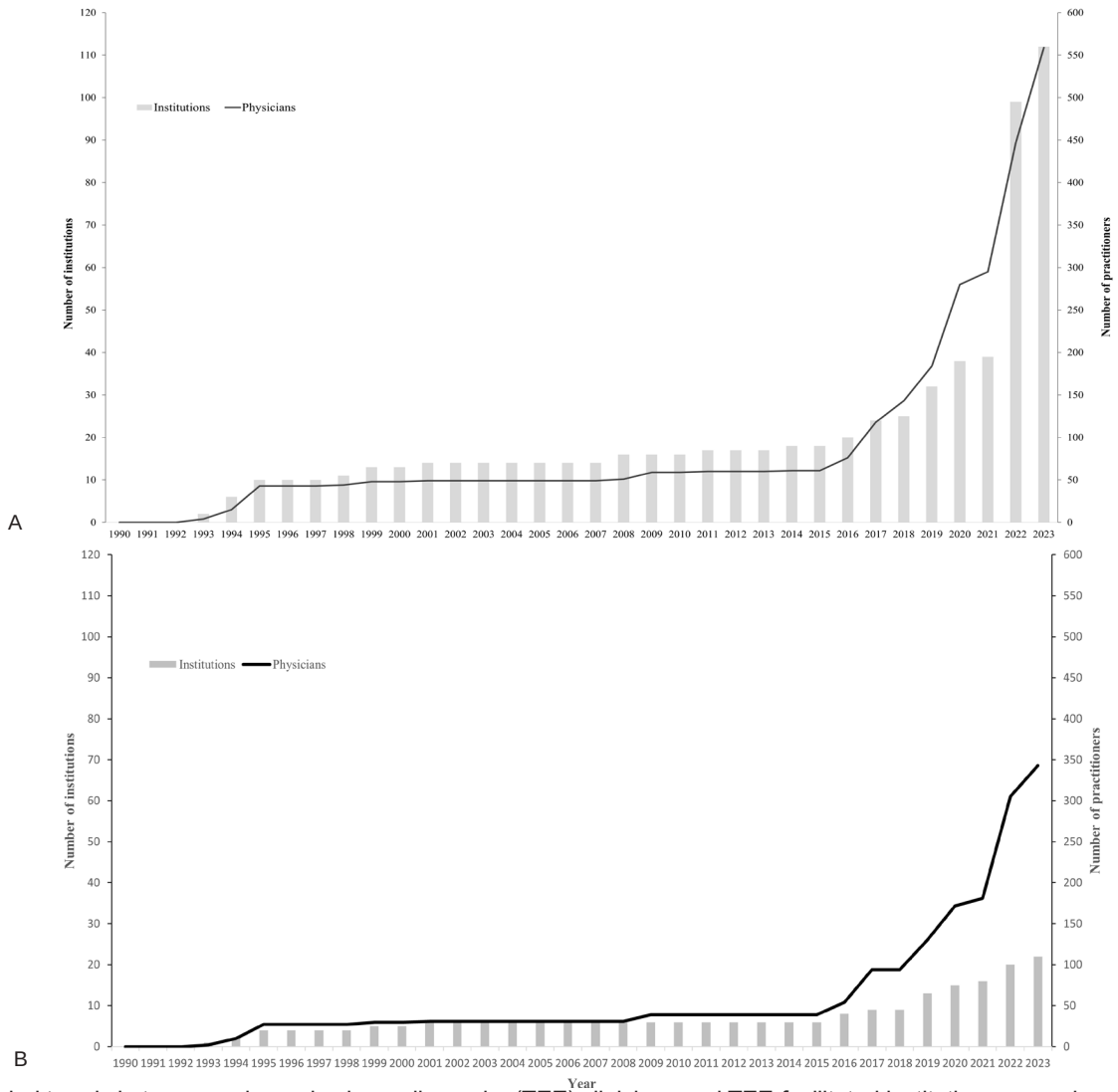

Figure 2. Global trends in transesophageal echocardiography (TEE) clinicians and TEE-facilitated institutions as analyzed in published papers (A), with specific analysis in research articles (B).

Table 1. Distribution of transesophageal echocardiography-related papers published by country.

Country	Number of publications	%	Total times cited
United States	51	51.5	762
South Korea	11	11.1	148
Canada	11	11.1	96
Taiwan	7	7.1	69
Italy	4	4.0	36
United Kingdom	3	3.0	45
United Arab Emirates	2	2.0	16
Germany	2	2.0	2
Malaysia	2	2.0	0
France	1	1.0	105
Turkey	1	1.0	2
Belgium	1	1.0	2
Denmark	1	1.0	2
Ireland	1	1.0	0
Austria	1	1.0	0

an inflection point in 2018, while the number of TEE-performing institutions rose at a rate of 2.1 per year after an inflection point in 2016.

Characteristics of the TEE-related Publications

The 99 retrieved publications originated from 15 countries, and most studies were from the United States (51, 51.5%), followed by South Korea (11, 11.1%), Canada (11, 11.1%), and Taiwan (7, 7.1%) (Table 1). The articles were published in 36 journals, the majority of which were published in the *Annals of Emergency Medicine* (18, 18.2%) and the *American Journal of Emergency Medicine* (15, 15.2%) (Supplementary Table S3).

To present the current status of EM TEE in published articles in more detail, we extracted characteristics of this modality in clinical practice from observational studies and case reports. Overall, 77 of 81 (95.1%) non-review studies were performed in EDs, six (7.4%) in the intensive care unit, and three (3.7%) in prehospital settings (Table 2). The EM TEE was primarily performed by EPs (56, 69.1%), with 18 (22.2%) of the articles mentioning that EM TEE was performed by ED residents. In the subgroup analysis of 33 research articles on TEE in EM, 32 articles (97.1%) reported TEE being performed in EDs, with 30 articles (90.9%) indicating that the procedures were conducted by EPs.

The EM TEE was predominantly used for adult patients (56, 69.1%). Five articles reported on the use of TEE in the pediatric population. However, these studies were conducted only on adolescents and not on younger children.[14-18] Owing to the different sizes of EM TEE devices used in pediatric and adult populations, there are currently no articles exploring the application of EM TEE in young children with cardiac arrest.[19] The most common indications among all studies for TEE in EM were cardiac arrest (72, 72.7%); shock (13, 13.1%); procedural guidance (11, 11.1%); and aortic disorders (10, 10.1%) (Supplementary Table S4). It is worth noting that among the 16 articles published before 2000, 10 specifically focused on the indication of aortic disorders. Since 2008, articles focusing on cardiac arrest as an indication have become predominant, and the number of articles has exponentially increased since 2018 (Figure 3A). A similar trend was observed in research articles (Figure 3B).

DISCUSSION

To our knowledge, this is the first study to evaluate the trends in TEE-related research of EM and analyze their characteristics. Our study provides a quantitative analysis of the evolving publication trends of TEE in EM. We observed a marked increase in the number of published articles, as well as the number of institutions and TEE practitioners described in these articles, after an inflection point around 2018. Most EM TEE publications were authored by EPs, with a significant focus on indications for cardiac arrest. A similar trend was observed when analyzing research articles specifically.

The first TEE-related article on EM was published in 1991, and EM TEE was primarily used to diagnose aortic dissection and blunt chest injuries in the 1990s.[6, 14, 20, 21] In the late 1990s and early 2000s, there were some TEE-related articles during this period focused on studying physiology of the cardiac pump theory rather than the application of TEE in clinical practice.[22-24] In 2008 Blaivas et al reported a case series of TEE with six cases, offering distinct advantages of TEE over TTE in patients with cardiac arrest and undergoing cardiopulmonary resuscitation (CPR).[7] Since then, TEE-related articles have gradually increased and focused on TEE use in assessing CPR quality and cardiac arrest etiologies.[25,26] In 2018, ACEP published clinical guidelines for TEE applications in cardiac arrest resuscitation.[9] Published articles related to TEE exponentially increased thereafter (Figure 1). In the 2020s Teran et al initiated a multicenter TEE registry study[27]; subsequently, the recorded number of TEE practitioners and institutions facilitating TEE exponentially increased since 2020 (Figure 2).

Similar to the trend observed in our study, a recent North American cross-sectional survey revealed that over 80% of EPs expressed interest in performing TEE in EDs where it is not currently used.[28] However, the initiation and development of EM TEE programs face multiple barriers, including safety concerns, financial constraints, credentialing/privileges issues, and the absence of TEE-trained EPs or champions. The main barrier for EPs to perform TEE was the concern of associated complications, which aligns with our findings in this scoping review. We observed that many TEE-related articles focus on the safety of TEE use in the ED setting.[29-33] Furthermore, one of

Table 2. Characteristics of transesophageal echocardiography-related articles.

	Number (%) of articles*		Number of articles focusing on research studies[#]	%
Setting				
Emergency department	77	95.1	32	97.1
ICU[**]	6	7.4	5	15.2
Prehospital	3	3.7	2	6.1
Operating room	3	3.7	2	6.1
NA[†]	3	3.7	0	0
Population				
Adult	56	69.1	25	78.8
Pediatric	5	6.2	3	9.1
NA[†]	24	29.6	8	24.2
Specialty of Practitioners				
Emergency physician[§]	56	69.1	30	90.9
Cardiologist	10	12.3	4	12.1
Intensivist	8	9.9	6	15.2
Echocardiographer[‡]	1	1.0	1	3.0
EMS physician	1	1.0	0	0
NA[†]	17	21.0	1	3.0

ICU, intensive care unit*; NA*, not applicable.
*The number and percentage of published papers were calculated from 81 observational studies and case reports, with some studies reporting multiple characteristics.
#The number and percentage of published papers were calculated from 33 research papers, with some studies reporting multiple characteristics.
**The articles that mentioned the ICU setting also included patients who underwent TEE in the ED within the same study.
†Some data were not applicable because the study was either a simulation or an educational study.
§Eighteen of the 56 studies demonstrated that emergency medicine residents and fellows provided TEE, contributing to 22.2% of the extracted data in TEE-related studies.
‡This study (Cohn, SM, 1995)[21] did not mention the specialty of the echocardiographers.

our included studies suggested that charging higher fees for TEE-guided resuscitation could promote the development of TEE programs, especially if evidence continues to show that TEE improves resuscitation quality.[28]

Another common barrier is the need for resources to credential and privilege users. Our scoping review also found a growing trend in studies on competency maintenance and quality assurance.[34,35] Interestingly, 16.2% of the included articles focused on educational issues, such as TEE hands-on training, teaching programs, and evaluation of performance (Supplementary Table S2). Furthermore, 18 of the included studies enrolled ED residents (Table 2); eight of these 18 articles focused on educational issues, while in the remaining 10, residents performed TEE based on ACEP training and credentialing recommendations.[9] These trends suggest that TEE education is an important research area with evaluation of residency training and certification systems to further support expansion of TEE in the ED.

Based on the trend analysis, EM TEE-related studies focus primarily on resuscitation, especially in patients with cardiac arrest. Current guidelines recommend chest compressions on the lower sternum, but factors like cardiomegaly, lung disease, and anatomical variations may limit effectiveness; future studies will explore how TEE improves the chest compression position during CPR, diagnosing the etiology of cardiac arrest, and prognostication of survival.[36] Currently, three-dimensional (3D) TEE is widely used under many critical conditions.[37,38] As the time required for 3D reconstruction decreases and image quality improves, the application of 3D TEE in resuscitation may play a valuable role in the future.[38] Moreover, the development of artificial intelligence (AI) to capture and process TEE images should improve the speed and accuracy of this POCUS modality, making it more accessible to clinicians across various specialties.[38,40] With the application of 3D and AI techniques, TEE may be more broadly used in resuscitation and could further expand clinical applications to resource-limited settings in the future.[41]

LIMITATIONS

The main strength of this scoping review is its quantitative review of current trends in TEE-related

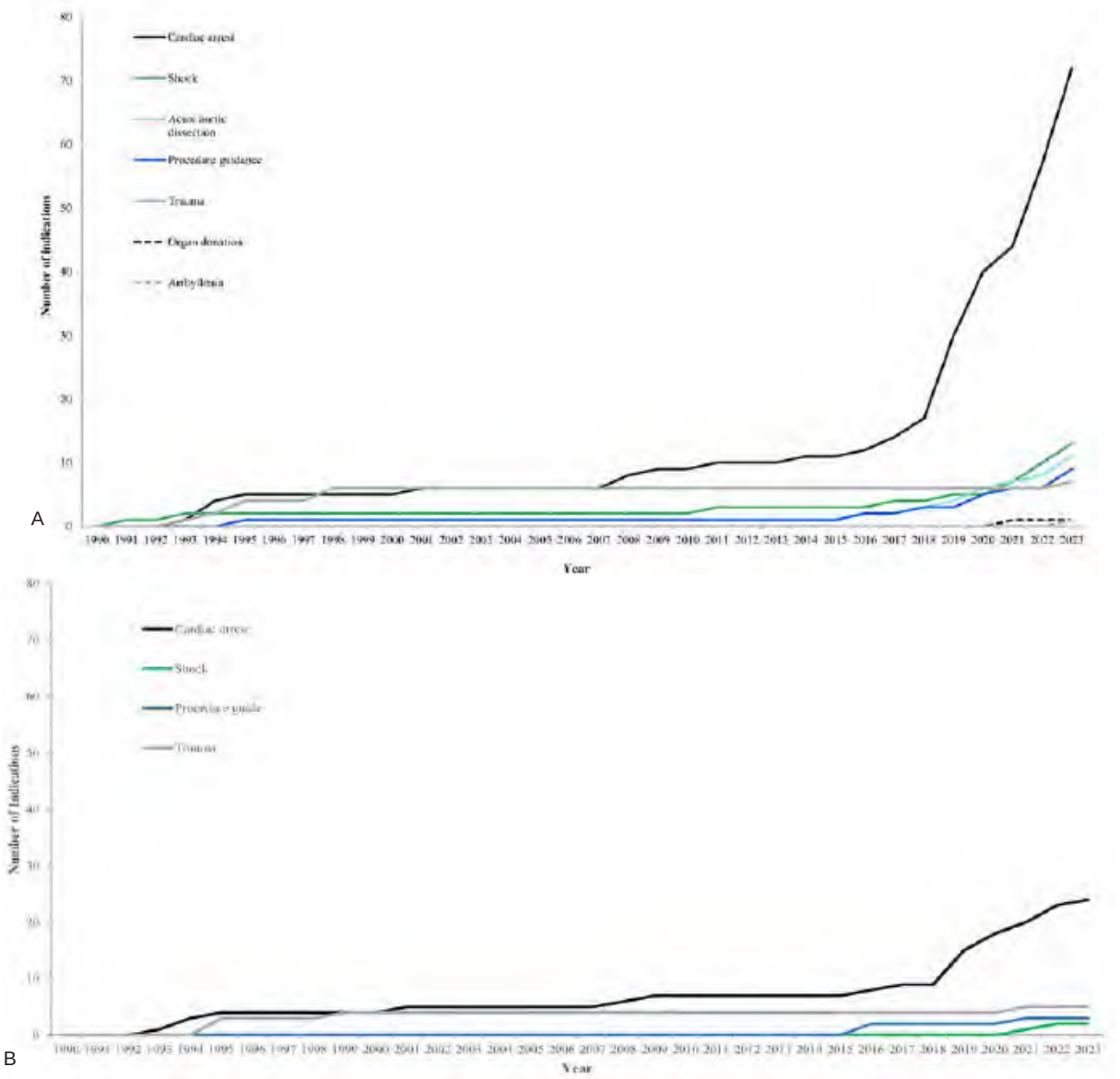

Figure 3. Timeline of indications for transesophageal echocardiography as analyzed in published papers (A), with specific analysis in research papers (B).

publications in EM. However, this study had some limitations. First, our study has a risk of publication bias. Studies tend to be accepted for publication if they have significant findings. Conversely, the lack of benefit for certain indications may be under-represented because of rejection of manuscripts that lack positive, significant, or novel results. Second, the number of EM TEE practitioners and EM TEE-performing institutions may have been underestimated, as some practitioners and institutions do not publish their work or conduct clinical research. Nevertheless, the observed trends in these numbers still provide important insight into this burgeoning field. Third, our study classified countries according to the first author's affiliation, which likely underestimated the extent of international collaborative research and contributions.

Fourth, the impact of studies conducted after 2023 was underestimated. This resulted from the gap between the paper's publication and the appearance of citations in other journals. Furthermore, studies published in 2022 may also not have sufficient time to accumulate citations. This phenomenon has been observed in previous studies.[42] Finally, there is a possibility of bias in our data due to the potential misclassification of the setting and physicians involved in TEE administration. Although our objective was to categorize these variables accurately, varying healthcare systems, definitions of healthcare facilities, and

specialist roles across countries might have influenced these classifications.

CONCLUSION

This study highlights the ongoing acceleration in the number and variety of TEE-related published research in EM. Among the indications for TEE, cardiac arrest remains the most frequently discussed, indicating a predominant area of interest within TEE-related publications. This scoping review provides insights into the expanding interest and applications of TEE in the field of EM.

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Evaluation of Point-of-Care Ultrasound Use in Emergency Medicine Residents: An Observational Study

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Introduction: Point-of-care ultrasound (POCUS) is integral to emergency medicine (EM) training. It is unclear how EM residents use POCUS and how these skills are maintained as they progress in residency training. The purpose of this study was to evaluate resident use of POCUS at various timepoints in EM training.

Methods: This was a retrospective cohort study of EM residents at a single, three-year training program between July 1, 2014–June 30, 2022. Residents were included if they had completed three consecutive years of training and an ultrasound rotation in their postgraduate year (PGY)-1. The following time points were assessed: PGY-1 rotation and 3-, 6-, 12-, 18-, and 24-months post-rotation. Number of scans, accuracy of interpretation, acceptability for credit, and percentage of technically limited studies (TLS) were collected at each point. We analyzed performance characteristics using mixed-effects binomial logistic regression with time as a fixed effect and resident as a random effect. Models were fit separately for each performance characteristic and likelihood ratio tests were performed to determine whether performance varied over time.

Results: A total of 65 residents were included with a total of 13,229 exams performed during the study period. Cardiac and focused assessment with sonography in trauma examinations were performed most commonly. Overall accuracy of all exams during the examination period was 97.1% (95% confidence interval [CI] 96.2-98.0%), TLS was 14.5% (95% CI 9.7-20.6%), and acceptability was 82.9% (95% CI 76.3-88.2%). Trend over time (3, 6, 12, 18, and 24 months) found no differences in accuracy ($P = 0.84$), TLS ($P = 0.20$), or acceptability ($P = 0.28$). Further analyses by individual exam types also showed no significant differences in accuracy, acceptability, nor TLS.

Conclusion: Accuracy, acceptability, and percentage of technically limited scans did not significantly vary over time, suggesting that POCUS skills are maintained from PGY-1 rotation to each time point evaluated in this study. [West J Emerg Med. 2025;26(3)478–485.]

INTRODUCTION

The Accreditation Council for Graduate Medical Education lists point-of-care ultrasound (POCUS) as a core competency for emergency medicine (EM) residency training.[1] The American College of Emergency Physicians (ACEP) provides guidance on what this training should entail,

including a two-week rotation as a postgraduate year (PGY)-1 resident and at least one additional week in subsequent years of training.[2,3] As a result, it is standard to have a dedicated POCUS rotation in EM training; however, training curriculums vary in length and timing.[4] Additionally, there are often limitations of institutional curriculums and exposure to pathology based on one's training setting.[5]

Some data suggests a decrease in POCUS use and skill as the time from initial training progresses.[6-9] A study of a four-year EM residency demonstrated fewer scans performed between the PGY-1 to PGY-2 year, as well as between the PGY-3 and PGY-4 year.[9] In this same group, it was observed that the rate of technically limited studies (TLS, ie, lacking the proper number of views, or the images themselves were not interpretable) increased as training progressed.[9] Training users in POCUS is resource-intensive, often requiring an asynchronous curriculum, dedicated one-on-one time at the bedside with faculty, and image review for feedback. Thus, there is a need to better understand the use, accuracy, and retention of POCUS skills among EM residents as they progress through training.

Our primary objective in this study was to evaluate use of POCUS among EM residents at various time points through residency training. The secondary objective was to evaluate the trends in accuracy, acceptability, and percentage of TLS at specific time points as potential targets for re-education.

Population Health Research Capsule

What do we already know about this issue?
There is variability in how EM residents learn point-of-care ultrasound, with some studies demonstrating a decline in skills as they progress through training.

What was the research question?
We evaluated trends in ultrasound skills longitudinally at various points in a resident's training.

What was the major finding of the study?
Over time, we found no differences in accuracy (97.1%) or acceptability (82.9%) of scans, or proportion of technically limited studies (14.5%, P >0.05 for all).

How does this improve population health?
Understanding nuances to training healthcare professionals in ultrasound can build capacity in local health systems and in resource-limited settings.

METHODS

Study Design

This was a retrospective, observational cohort study of a three-year EM residency training program at a single, academic medical center from July 1, 2014–June 30, 2022, including six residency classes. Data prior to 2014 was not available for inclusion. This study was reviewed by the institutional review board and determined to be exempt from review.

Study Protocol

Dates of the PGY-1 ultrasound rotation were obtained from information stored in an online residency management program (MedHub, Minneapolis, MN) and confirmed with the residency education coordinator. All POCUS images are stored in a cloud-based storage software program (QPathE, Telexy Healthcare Inc, British Columbia, Canada). Total number of scans obtained, accuracy of interpretation, acceptability for credentialing, and percentage of TLS were collected using the analytics function in QPathE.

We collected data at five time points: PGY-1 rotation (defined as the ultrasound rotation start date to rotation end date); three months (end date of PGY-1 rotation plus 90 days); six months (end date of PGY-1 rotation plus 180 days), 12 months (end date of PGY-1 rotation plus 360 days), 18 months (end date of PGY-1 rotation plus 540 days); and 24 months (end date of PGY-1 rotation plus 720 days). Outcome measures were a cumulative total of all scans performed to that specific time point. These time points were chosen a priori based on consensus agreement among faculty members from the residency leadership team and members of the division of ultrasound as time points of interest for potential re-education. Approximately 700 studies total (~4.8%) were performed prior to the PGY-1 rotation; given this, and the fact that residents do not initiate their asynchronous curriculum until the PGY-1 rotation, the decision was made to not evaluate or include scans performed prior to the PGY-1 rotation.

Two independent reviewers (MF, MV) were trained to abstract data from QPathE using a standardized protocol taught by the study principal investigator (HK) in a two-hour training period. To ensure quality, a random sampling of 50 single cases from the entire cohort was collected by the principal investigator and cross-checked with the pull by the independent reviewers. We calculated overall agreement for the five above variables (total number of scans obtained, accuracy of interpretation, acceptability for credentialing, and number of TLS studies) to be 100% for each individual variable.

Inclusion and Exclusion Criteria

All EM residents were included if they completed a dedicated, four-week PGY-1 ultrasound rotation. Residents

were excluded if they had interruptions in their rotation (ie, due to the COVID-19 pandemic), or interruptions in their residency training and/or were not available for analysis at the 24-month time mark. For evaluation of the trend over time, we excluded residents if they did not complete any additional POCUS exams in the 24-month time frame. The following exam types were included for evaluation: aorta; biliary; cardiac; focused assessment with sonography in trauma (FAST); renal; soft tissue/musculoskeletal (ST/MSK); and thoracic. We excluded bowel, deep venous thrombosis, early pregnancy, and ocular studies due to low overall numbers of these exams (attributed to institutional-specific factors).

Internal Ultrasound Education/Training Requirements

During the study period, all EM residents completed a consecutive four-week rotation, shared with an anesthesiology rotation, at various time points in the PGY-1 year. All EM residents completed their rotation primarily at the academic medical center ED with ~65,000 annual visits per year. Residents were required to complete at least 100 POCUS studies by the end of the PGY-1 rotation, 25 of which were required to be FAST examinations; this requirement was initiated in 2019. At the time of residency graduation, residents were required to complete a total of 150 POCUS examinations. Residents had the option to schedule additional ultrasound elective experiences as individual ultrasound shifts, two-week rotations, four-week rotations, or split with an additional elective in the PGY-2 and/or PGY-3 years (15% of the study cohort completed at least one elective experience, although the individual experiences were not tracked). Additional details about the PGY-1 rotation are highlighted in the Supplementary Materials (Appendix 1a).

Clinical Operations and Ultrasound QA

Ultrasound machines for clinical use varied during the study period. They included Edge I/II and M-Turbo (Fujifilm Sonosite, Inc, Bothel, WA) and Sparq ultrasound systems (Philips NV, Amsterdam, Netherlands), all with curvilinear, linear and phased array transducers. The PGY-1 resident on their rotation used a cart-based ultrasound machine, the Edge II, purchased solely for educational use, with three standard probes (5-2 MHz curvilinear probe, 5-1 MHz phased array probe, and 10-5 MHz linear probe). The rotation required dedicated scanning in the department for a minimum of 20 hours/week for the duration of the rotation. When scanning independently, all residents were required to scan patients with confirmatory imaging.

To earn credit, residents were required to obtain a specific number of views for each study indication, which was shared with the resident at the start of their PGY-1 rotation. (See Supplementary Materials, Appendix 1b) for the required views for ultrasound indications). The resident was required to fill out a standardized worksheet for the study in QPathE and submit the study for quality assurance (QA). Four ultrasound fellowship-trained faculty performed weekly QA on all POCUS examinations on a rotating schedule. During these sessions, the ultrasound-fellowship trained faculty member assigned a measure for the accuracy of the residents' interpretation of the images (eg, true positive [TP], true negative [TN], false positive [FP], false negative [FN]), whether the images were considered to be TLS, and whether the scan was acceptable for credit ([Yes/No]). To have the exam accepted for credit, the resident 1) must have obtained the correct number of ultrasound images and 2) obtained images that were interpretable by the faculty member (ie, not TLS), and have made a correct interpretation of the clips (eg, TP or TN). Residents were not given partial credit for incomplete exams and were given credit only for exams they personally performed (ie, no shared or split credit for scans obtained with other residents or students). Only POCUS examinations that were submitted for QA were analyzed.

Statistical Analysis

Total number and percentages were collected via analytics in QPathE. We evaluated three measurements of performance at each time point for accuracy, TLS, and acceptability percentages. We defined accuracy as the percentage of adequate scans that were correctly interpreted (TP + TN/TP + TN + FP + FN). The TLS was defined as what percentage of scans were inadequate for interpretation (TLS/TP + TN + FP + FN + TLS), and acceptability was defined as the percentage of scans that were approved for resident credit (TP+TN/TP+TN+FP+FN+TLS).[9] The pathology percentage was also collected at the end of the PGY-1 rotation and at the end of the study period (24 months). Pathology was defined as the number/percentage of true positive and false negative studies over all scans that were adequate for interpretation (TP+FN/TP+TN+FN+FP).

We analyzed performance characteristics over the course of a resident's training period using mixed-effects binomial logistic regression with time as a fixed-effect factor and treating academic year and subject (within year) as random factors. These models involve ratios of counts (ie, y/m) as the response computed separately for each resident. Analysis of TLS and acceptable scans both used m = TP+TN+FP+FN+TLS as the binomial denominator and y = TLS or TP+TN as the numerator for TLS and acceptable performance measures, respectively. Accuracy involved the number of correctly classified findings (y=TP+TN) relative to the total number of studies that were not technically limited (m=TP+FP+TN+FN). Models were fit separately for each performance characteristic, and likelihood ratio tests were performed to determine whether performance varied over time. We checked all models for adequacy via half-normal plots of the deviance residuals.[10]

RESULTS

Totals and Overall Accuracy, TLS, and Acceptability Percentages

In total, 70 residents met initial criteria for evaluation. Four residents were excluded (two due to interruptions in training and two due to interruptions in their PGY-1 rotation due to the COVID-19 pandemic). One additional resident was excluded due to completing no scans in the 24-month study period, leaving 65 total residents for the trend-over-time analysis. Of these residents, 20 (30.7%) were female and 45 (69.2%) were male. These 65 residents completed (with QA) a total of 13,229 POCUS examinations during the study period.

In the PGY-1 rotation, the most common study performed was the FAST examination, which accounted for 22.2% of all exams performed. Thoracic (20.5%) and renal (19.0%) studies were the next most common applications. At the end of the study period (24 months post-PGY-1 rotation), FAST remained the most commonly performed exam type (25.4%). Cardiac examinations were the second most common, accounting for 20.4% of all studies obtained at this time point. Overall accuracy for all included residents and exam types during the study period was 97.1% (95% CI 96.2-98.0%); TLS was 14.5% (95% CI 9.7-20.6%); and acceptability was 82.9% (95% CI 76.3-88.2%). These findings are summarized in Tables 1 and 2.

Trends in Accuracy, Technical Limitations, and Acceptability % Between 3-24 Months Post-PGY-1 Rotation

Accuracy percentage during the study period (3-24 months post-PGY-1 rotation) was 97.1% (95% CI 96.2–98.0%) and did not vary over time ($P = 0.84$). The percentage of technically limited studies during the study period was 14.5% (95% CI 9.7-20.6%) and did not vary over time ($P = 0.20$). Acceptability percentage during the study period was 82.9% (95% CI 76.3-88.2) and did not vary over time ($P = 0.28$). Evaluation by individual exam types, analysis for any effect, as well as the trend between the five various time points, demonstrated no significant findings. These findings are summarized in Figure 1, Table 3, and Table 4.

DISCUSSION

This study highlights trends in POCUS use, including number and types of exams performed, as well as the accuracy, TLS, and acceptability percentages in exams performed by EM residents at five time points beyond the dedicated PGY-1 rotation. Our data highlights several findings, including differences in use of POCUS in the PGY-1 rotation and in the 24 months post-rotation. Additionally, our data also highlights a stability and maintenance of POCUS image interpretability, acceptability, and technically limited studies for at least up to 24 months after a focused PGY-1 rotation.

Use of and experience with POCUS seemed to vary between the PGY-1 rotation and at the end of the study period. Only 14.4% of examinations performed in the PGY-1 rotation were cardiac exams, although at the end of the study period, cardiac exams accounted for 20.4% of all exams. Use of the FAST remained high both in the PGY-1 rotation (22.2%) and at the end of the study period (25.4%). This may be the result of various factors, including the requirements for scanning on patients with confirmatory imaging in the PGY-1 rotation, exposure to core EM faculty credentialed to perform various POCUS studies, and the overall training environment internal to our institution, with in-house 24/7 radiology technicians to complete confirmatory exams.

Aorta, renal, and thoracic studies declined in use between PGY-1 rotation and the end of the study period. It is likely that the types of scans performed in the PGY-1 rotation were influenced by the requirements of the rotation, while the data at the 24-month time point was likely more influenced by the scans that are deemed clinically useful in the ED environment, accounting for the difference observed at these later time points. These findings may be of value to ultrasound educators creating training POCUS curriculums.

Table 1. Total number of ultrasounds by exam type and the percentages of scans that were accurate and acceptable or technically limited.

Exam	Total (%)	Accuracy % (95% CI)	TLS % (95% CI)	Acceptability % (95% CI)
All Scans	13,229	97.1 (96.2-98.0)	14.5 (9.7-20.6)	82.9 (76.3-88.2)
Aorta	960 (7.3)	100 (n/a)	16.5 (10.1-23.1)	81.9 (75.9-88.4)
Biliary	1,789 (13.5)	98.1 (95.3-99.6)	13.5 (9.5-19.0)	83.6 (77.4-89.0)
Cardiac	2,116 (16.0)	98.0 (96.0-99.3)	12.4 (7.4-19.1)	84.7 (77.5-90.4)
FAST	3,051 (23.1)	96.7 (95.0-98.4)	22.5 (14.5-32.0)	75.1 (65.3-83.7)
Renal	2,235 (16.9)	97.2 (94.0-99.4)	9.1 (4.2-18.7)	88.3 (76.8-95.9)
ST/MSK	638 (4.8)	97.9 (95.9-100.0)	9.3 (4.3-15.8)	88.4 (82.6-93.2)
Thoracic	2,240 (18.4)	95.9 (93.6-98.0)	13.1 (9.0-17.2)	83.8 (79.2-88.5)

CI, confidence interval; *FAST*, focused assessment with sonography in trauma; *ST/MSK*, soft tissue/musculoskeletal; *TLS*, technically limited study.

Table 2. Number and type of scans by ultrasound examination over 24-month period, and percentage of their accuracy, acceptability, and technical limititations.

	Aorta	Biliary	Cardiac	FAST	Renal	ST/MSK	Thoracic
PGY-1 Rotation							
Number of Scans, n(%)	761 (7.8)	1,288 (13.3)	1,400 (14.4)	2,159 (22.2)	1,846 (19.0)	271 (2.8)	1,990 (20.5)
Accuracy %	99.8	96.4	98.7	96.3	97.7	99.7	97.0
TLS %	27.5	22.7	17.5	24.3	16.7	10.0	14.1
Acceptable %	78.2	75.2	81.3	72.9	81.4	89.7	83.2
Pathology %	5.2	14.9	10.3	14.2	10.5	55.7	20.2
3 months post-rotation							
Number of Scans, n(%)	12 (3.9)	55 (17.8)	67 (21.7)	71 (23.0)	26 (8.4)	27 (8.7)	51 (16.5)
Accuracy %	100	94.9	98.2	95.8	80.0	100	97.2
TLS %	16.7	16.4	17.9	22.5	19.2	18.5	19.6
Acceptable %	83.3	80.0	80.6	74.6	69.2	81.5	76.5
6 months post-rotation							
Number of Scans, n(%)	27 (3.7)	110 (15.2)	140 (19.4)	185 (25.6)	81 (11.2)	84 (11.6)	96 (13.3)
Accuracy %	100	94.3	98.2	95.9	89.2	96.5	98.0
TLS %	25.9	16.4	13.6	20.5	16.0	15.4	14.6
Acceptable %	74.1	80.0	85.0	77.8	77.8	82.1	83.3
12 months post-rotation							
Number of Scans, n(%)	91 (5.5)	241 (14.4)	305 (18.3)	450 (27.0)	192 (11.5)	173 (10.4)	217 (13.0)
Accuracy %	100	95.6	98.1	94.9	92.3	97.9	97.8
TLS %	19.8	16.6	14.1	24.9	13.0	12.7	14.7
Acceptable %	80.2	80.1	83.9	72.7	82.8	86.1	82.5
18 months post-rotation							
Number of Scans, n(%)	133 (5.3)	361 (14.4)	478 (19.1)	678 (27.1)	278 (11.1)	261 (10.4)	314 (12.5)
Accuracy %	97.0	97.3	97.6	96.6	95.0	98.1	97.7
TLS %	18.0	16.9	15.1	26.1	12.2	10.7	13.7
Acceptable %	80.5	80.3	82.6	71.1	84.2	87.7	83.4
24 months post-rotation							
Number of Scans, n(%)	199 (5.7)	501 (14.3)	716 (20.4)	892 (25.4)	389 (11.1)	367 (10.4)	450 (12.8)
Accuracy %	96.7	97.4	96.8	97.1	96.3	97.5	96.8
TLS %	17.6	15.4	14.0	25.7	13.1	10.1	14.2
Acceptable %	80.9	81.8	83.5	71.9	83.8	88.0	82.2
Pathology %	15.2	22.9	25.5	18.1	27.5	70.9	36.8

Outcome measures were a cumulative measure of all scans performed to that specific time point.
FAST, focused assessment with sonography in trauma; *ST/MSK*, soft tissue/musculoskeletal; *TLS*, technically limited study.

Our study also highlights that POCUS skills (eg, accuracy of interpretation and acceptability for credit) are maintained up to at least 24 months post PGY-1 rotation. This is in contrast to the findings by Schleifer et al, who observed a decline in POCUS skills as residents progressed through training. This study also demonstrated that TLS rates increased from 4.7% to 13.6% from PGY-1 to PGY-4, while accuracy remained stable.[9] Numerous differences in training experiences may account for this. For example, in the Schleifer study PGY-4 residents served in a supervisory role, and thus this decline could be attributed to less hands-on scanning in lieu of supervising junior residents. This is suggested by not only a drop in POCUS performance in the PGY-4 year, but also a decrease in the total number of scans obtained in later years. In our three-year training program, PGY-3 residents do not directly supervise junior residents. A multicenter analysis of comparative residency programs may be helpful.

Our trend-over-time analysis demonstrated that accuracy remained quite high (97.1%) when studies were deemed

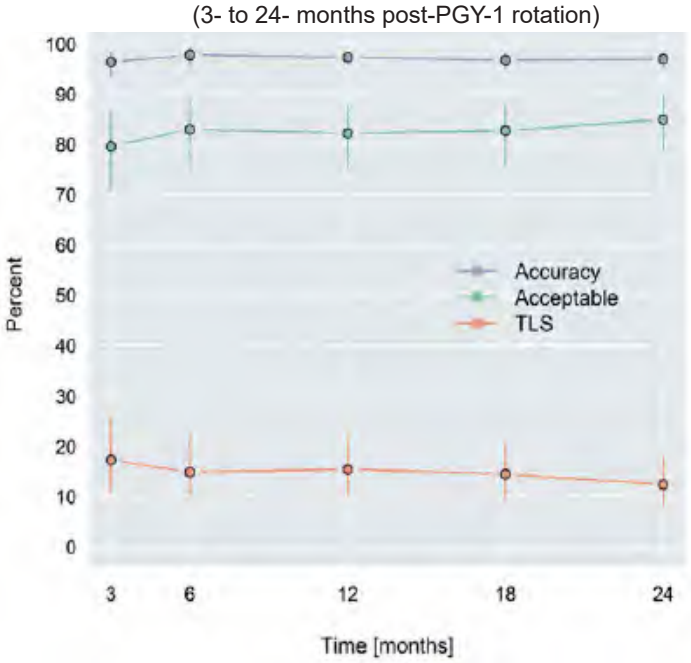

Figure 1. Trend of accuracy, technically limited studies, and acceptability percentages over time.
95% confidence intervals (CI) on the figure are noted as the whiskers extending from each plotting symbol.
TLS, technically limited study.

technically adequate. This may serve as a proxy for image *interpretation* skills. One theory as to why this may be is that residents may not have submitted exams for QA if they perceived them to be of suboptimal quality. However, upon closer evaluation of our data, we found that approximately 88% of scans where the resident was listed as the "operator" were ultimately submitted for QA. Another theory is that perhaps residents perform and submit mostly normal studies to obtain credit and reach their requirements for graduation. Evaluation of the percentage of pathology highlighted that most exams performed in the PGY-1 rotation were normal, which also may have contributed to the high accuracy. Additionally, the TLS percentage remained unchanged over the study period. Given limitations of QPathE and the volume of studies, we could not further elucidate why specific images were deemed technically limited. Further study of why studies are rejected would be helpful to know as potential targets for POCUS re-education or emphasis in later years of training.

Ultimately, this study highlighted several interesting differences between residents' use of POCUS in the PGY-1 rotation and as they progressed through training in their day-to-day clinical shifts. Given the observed differences, there seems to be value and unique exposures in both experiences. In the PGY-1 rotation, residents focused on gaining skills and were exposed to largely normal examinations, while in their day-to-day practice as they progressed in training, residents focused on clinically impactful studies (such as cardiac and FAST exams) and had more exposure to pathology. Our findings also demonstrate that accuracy, acceptability, and the percentage of TLS did not significantly vary over time, suggesting that POCUS skills are maintained from their initial PGY-1 ultrasound rotation to each time point, up to 24 months post PGY-1 rotation examined in this study.

LIMITATIONS

Our study does have several limitations. We included only scans submitted for QA; residents may been self-selecting which exams they submitted for credit, thus resulting in the high accuracy and acceptability that was observed in this study. Next, given that residents in training were required to have confirmatory imaging, their independent review of these results may have also influenced their completion of their QA worksheets in the PGY-1 rotation and potentially further influenced accuracy of interpretation and acceptability. In clinical practice, however, confirmatory imaging is not required if the EM attending supervising is credentialed to perform POCUS, and no differences in acceptability, accuracy, or TLS percentages were observed in the trend-over-time analysis. Next, given limitations of selections in QPathE and due to the high volume of scans, we could not evaluate individual cases to understand why an exam

Table 3. Accuracy, TLS, and acceptability % trend over time (3- to 24- months post-PGY-1 rotation).

Time	Accuracy % (95% CI)	TLS % (95% CI)	Acceptability % (95% CI)
Overall	**97.1 (96.2-98.0)**	**14.5 (9.7.20.6)**	**82.9 (76.3-88.2)**
+3 months	96.5 (93.6-98.3)	17.3 (11.1-25.7)	79.6 (70.7-86.5)
+6 months	97.8 (95.8-99.0)	14.9 (9.4-22.4)	83.0 (75.1-88.9)
+12 months	97.3 (95.9-98.4)	15.4 (10.1-22.3)	82.2 (75.0-88.0)
+18 months	96.7 (95.1-98.1)	14.5 (9.5-21.1)	82.7 (75.5-88.4)
+24 months	97.0 (95.5-98.2)	12.4 (8.0-12.8)	84.9 (78.5-89.9)
P-value	0.84	0.20	0.28

TLS, technically limited study; *CI,* confidence interval.

Table 4. Trends in accuracy, TLS, and accuracy percentages between 3-24 months post PGY-1 rotation by individual exam type with no observable differences noted. Estimates are based on mixed-effects binomial logistic regression. [a] = Likelihood ratio test for any difference in percentage among five time points (3, 6, 12, 18, and 24 months). [b] = Likelihood ratio test for whether percentages followed an increasing or decreasing trend over time.

Exam	Accuracy %	TLS %	Acceptable %
Aorta			
Number of residents, n	n=44	n=47	n=47
Average % (95% CI)	100	16.5 (10.1-23.1)	81.9 (75.9-88.4)
P (Any effect) [a]	N/A[1]	*P*=0.40	*P*=0.66
Biliary			
Number of residents, n	n=60	n=62	n=62
Average % (95% CI)	98.1 (95.3-99.6)	13.5 (9.5-19.0)	83.6 (77.4-89.0)
P (Any effect) [a]	*P*=0.88	*P*=0.72	*P*=0.69
Cardiac			
Number of residents, n	n=62	n=64	n=64
Average % (95% CI)	98.0 (96.0-99.3)	12.4 (7.4-19.1)	84.7 (77.5-90.4)
P (Any effect) [a]	*P*=0.86	*P*=0.23	*P*=0.32
P (Trend) [b]	*P*=0.31	*P*=0.21	*P*=0.50
FAST			
Number of residents, n	n=64	n=65	n=65
Average % (95% CI)	96.7 (95.0-98.4)	22.5 (14.5-32.0)	75.1 (65.3-83.7)
P (Any effect) [a]	*P*=0.31	*P*=0.55	*P*=0.27
P (Trend) [b]	*P*=0.95	*P*=0.43	*P*=0.45
Renal			
Number of residents, n	n=59	n=59	n=59
Average % (95% CI)	97.2 (94.0-99.4)	9.1 (4.2-18.7)	88.3 (76.8-95.9)
P (Any effect) [a]	*P*=0.29	*P*=0.60	*P*=0.26
P (Trend) [b]	*P*=0.07	*P*=0.92	*P*=0.35
ST/MSK			
Number of residents, n	n=63	n=63	n=63
Average % (95% CI)	97.9 (95.9-100.0)	9.3 (4.3-15.8)	88.4 (82.6-93.2)
P (Any effect) [a]	*P*=0.24	*P*=0.44	*P*=0.44
P (Trend) [b]	*P*=0.53	*P*=0.15	*P*=0.27
Thoracic			
Number of residents, n	n=56	n=58	n=58
Average % (95% CI)	95.9 (93.6-98.0)	13.1 (9.0-17.2)	83.8 (79.2-88.5)
P (Any effect) [a]	*P*=0.33	*P*=0.60	*P*=0.32
P (Trend) [b]	*P*=0.27	*P*=0.97	*P*=0.59

FAST, focused assessment with sonography in trauma; *ST/MSK*, soft tissue/musculoskeletal; *TLS*, technically limited scan.

was deemed to be TLS or not acceptable. Given the high percentages of accuracy and acceptability that were observed, we hypothesize that this may have been due to technical issues surrounding image acquisition; however, future reviews in understanding rejected scans are needed.

Next, we did not adjust for timing of the PGY-1 rotation and exposures to POCUS prior to a resident's PGY-1 rotation, and whether skills learned prior to the PGY-1 rotation could also have accounted for the observed high percentages of accuracy and acceptability. However, only 5% of residents' total number of scans performed were obtained prior to the PGY-1 rotation, and most POCUS learning seems to start in the PGY-1 rotation. Many other factors may influence the use of POCUS and could not be adjusted for, including prior experience in POCUS in medical school curricula, exposure to a broader EM faculty group with varying credentials in POCUS, and exposure to specific pathology. A multicenter study evaluating residents' use of POCUS would be helpful to the greater community for broader awareness on where to focus POCUS educational efforts.

CONCLUSION

In this single-center study, residents' use of and experience with point-of-care ultrasound varies between the PGY-1 rotation and post-PGY-1 rotation time periods. Accuracy, acceptability, and percentage of technically limited studies did not significantly vary over time, suggesting that learned POCUS skills in a PGY-1 rotation are maintained at these various timepoints, including up to 24 months post PGY-1 rotation. These findings appeared to be stable even when analyzed by individual exam types.

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Patient Sociodemographic Factors Are Associated with Receiving Point-of-care Ultrasound in the Emergency Department

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Background: Point-of-care ultrasound (POCUS) is widely used in emergency medicine (EM) and increasingly throughout healthcare. Prior studies have revealed disparities in the use of imaging in the emergency department (ED) based on sociodemographic factors; however, the association between these factors and POCUS use is unknown. Our aim was to compare the odds of receiving POCUS in the ED based on patient race and ethnicity, language, sex, and type of insurance.

Methods: We reviewed electronic health records (EHR) matched to a departmental POCUS database from November 2021–June 2023 at an academic Level I trauma center. We included ED patients diagnosed with an International Classification of Diseases code mapped to chest or flank pain, who had a cardiac troponin obtained, or had been evaluated as a trauma activation or alert. Our primary outcome was whether a patient received transthoracic echocardiography (cardiac), renal, or focused assessment with sonography in trauma. Predictor variables were race/ethnicity group (non-Hispanic [NH] White, NH Black, Hispanic, other), patient language, sex assigned at birth, and insurance type as recorded in the EHR. We performed descriptive analyses and logistic regression (adjusted odds ratio [aOR], 95% confidence interval [CI]) controlling for body mass index, age, comorbidities, and triage hypotension or tachycardia.

Results: Of the 25,389 ED patients meeting inclusion criteria, 79.5% were NH White, 95.3% listed English as their primary language, 51.5% were female, and 33.4% had private payor insurance. After adjusting for confounding, patients had lower odds of receiving POCUS if they were "other" race/ethnicity as compared to NH White (aOR 0.65, CI 0.42-0.99, $P = .04$), female as compared to male (aOR 0.81, CI 0.69-0.94, $P = .007$), or if they had Medicare (aOR 0.67, CI 0.54-0.84, $P < .001$) or Medicaid (aOR 0.66, CI 0.52-0.83, $P = .001$) as compared to private payors.

Conclusion: Overall, patients of female sex and patients with Medicaid or Medicare had lower odds of receiving point-of-care ultrasound in the ED. Although we did not find a difference in POCUS use among non-Hispanic White, NH Black, and Hispanic patients, patients belonging to other race/ethnicity categories had lower odds of receiving POCUS compared to NH White patients. [West J Emerg Med. 2025;26(3)486–490.]

INTRODUCTION

Point-of-care ultrasound (POCUS) is an integral part of evaluation and treatment in emergency medicine (EM) and has been shown to have utility in the diagnosis of cardiac conditions including heart failure and renal disease such as urolithiasis.[1-3] The use of POCUS is also associated with faster treatment for life-threatening conditions including cardiac tamponade, ectopic pregnancy, and hemoperitoneum in blunt

abdominal trauma.[4,5,6] Little is known about whether POCUS use varies based on a patient's sociodemographic characteristics. Prior studies of radiograph and computed tomography (CT) use found that White patients and those with private insurance were more likely than patients who were not White or were insured by Medicare or Medicaid to have imaging ordered in the emergency department (ED).[7,8] Because the decision to perform POCUS is largely based on clinical judgment and, therefore, subject to individual biases, we hypothesized that there may be unmeasured inequities in how POCUS is used. In this study, we aimed to compare the odds of ED POCUS use based on patient race and ethnicity, language, sex, and insurance type.

Population Health Research Capsule

What do we already know about this issue?
Prior studies raise concern that White, privately insured patients are more likely to receive emergency department (ED) imaging.

What was the research question?
We compared the odds of receiving point-of-care ultrasound (POCUS) in the ED based on patient race and ethnicity, language, sex, and insurance type.

What was the major finding of the study?
Female (aOR 0.81, CI 0.69-0.94), Medicare (aOR 0.67, CI 0.54-0.84) and Medicaid (aOR 0.66, CI 0.52-0.83) patients had lower odds of POCUS use, compared to non-Hispanic Whites.

How does this improve population health?
Disparities in POCUS use illuminate the need for critical review of current practice. Future work might focus on factors contributing to these disparities, and interventions to address them.

METHODS

We conducted a single-site, retrospective review of ED encounters from November 2021–June 2023 at an academic Level I trauma center with a three-year EM residency, >50,000 annual patient visits, and over 1,500 annual POCUS examinations and no emergency ultrasound fellowship at the time of the study. The overall ED population served is approximately 75% non-Hispanic White (NHW) and 50% female. Because transthoracic echocardiography (cardiac), focused assessment with sonography in trauma (FAST) including extended FAST, and renal were the most performed POCUS study types, we targeted these studies for inclusion. We queried the electronic health record (EHR) for adult and pediatric ED patients who 1) had a cardiac troponin obtained or 2) were diagnosed with an *International Classification of Diseases*, 10th Modification (ICD-10) code related to chest pain including ST-elevation myocardial infarction (STEMI), non STEMI, stable or unstable angina, other chest pain, chest pain unspecified, syncope, pericardial effusion, cardiac tamponade, blunt cardiac injury, myocarditis, pericarditis, or pulmonary embolism included in the cardiac POCUS subgroup. The ICD-10 codes related to flank pain, including renal colic, nephrolithiasis, renal abscess, pyelonephritis, hydronephrosis, or ureteral stricture, were included in the renal POCUS subgroup, and those who were activated as a trauma surgery alert or activation based on hospital protocol were included in the FAST POCUS subgroup. The ICD-10 codes were mapped to ED diagnoses with the assistance of an ED coding specialist.

We extracted demographic and clinical variables from the EHR using system-level query tools, including age, legal sex (male, female, nonbinary), height, weight, triage vitals (categorized as normal or abnormal for age for hypotension (<90 millimeters of mercury systolic in adults) and tachycardia [>110 beats per minute], ICD-10 diagnoses, comorbidities using the revised Charlson Comorbidity Index (CCI) (analyzed as both comorbidities recorded based on patient problem list ICD-10 codes vs not recorded, and for those with comorbidities recorded, a score of 0 vs >0), and preferred language (English, Spanish, and other). For race and ethnicity, we used a collapsed category methodology similar to Ross et al (NHW, non-Hispanic Black [NHB], Hispanic, and other race).[7] Insurance type was divided into uninsured, Medicare, Medicaid, and private payors.

Our emergency ultrasound quality assurance (QA) database was queried for corresponding POCUS exams and matched to EHR records by medical record number and date of ED visit. All POCUS exams are reviewed and scored for quality by emergency ultrasound fellowship-trained physicians. The POCUS images and reports are then stored in an emergency ultrasound QA database. We assessed differences in clinical vs educational POCUS and POCUS quality as documented in the QA database (categorized as quality scores of 1-3 vs 4-5) by patient demographics using chi-squared tests.

We compared the proportion of ED encounters where POCUS was performed, using descriptive statistics. Associations between POCUS and patient demographics were assessed using logistic regression models accounting for age, calculated body mass index (BMI), presence of comorbidities, and abnormal triage blood pressure or heart rate. Secondary analyses included cardiac, FAST, and renal POCUS subgroups. To determine whether our model should include any interaction terms between patient demographics and POCUS while accounting for age, BMI, CCI, and abnormal

triage vitals, we employed the BranchGLM package in R for best subset selection using Akaike information criterion (AIC).[9,10,11] We used R software (R Foundation for Statistical Computing, Vienna, Austria) for analyses and data management. The study was approved by our institutional review board, and we followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidance.[12]

RESULTS

There were 25,389 patients who met the inclusion criteria; of these, 6,266 were excluded from the analysis due to missing covariates, leaving a full analysis population of 19,123 composed of 15,677 cardiac patients (82%), 3,443 renal patients (18%), and 1,215 trauma patients (6.4%). Total percentages exceeded 100% due to patients meeting multiple inclusion criteria (eg, a trauma alert with a troponin obtained). Among the full-analysis population, most patients spoke English (96.6%), and the mean age and BMI were similar between non-POCUS and POCUS groups (56.9±20.7 vs 57.2±20.8 years) and (30.2±9.5 vs 29.9±8.1 kilograms /m^2). The number of patients with no comorbidities documented (10,321 [55.9%] vs 382 [57.2%]) and the frequency of CCI scores of zero when comorbidities were documented (6,199 [33.6%] vs 221 [33.1%]) were also similar between non-POCUS and POCUS groups (Supplemental Table 1). Patients who received POCUS were more frequently hypotensive (49 [7.3%] vs 526 [2.9%]) and tachycardic (124 [18.6%] vs 2,774 [15.0%]). Patient sociodemographic characteristics and odds of receiving POCUS are shown in Table 1.

Patients who listed Spanish or other as their language preference had similar odds of receiving POCUS to those listing English (Spanish, odds ratio [OR] 1.16, 95% confidence interval [CI] 0.65-2.08) (other, OR 0.73 [95% CI 0.38-1.42]). Due to small sample sizes for some patient-language subgroups, adjusted ORs and subgroup analyses are not reported. Likewise, POCUS subgroups without statistically significant differences in the setting of smaller sample sizes are shown in Table 2.

Following best subset selection assessing all possible combinations of two-way interactions between patient demographics, we found no meaningful interactions as determined by the Akaike information criterion. There were no significant associations when assessing differences in clinical vs educational POCUS or differences in POCUS quality by patient demographic characteristics.

DISCUSSION

Overall, we found that for patients presenting to the ED with an indication for echocardiography, renal, or FAST POCUS, being female, or having Medicare or Medicaid insurance was associated with lower odds of receiving POCUS. In addition, patients who were categorized as other race/ethnicity (comprised primarily of patients identifying as Asian, American Indian, Native Hawaiian, and mixed or other race) were less likely to receive POCUS than patients who were NHW. To our knowledge, an evaluation of these inequities in POCUS use has not previously been reported. However, our findings are consistent with disparities that have been previously reported for other ED imaging modalities.[7,8]

Table 1. Frequency of receiving point-of-care ultrasound (POCUS) in the emergency department by patient sociodemographic characteristics, with unadjusted and adjusted odds ratios of receiving POCUS.

Characteristic	No POCUS (N=18,455)	POCUS (%) (N=668)	OR [95% CI]	aOR [95% CI][a]
Race/Ethnicity				
Non-Hispanic White	15,128	568 (3.62%)	1.00	1.00
Non-Hispanic Black	1,669	50 (2.91%)	0.80 [0.60-1.07]	0.82 [0.61-1.10]
Hispanic	715	27 (3.64%)	1.01 [0.68-1.49]	1.02 [0.69-1.52]
Other	943	23 (2.38%)	0.65 [0.43-0.99]	0.65 [0.42-0.99]
Legal Sex				
Male	9,264	373 (3.87%)	1.00	1.00
Female	9,190	295 (3.11%)	0.80 [0.68-0.93]	0.81 [0.69-0.94]
Insurance Status				
Private payor	5,421	239 (4.22%)	1.00	1.00
Medicare	8,535	286 (3.24%)	0.76 [0.64-0.91]	0.67 [0.54-0.84]
Medicaid	3,509	99 (2.74%)	0.64 [0.50-0.81]	0.66 [0.52-0.83]
Uninsured	328	15 (4.37%)	1.04 [0.61-1.77]	1.04 [0.61-1.77]
Other	662	29 (4.20%)	0.99 [0.67-1.47]	0.90 [0.60-1.36]

[a]Adjusted for body mass index, age, Charlson Comorbidity Index scores, and hypotension or tachycardia at triage.
POCUS, point-of-care ultrasound; *OR,* odds ratio; *CI*, confidence interval.

Table 2. Frequency of receiving point-of-care ultrasound in the emergency department by patient sociodemographic characteristics for included subgroups.

	Cardiac POCUS/no POCUS (%)	Renal POCUS/no POCUS (%)	FAST POCUS/no POCUS (%)
Race/Ethnicity			
Non-Hispanic White	404/12,969 (3.12%)	96/2,726 (3.56%)	70/1,001 (6.99%)
Non-Hispanic Black	38/1,440 (2.64%)	7/287 (2.44%)	5/87 (5.75%)
Hispanic	19/572 (3.33%)	8/174 (4.60%)	2/47 (4.26%)
Other	14/696 (2.01%)	5/256 (1.95%)	4/80 (5.00%)
Sex			
Male	264/8,076 (3.27%)	54/1,371 (3.94%)	59/839 (7.03%)
Female	211/7,600 (2.78%)	62/2,072 (2.99%)	22/376 (5.85%)
Insurance Status			
Private payor	156/4095 (3.81%)	50/1400 (3.57%)	34/513 (6.63%)
Medicare	237/8059 (2.94%)	36/1061 (3.39%)	16/243 (6.58%)
Medicaid	62/2702 (2.29%)	24/840 (2.86%)	13/311 (4.18%)
Uninsured	7/253 (2.77%)	2/58 (3.45%)	6/43 (13.95%)
Other	13/568 (2.29%)	4/84 (4.76%)	12/105 (11.43%)

FAST, focused assessment with sonography in trauma; POCUS, point-of-care ultrasound.

Prior analysis of a national ED dataset found that patients belonging to any minoritized race/ethnicity group other than White were less likely to get any ED imaging, including radiograph, CT, MRI, or ultrasound (OR 0.84, CI 0.79-0.89) but did not find a difference when isolating the odds of ultrasound ordered from the ED (OR 1.03, .CI 92-1.14).[7] The same study found that female patients had lower odds of getting any imaging (OR 0.95, CI 0.91-0.99), but did not specifically examine odds of ultrasound.[7] Likewise, patients with Medicaid and Medicare had lower odds of getting any imaging (OR 0.82, CI 0.76-0.88 and OR 0.87, CI 0.80-0.95, respectively). A national study of pediatric ED patients also noted markedly lower odds of imaging for patients who were NHB compared to NHW (aOR 0.82, CI 0.82-0.83) and fewer ultrasounds (aOR 0.69, CI 0.68-0.70), but it did not specifically look at radiology-performed studies vs POCUS.[13]

Our inclusion criteria were intentionally broad to capture ED patients where the specific types of POCUS examined would likely be indicated based on diagnosis codes. However, this approach could have underestimated disparities in POCUS use if clinicians failed to make the correct diagnosis more frequently in minoritized patient groups; it is possible that POCUS use in patients who did not receive it may have led to a correct diagnosis that would have not otherwise been made.

The downstream consequences of disparate rates of POCUS use are uncertain and are an area for further study, as they may be contributing to larger scale disparities in emergency care. However, we postulate that based on the known benefits of POCUS, such as identification and earlier drainage of pericardial effusion,[1] lower rates of POCUS use may result in delays in care and more missed diagnoses for certain sociodemographic groups.

LIMITATIONS

Our findings are subject to the limitations of a retrospective study, including reliance on EHR data for sociodemographic variables. For example, EHR options for self-reported race/ethnicity not identifying as NHW, NHB, or Hispanic were prespecified to be grouped into an "other" category due to small expected sample sizes. While differences in POCUS use for this group were notable, interpreting this finding is more difficult due to this group's heterogeneity. Second, some POCUS examinations were performed for educational rather than clinical purposes; however, we found no significant change in odds of receiving POCUS when evaluating clinical vs educational ultrasound using a modified sensitivity analysis. Although we adjusted for common reasons that POCUS may be more likely to be performed, there may have been other unmeasured patient-level factors that could have moderated the disparities seen.

As a pilot study, our sample size was not sufficient to conclusively evaluate for disparities in each POCUS subtype. In addition, few FAST examinations were documented despite an institutional expectation of including FAST in the trauma assessment. We believe this was likely due to images not being saved by the performing physician in the context of a variety of factors, including patient acuity and no middleware access for trauma surgery during the study period. Therefore, FAST exams in the current study include only those documented by emergency physicians. Patients who did not receive POCUS

could have received alternative imaging; however, there is no direct imaging replacement for echocardiography other than cardiology-performed echocardiology, which is not routinely available in our ED.

CONCLUSION

Overall, female patients and patients with Medicaid or Medicare had lower odds of receiving point-of-care ultrasound in the ED. Although we did not find a difference in POCUS use among non-Hispanic White, non-Hispanic Black, and Hispanic patients, patients belonging to other race/ethnicity categories had lower odds of receiving POCUS compared to non-Hispanic White patients. Future research might focus on factors contributing to these disparities and developing targeted interventions to address them.

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Non-invasive Monitor of Effective Chest Compressions with Carotid and Femoral Artery Ultrasound in the Emergency Department

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Background: End-tidal carbon dioxide ($EtCO_2$) has been regarded as the gold standard for assessing the effectiveness of cardiopulmonary resuscitation (CPR). However, the clinically observed limitations of $EtCO_2$ influenced by ventilation during CPR suggest the need to implement a new, non-invasive hemodynamic monitoring method to evaluate and optimize CPR effectiveness in real time.

Methods: For this prospective study we enrolled 31 cardiac arrest (CA) patients who presented to the emergency department (ED) and 13 healthy volunteers as point-of-care ultrasound (POCUS) controls. Two physicians not involved in the resuscitation team performed POCUS of the bilateral carotid and femoral arteries during chest compression within the first 10 minutes of CPR. The clinical data and presumed CA cause were recorded. We observed the arterial pulse and measured the peak systolic velocity (PSV). The $EtCO_2$ values during POCUS were also recorded. We explored the correlation between arterial PSV and $EtCO_2$.

Results: The mean age of the patients was 69 ± 2 years, and 22 were male. Of 25 patients who experienced out-of-hospital cardiac arrest, 18 had an average no/low-flow time >30 minutes before ED arrival. Five patients achieved return of spontaneous circulation (ROSC). We found no significant difference in arterial PSV between ROSC and non-ROSC patients. The PSV of the left femoral artery was most consistently and positively correlated with $EtCO_2$ in CA patients (R^2 0.35, P=0.003).

Conclusion: Detection of arterial peak systolic velocity by point-of-care ultrasound, especially of the left femoral artery, might be a feasible method for non-invasive, real-time monitoring of chest compression effectiveness during CPR. [West J Emerg Med. 2025;26(3)491–499.]

INTRODUCTION

Cardiac arrest (CA) is a major public health issue with high mortality and disability rates, posing a serious threat to human life. In China, survival rates and good neurological outcomes among CA patients are significantly lower than in developed countries, at only 1.2% and 0.8%, respectively.[1] Chest compression, the core of cardiopulmonary resuscitation (CPR), is crucial for restoring perfusion to vital organs.[2] High-quality chest compression can increase blood flow to 25-40% of normal levels,[3,4] promoting myocardial contraction and reducing cerebral ischemic injury. However, there is currently no universally recognized indicator for monitoring the effectiveness and quality of chest compression in Advanced Cardiac Life Support (ACLS).

A rescue team leader or a real-time feedback device can help supervise and optimize the rescuer's compressions.[5,6] But it is difficult to comprehensively improve the quality and continuity of chest compression when the rescuer lacks systematic and continuous CPR training, or a feedback device may sometimes disrupt rhythmic compressions. Patients' physiological parameters such as pressure indicators, pulse oxygen saturation (SpO2) waveform, and end-tidal carbon dioxide ($EtCO_2$) can also reflect the quality of chest compression.[2,4,7] Pressure indicators, including cerebral perfusion pressure and arterial diastolic pressure, are mainly suitable for patients who have already undergone pressure monitoring before CA, for it is difficult to insert intravascular catheters during CPR, and the catheterization process may interrupt the compressions and reduce the number of chest compression fractures (CCF). The SpO2 waveform, the amplitude and peak of which is determined by peripheral arterial blood pressure, is also recommended as an effective monitor.[8] A study involving 441 CA patients demonstrated that the SpO2 waveform analysis can effectively predict return of spontaneous circulation (ROSC).[9] However, there are also limitations in monitoring SpO2 waveform in different cases: peripheral hypoperfusion due to long low/no-flow period[10]; venous pulsation due to arteriovenous fistula[11]; abnormal hemoglobin,; skin color changes due to special diseases or poisoning; and others.[12]

High-level $EtCO_2$ has been considered a sign of high-quality chest compression and of impending ROSC.[13,14] However, various medical conditions can alter EtCO2 values, even in similar compression conditions, limiting the ability of EtCO2 to accurately evaluate the quality of chest compression. In conditions such as pulmonary embolism or tension pneumothorax that lead to disturbance of the ventilation-perfusion ratio, $EtCO_2$ values are always quite low. In contrast, higher $EtCO_2$ values could be detected in obstructive airway diseases such as asphyxia, severe asthma, and chronic obstructive pulmonary disease.[14,15]

Point-of-care ultrasound (POCUS) is widely available in emergency departments (ED) and has been increasingly used to help manage CA patients during both CPR and the post-resuscitation period.[16,17] Many POCUS protocols have been used to differentiate potential causes, guide further management, and predict prognosis during CPR; these include COACHRED, FEEL, CASA, pulseless electrical activity (PEA) and CAUSE[18] Ultrasound images of the heart, lung, and aorta can display visible cardiac activity, distinguish between true asystole and fine ventricular fibrillation, and identify the reversible cause of CA. Point-of-care ultrasound can also be used to detect the site and effectiveness of chest compression by directly observing heart motion during CPR.[17] Some clinical studies on CA patients indicated that Doppler ultrasound of the carotid and femoral arteries, superior to the manual method, could check the pulse faster and more accurately.[19,20]

In one prehospital CA case POCUS was recommended for checking the pulse and evaluating the presence of carotid blood flow under chest compression.[21] An experiment on Landrace pigs found that a wearable Doppler patch to monitor carotid blood flow could provide valuable information about arrhythmia and the quality of CPR, identify ROSC in a timely and effective manner, and assist in managing hemodynamics after ROSC.[22] In summary, current research indicates that POCUS can be used in CA management to identify causes and monitor ROSC. However, no evidence suggests that POCUS can improve patient prognosis.

Considering the many limitations in using EtCO2 to monitor chest compression, our goal in this study was to investigate for a correlation between arterial PSV and EtCO2 values during CPR to determine whether real-time arterial POCUS could be used to evaluate the effectiveness of chest compression.

Population Health Research Capsule

What do we already know about this issue?
$EtCO_2$ is the gold standard for cardiopulmonary resuscitation (CPR) quality assessment but has limitations due to ventilation interference, while ultrasound's role remains exploratory.

What was the research question?
Does real-time arterial POCUS (carotid/femoral peak systolic velocity [PSV]) better predict CPR compression quality than $EtCO_2$?

What was the major inding of the study?
Left femoral PSV correlates with $EtCO_2$ (R^2=0.35, P=0.003) during CPR, suggesting POCUS monitoring feasibility.

How does this improve population health?
Arterial POCUS may provide real-time, non-invasive monitoring of CPR effectiveness, potentially improving resuscitation quality and outcomes in CA patients.

METHODS

Design and Setting

This single-center, prospective, observation study was performed in the ED in a Chinese tertiary-care hospital with an annual volume of 120,000 emergency visits. Our rescue area contains seven core beds with monitors and ventilators, as well as one fixed and two portable ultrasound devices, and one transesophageal ultrasound device. All emergency physicians of the resuscitation team have obtained Basic Life Support (BLS) and ACLS certification and mastered rescue skills. The study

was approved by the ethics committee of Zhongnan Hospital of Wuhan University (No. LINYANLUN 2022133 dated August 15, 2022) and registered on Clinical Trials (NCT05859516). The study's principles were in accordance with the Declaration of Helsinki. A waiver of informed consent was granted by the institutional review board.

Participants

This study, which spanned March 2023–April 2024, included in-hospital cardiac arrest (IHCA) and out-of-hospital cardiac arrest (OHCA) patients who presented to the ED and received BLS/ACLS during the observation period. Due to the availability of manpower, we chose to observe from 8 AM to 10 PM every Monday through Friday. The CA patients received mechanical chest compression with the Lund University Cardiopulmonary Assist System (LUCAS) (Lund University, Sweden) and tracheal intubation for ventilation. Patients were excluded if they were <18 years, pregnant, or had been diagnosed with neck, chest or extremities trauma. We also enrolled 13 healthy volunteers as POCUS control.

Ventilation and $EtCO_2$ Record

In accordance with the current guidelines, the LUCAS CPR procedure began with 100-120 chest compressions per minute upon CA patients. Tracheal intubation was simultaneously performed, and an $EtCO_2$ monitoring device was connected. The tidal volume was 6 milliliters per kilogram, and the ventilation frequency was 10 breaths per minute. The $EtCO_2$ waveform and every minute's value during the POCUS period were recorded for further analysis.

Point-of-care Ultrasound Implementation

Two research physicians, proficient in vascular ultrasound after completing one-day Critical Care Ultrasound Study Group (CCUSG) training and one week of intensive practice, were awarded assessment certificates and assigned to performt POCUS in this study. They were solely responsible for performing POCUS and measuring parameters but had no knowledge of the intervention measures or resuscitation outcomes for CA patients. They started to perform POCUS during chest compression within the first 10 minutes of CPR in the ED. The POCUS was performed with Mindray M9 (Shenzhen Mindray Bio-Medical Electronics Co., Ltd, Shenzhen, China). The staff used the L12-4s (12-4 MHz) linear-array probe to obtain vascular long-axis sections with pulse wave Doppler mode in the order of right carotid artery (RCA), left carotid artery (LCA), right femoral artery (RFA), and left femoral artery (LFA).

The POCUS was stopped when the patient reached ROSC or received chest compression for >30 minutes in the ED. The standard for satisfactory POCUS is to clearly display the vessel lumen, the blood-flow time curve, and allow for the measurement of peak systolic velocity (PSV). At least three high-quality, clear images or videos of each vessel were stored and subsequently exported for analysis. The PSV and inner diameter of each vessel were measured three times, and the average values were recorded.

DATA Collection

The CPR was maintained for at least 30 minutes, until ROSC or the exitus decision was made. The patient's demographics/health data were collected and recorded on the data collection form, including age, sex, CA location, initial rhythm on presentation, prehospital no/low-flow time, CPR time in the ED, clinical outcome, possible CA cause, and $EtCO_2$ values.

Outcome Measures

The primary outcome of this study was to measure the PSV and vessel diameter in CA patients and healthy volunteers. The secondary outcome was to explore the correlation between arterial PSV and $EtCO_2$ values in monitoring the effectiveness and quality of chest compression.

Statistical Analysis

Descriptive statistics were expressed as medians, standard deviations, interquartile ranges, frequencies, and proportions. For comparisons between groups, we used a paired-samples *t* test, independent samples *t* test in normal data, and rank-sum test in non-normal data. We used simple linear regression to detect the correlation between PSV and $EtCO_2$. Statistical calculations were performed at a 95% confidence interval on GraphPad Prism software v 9.5.0.730 (Dotmatics, Ltd, Bishops Stortford, Hertfordshire, England). A *P*-value of <0.05 was considered statistically significant.

RESULTS

General Characteristics of Patients

This study included 31 CA patients. As shown in Figure 1, we excluded 90 patients who presented at non-target times (night or weekends). An additional 48 patients were excluded for ROSC

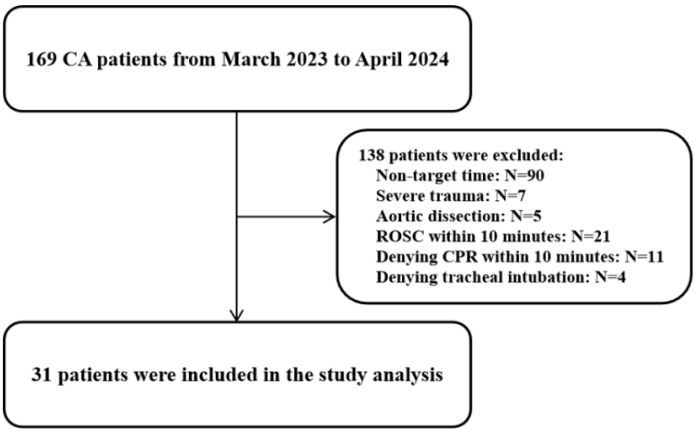

Figure 1. Study population.
CA, cardiac arrest; *ROSC*, return of spontaneous circulation; *CPR*, cardiopulmonary resuscitation.

or denying CPR/tracheal intubation within 10 minutes or who had been diagnosed with severe trauma or aortic dissection. As shown in Table 1, the mean age of the patients was 69±2 years, and 22 (71.97%) patients were males. Twenty-five (80.65%) patients suffered from OHCA, 18 of them with an average no/low-flow time >30 minutes before ED arrival. Most patients had non-shockable initial rhythms (PEA 6.45%, asystole 83.87%) on arrival. Twenty-nine (93.55%) patients were treated with CPR >30 minutes in the ED. Five patients achieved ROSC, and two survived to intensive care unit admission. According to the symptoms, past history, and available laboratory results and imaging examinations, the possible CA cause is shown in Table 1. The $EtCO_2$ values during POCUS period were 13.56±1.31 millimeters of mercury (mmHg).

Table 1. General characteristics of included cardiac arrest patients in the emergency department.

Gender	
Male	22 (71.97%)
Female	9 (29.03%)
Age	69±2 years
Cardiac arrest location	
OHCA	25(80.65%)
IHCA	6(19.35%)
Prehospital no/low-flow time	
<30 minutes	7(28.00%)
≥30 minutes	18(72.00%)
Initial emergency department rhythm	
PEA	2(6.45%)
Ventricular fibrillation/ventricular tachycardia	3(9.68%)
Asystole	26(83.87%)
CPR time in emergency department	60[38,80]
<30 minutes	2(6.45%)
≥30 minutes	29(93.55%)
Clinical Outcome	
ROSC	5(16.13%)
Survived to ICU admission	2(6.45%)
Non-ROSC	26(83.87%)
Possible cause of cardiac arrest	
Acute myocardial infarction	11(35.48%)
Sepsis	3(9.68%)
Asphyxia	2(6.45%)
Arrhythmia	1(3.23%)
Heart failure	1(3.23%)
Respiratory failure	1(3.23%)
Acute gastrointestinal bleeding	1(3.23%)
Unknown	11(35.48%)
$EtCO_2$	13.56±1.31 mmHg

OHCA, out-of-hospital cardiac arrest; *IHCA*, in-hospital cardiac arrest; *PEA*, pulseless electrical activity; *CPR*, cardiopulmonary resuscitation; *ROSC*, return of spontaneous circulation; *ICU*, intensive care unit; *$EtCO_2$*, end-tidal carbon dioxide; mmHg, millimeters of mercury.

Comparison of PSV Between CA Patients and Volunteers

The blood flow of the bilateral carotid and femoral arteries are shown in Figure 2. Peak systolic velocity and inner diameter of the arteries in CA patients and volunteers are compared in Table 2. Among the patients, PSV of the LCA was significantly higher than PSV of the RCA (81.86±8.07 vs 57.12±5.22 centimeters per second [cm/s], P=0.02), with similar changes between LCA and LFA (81.86±8.07 vs 59.03±6.26 cm/s, P=0.03). Neither was there an obvious difference among the inner diameters of four arteries, which reflected the consistency of vascular resistance. Interestingly, we found that PSV of the RCA in CA patients was lower than in that of volunteers (57.12±5.22 vs 76.00±6.75 cm/s, P=0.04), and the inner diameter of the LCA was slightly narrower in CA patients compared with volunteers (0.51±0.03 vs 0.61±0.02 cm/s, P=0.03).

Comparison of PSV Between ROSC and Non-ROSC Patients

We listed PSV and the inner diameter of bilateral carotids of five ROSC patients in Table 3. We also recorded $EtCO_2$ values at one minute before ROSC and found that all the values were above average (13.56±1.31 mmHg). There was no correlation between PSV and $EtCO_2$ values upon ROSC. We found no significant difference in PSV or inner diameter of any artery between ROSC and non-ROSC patients (Table 4).

The Correlation Between PSV and $EtCO_2$ During CPR

Then we explored the correlation between PSV and $EtCO_2$ in CA patients. In Figure 3, the PSV of the LFA was most consistently and positively correlated with $EtCO_2$ (R^2=0.35,

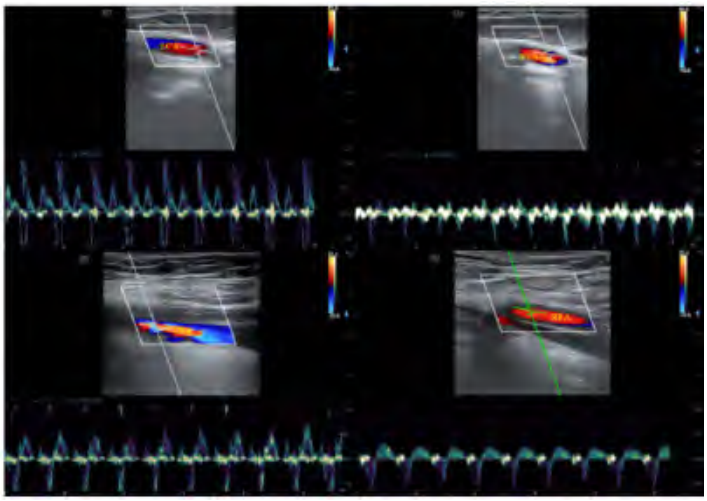

Figure 2. The blood flow of the bilateral carotid and femoral arteries. Top left: LCA; top right: RCA; bottom left: LFA; bottom right: RFA. *LCA*, left carotid artery; *RCA*, right carotid artery; *LFA*, left femoral artery; *RFA*, right femoral artery.

Table 2. Peak systolic velocity and vessel diameter in cardiac arrest patients and volunteers.

	CA patients		Volunteers	
	PSV (cm/s)	D (cm)	PSV (cm/s)	D (cm)
LCA	81.86±8.07[ab]	0.51±0.03	82.67±7.58	0.61±0.02[d]
RCA	57.12±5.22	0.56±0.03	76.00±6.75[c]	0.62±0.02
LFA	59.03±6.26	0.48±0.03	-	-
RFA	64.27±6.19	0.53(0.46,0.68)	-	-

PSV: [a]LCA VS RCA , $P<0.05$, [b]LCA VS LFA, $P<0.05$, [c]Volunteers vs CA patients, $P<0.05$.
Inner diameter: [d]Volunteers vs CA patients, $P<0.05$.
CA, cardiac arrest; *PSV*, peak systolic velocity; *D*, inner diameter of vessel; *cm*; centimeters; *LCA*, left carotid artery; *RCA*, right carotid artery; *LFA*, left femoral artery; *RFA*, right femoral artery.

Table 4. Peak systolic velocity and inner diameter of vessel in ROSC* and non-ROSC patients.

	ROSC (n=5)		**non-ROSC (n=26)**	
	PSV (cm/s)	D (cm)	PSV (cm/s)	D (cm)
LCA	65.29±21.75	0.53±0.07	85.18±8.72	0.51±0.03
RCA	67.01±12.27	0.56±0.05	61.21±8.23	0.55±0.03
LFA	83.27±45.02	0.57±0.03	69.38±8.94	0.46±0.03
RFA	67.57±19.37	0.53±0.06	63.53±6.48	0.56±0.03

PSV, peak systolic velocity; *ROSC*, return of spontaneous circulation; *PSV*, peak systolic velocity; *D*, inner diameter of vessel; *LCA*, left carotid artery; *RCA*, right carotid artery; *LFA*, left femoral artery; *RFA*: right femoral artery.

$P=0.003$). The PSV of the RCA was also positively correlated with $EtCO_2$ ($R^2=0.19$, $P=0.04$). Then we divided OHCA patients into two groups based on the prehospital no/low-flow time and found that $EtCO_2$ values showed no significant difference between two groups (Table 5). As shown in Figure 4, the PSV of the LFA was most positively correlated with $EtCO_2$ ($R^2=0.67$, $P=0.002$) in patients with arrest time >30 minutes. No significant correlation between PSV and $EtCO_2$ was found in any artery in patients with arrest time <30 minutes.

DISCUSSION

This was a prospective study to analyze blood flow of the bilateral carotid and femoral arteries during CPR and the first to explore the correlation between arterial PSV and $EtCO_2$ on monitoring the effectiveness of chest compression by POCUS in real clinical scenes. Firstly, this study showed that real-time arterial evaluation with POCUS might be a feasible method to monitor the quality of chest compression. Secondly, we found no significant difference in PSV of any artery between ROSC and non-ROSC patients, which suggests the consistency of the quality of chest compression. Thirdly and most interestingly, we found a significantly positive correlation between PSV of LFA and $EtCO_2$ in CA patients. Our findings suggest that arterial POCUS, particularly of the LFA, could serve as a novel method for assessing the effectiveness and quality of chest compression. Additionally, we propose a new team composition for ACLS that would include an emergency POCUS physician to enhance resuscitation management.

A growing body of evidence suggests that the quality of CPR, mainly effective and continuous chest compression, is directly related to neurological function recovery and clinical prognosis of CA patients. However, there is still a lack of clinical standards and implementation criteria for quality control of CPR in China. The American Heart Association (AHA) guidelines specify the key points in CPR to ensure high-quality chest compression, including the compression location, posture, depth, frequency, and sufficient rebound.[23] Chest compression fraction, which is calculated as the ratio of chest compression time to total CPR time, is used to evaluate the continuity of chest compression. The ideal target for CCF in clinical guidelines is 80%.[24]

Table 3. Peak systolic velocity of bilateral carotids and end-tidal carbon dioxide in five ROSC* patients.

	LCA-PSV (cm/s)	LCA-D (cm)	RCA-PSV (cm/s)	RCA-D (cm)	$EtCO_2$ (mmHg)
1	21.39	0.41	59.99	0.56	22
2	140.95	0.70	92.13	0.77	30
3	77.71	0.37	97.14	0.54	15
4	61.67	0.67	54.32	0.48	18
5	24.75	0.50	31.46	0.47	18

PSV, peak systolic velocity; *$EtCO_2$*, end-tidal carbon dioxide; **ROSC*, return of spontaneous circulation; *LCA*, left carotid artery; *D*, inner diameter of vessel; *RCA*, right carotid artery.

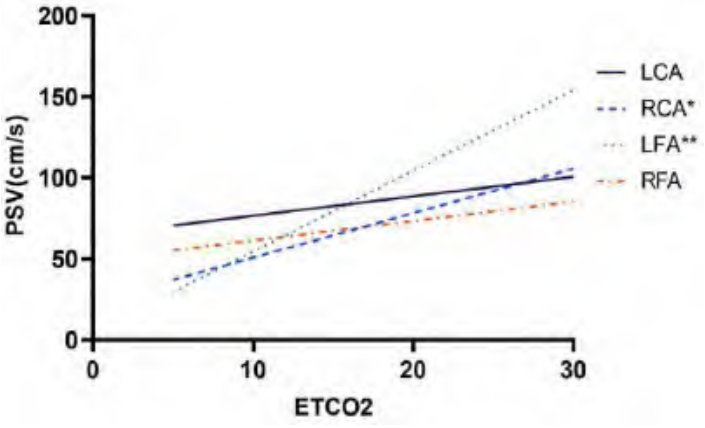

Figure 3. The linear regression lines for peak systolic velocity vs end-tidal carbon dioxide in all cardiac arrest patients.
PSV, peak systolic velocity; *$EtCO_2$*, end-tidal carbon dioxide; *LCA*, left carotid artery; *RCA*, right carotid artery; *LFA*, left femoral artery; *RFA*, right femoral artery.

Table 5. Peak systolic velocity and end-tidal carbon dioxide in OHCA* patients with different arrest time.

	CA time < 30min (n=7)		CA time ≥ 30min (n=18)	
	PSV (cm/s)	$EtCO_2$ (mmHg)	PSV (cm/s)	$EtCO_2$ (mmHg)
LCA	53.38±12.45		101.03±13.82	
RCA	61.04±11.24		68.33±17.16	
LFA	67.23±10.62	14.71±2.01	62.67 (22.26,129.1)	15.27±2.36
RFA	85.26±13.01		55.08±10.89	

PSV, peak systolic velocity; *$EtCO_2$*, end-tidal carbon dioxide; **OHCA*, out-of-hospital cardiac arrest; *CA*, cardiac arrest; *PSV*, peak systolic velocity; *$EtCO_2$*, end-tidal carbon dioxide; *LCA*, left carotid artery; *RCA*, right carotid artery; *LFA*, left femoral artery; *RFA*, right femoral artery.

End-tidal carbon dioxide, considered to reflect cardiac output and coronary perfusion pressure, has been recommended as a non-invasive monitor of CPR effectiveness by AHA guidelines since 2010.[4,25] The $EtCO_2$ value, normal 35-45 mmHg, will sharply decrease to <20 mmHg due to mismatched lung ventilation/perfusion in CA patients who recover after ROSC. At present, $EtCO_2$ has been mainly used for confirming tracheal intubation, predicting clinical outcome, and identifying ROSC during CPR.[14,26] Research has indicated that different compression depths can lead to changes in $EtCO_2$ levels, which are confirmed related to CPR quality.[2] However, $EtCO_2$ can be affected by many factors including the CA cause, pulmonary disease. and therapeutic drugs.[14,27,28] Esophageal intubation or complete obstruction of trachea by foreign body may lead to abnormal or no $EtCO_2$ waveform.[29]

Asphyxia often has a higher $EtCO_2$ value than cardiogenic causes due to CO_2 retention, while pulmonary embolism shows a lower level.[14] Patients with previous obstructive pulmonary diseases and receiving intravenous (IV) bicarbonate or vasoactive drugs infusion can show a higher $EtCO_2$ level,[27,28] which is also seen in CA patients with acute intracranial hypertension or excessive use of anesthetic drugs. In our study, we found no significant difference of $EtCO_2$ values in CA patients with different arrest times, consistent with a generally low $EtCO_2$ level in CA patients before ROSC. Differences in the $EtCO_2$ values and measured time in various studies have resulted in poor specificity of the $EtCO_2$ threshold, leading to uncertain recommended evidence in guidelines.[14] Some research suggests thresholds of 20 mmHg for detecting ROSC in early CPR,[7] while others recommend delta $EtCO_2$ >20 mmHg with highly specificity for ROSC in PEA patients.[30] If $EtCO_2$ continues to be lower than 10 mmHg after 20 minutes of CPR, it means difficult-to-achieve ROSC.[31] All these uncertain factors suggest further exploration for the specific $EtCO_2$ cut-off point during CPR in comprehensive clinical situations.[4]

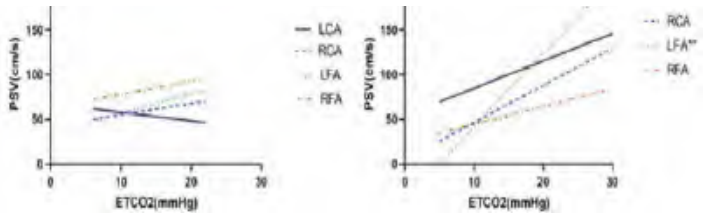

Figure 4. The linear regression lines for peak systolic velocity vs end-tidal carbon dioxide in *OHCA patients.
Prehospital CA time < 30 minutes, B. Prehospital CA time ≥ 30 minutes.
**OHCA,* out-of-hospital cardiar arrest*; PSV*, peak systolic velocity; *$EtCO_2$*, end-tidal carbon dioxide; *LCA*, left carotid artery; *RCA*, right carotid artery; *LFA*, left femoral artery; *RFA*, right femoral artery; *CA,* cardiac arrest.

In contrast, we found that POCUS centered on arterial blood flow and unaffected by aforementioned factors can effectively monitor the effectiveness and quality of chest compression. Our findings demonstrated successful completion of POCUS examinations on bilateral carotid and femoral arteries during CPR. The PSV of the four arteries showed good consistency of arterial pulsation and blood flow waveforms induced by chest compression. The PSV of the LFA showed the most positive correlation with $EtCO_2$ in CA patients. The LFA performs better than carotid arteries in consistency of PSV and the correlation between PSV and $EtCO_2$, which may be due to factors such as a smaller impact of chest compression pressure and skin amplitude on the LFA; a relatively flat surface position of the LFA for a larger contact area between the ultrasound probe and skin; and a simpler anatomical position to more easily explore and capture satisfactory images. Thus, we recommend the LFA as the preferred site for POCUS during CPR, considering that it will not affect chest compression, tracheal intubation in the head position, and IV medication in the upper limbs.

Point-of-care ultrasound can assist in evaluating the quality of chest compression, quickly diagnosing the reversible cause of cardiac arrest, monitoring intervention measures and patients' response, and also predicting the possibility of ROSC and clinical prognosis.[17,18] To evaluate CPR effectiveness, physicians can observe the compression and diastole of the heart directly by POCUS in real time.[17,32] Research has shown that POCUS may lead to an increase in interruption of compressions and CCF decrease.[33] So, it is recommended that a well-trained physician perform POCUS preferably in the subcostal or apical view within 10 seconds.[34]

Besides confirming reversible causes of non-defibrillation rhythm,[2,17] POCUS can also help rescuers visually establish vascular access and perform pericardiocentesis or thoracentesis to remove the cause of the CA.[34] A retrospective cohort study showed that POCUS-treated CA patients received more extended CPR and a higher intervention rate compared to those without POCUS.[35] In recent years, some research has focused on vascular

ultrasound during CPR and found that the accuracy of carotid or femoral artery ultrasound in confirming pulse is greatly superior to manual assessment.[19,20] Our research indicates expanding the current use of POCUS in CA patients to monitor and optimize the effectiveness and quality of chest compression through arterial PSV without interrupting compressions and other resuscitation protocols. The latest research has indicated that a small wearable ultrasound device can provide high-quality, real-time, and continuous tissue and vascular ultrasound data. The data is then transmitted to a tablet or smartphone wirelessly for specific evalution.[36] This provides new insight into the continuing research of POCUS application during CPR.

The PSV reflects the blood velocity passing through the carotid and femoral arteries during systole. Vascular PSV can represent the cardiac ejection to some extent during CPR and, thus, reflect the quality of chest compression. Peak systolic velocity-oriented POCUS, which can be quickly mastered with simple training, is easier to operate than transthoracic echocardiography and transesophageal echocardiography. More importantly, PSV-oriented POCUS does not increase the interruption of chest compression during CPR. There are also certain limitations to the reliability of PSV in reflecting actual arterial flow or perfusion. While the PSV can be quite high, the actual flow can decrease in case of vascular stenosis or obstruction.[37,38] Considering the age and gender of CA populations, atherosclerosis may be common and affect arterial PSV. Therefore, vascular plaque and integrity should be first evaluated when using PSV to reflect the quality of chest compression.

LIMITATIONS

There are several limitations in our study. First, this was a single-center study with a small sample size carried out only during working hours when the study team was present, which might account for the low R^2 overall. The small sample size partially resulted in the non-significant correlation between arterial PSV and $EtCO_2$ in CA patients with arrest time <30 minutes. Other accounting factors might include the prehospital CA duration, initial heart rhythm at ED admission and reversible etiology, etc. Second, POCUS results are related to the operators' personal experience. In our study, POCUS was performed by two experienced physicians who had systematically studied the CCUSG course, underwent intensive practice, and passed the assessment in one week, but human confounding factors cannot be completely avoided. Third, the rescue team was not blind to the arterial POCUS while the POCUS physicians had no knowledge of the resuscitation management and outcome. However, this might help improve the quality of chest compression.

Fourth, this study correlated POCUS measurements with the currently controversial parameter, $EtCO_2$, which might be problematic in truly reflecting the effectiveness of chest compression. Moreover, in real clinical CPR, it is not feasible to evaluate PSV and other parameters under varying qualities of chest compression. Fifth, due to the limited sample size and results, POCUS was shown to be capable of providing vascular PSV, but we found no impact on resuscitation outcomes. Sixth, in this study two additional physicians were involved in performing POCUS, which might be a challenge in many real-life clinical CPR scenarios. If rescuers take time to perform POCUS, it could lead to increased interruptions in compressions or a lower CCF, both of which are critical for effective CPR. However, our results confirm that arterial POCUS can provide additional data to aid in resuscitation efforts. This finding not only highlights the potential benefits of integrating POCUS into resuscitation protocols but also offers insights for future adjustments in the composition of ACLS team. Therefore, more multicenter studies should be conducted to eliminate various biases and further explore the role of POCUS in improving the effectiveness of CPR.

CONCLUSION

There are many limitations with regard to the use of $EtCO_2$ to monitor CPR quality. Our study supports the feasibility of using peak systolic velocity of the left femoral artery, determined by arterial point-of-care ultrasound, as a non-invasive tool to monitor chest compression effectiveness; however, further research is needed.

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Emergency Physician Assessment of Productivity and Supervision Practices

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Introduction: Despite a lack of data guiding safe standards for physician productivity and supervision of non-physician practitioners (NPP), legislation dictating supervision ratios for emergency physicians (EP) has been enacted in Florida and elsewhere across the country. To inform future legislation, we aim to identify current productivity and supervision practices among practicing EPs as well as those physicians' safety assessments of their current practices.

Methods: We conducted a cross-sectional observational study regarding EPs' perspectives on safe staffing and supervision models. A survey, consisting of 14 questions examining different variables affecting supervision and productivity, was used to determine physicians' opinions on the safety of productivity and supervision models across a range of annual volumes, employers, and years of experience. We coded safety assessments as binary (yes/no) and measured productivity by patients treated per hour. Ratios of physician to supervisee (either resident physician or or NPP) were given as number of supervisees: EP.

Results: The survey response rate was 4.8% (196/4,004). On average, most EPs treated 2.6 patients per hour, regardless of years of experience, employment model, or supervision model. More than 80% of EPs felt that their current patients-per- hour practice was safe. Direct supervision represented 59% of total visits and the majority in all employment models except for community contract-management groups (CMG). A minimum of 80% of physicians felt that their current supervision practices were safe across employment models, with the notable exception of community CMGs. Most felt that a safe ratio for direct supervision of NPPs was 1:1. Over 30% reported there was no safe staffing ratio for indirect supervision.

Conclusion: With the exception of those employed by community contract-management groups, EPs felt that their current productivity and supervision practices were safe; however, average productivity and supervision ratios are much lower than prior estimates and in current legislation governing emergency department practice. Standards of care for both productivity and supervision that take into account current practices and safety assessments should be established and considered when future policies and legislation are developed. [West J Emerg Med. 2025;26(3):500–506.]

INTRODUCTION

Background

Over the past several years, state legislatures have considered numerous bills related to physician scope of practice and supervision, with one common area of legislation related to the number of nurse practitioners (NP) or physician assistants (PA) that a physician may supervise simultaneously.[1,2] For example, in 2021 Florida increased the number of physician assistants a doctor may supervise from 4 to 10, with no stated limit on the number of NPs.[3,4] Despite the

frequency of introduction and importance of these policies to patient care, little is known about safe practices regarding physician supervision of NPs and PAs (collectively non-physician practitioners, or NPPs).[5,6] Furthermore, there is very limited recent data on physician productivity levels more generally, particularly in an emergency department (ED) setting where care occurs in an unscheduled manner.[7]

Some previous work has been limited by the operationalization of patient safety with "rare and proxy outcomes that probably represent only the 'tip of the iceberg.'"[5,8] Thus, there is a significant gap in the literature regarding current emergency physician (EP) productivity and supervision practices, as well as safety assessments of these practices. Ideally, safety of productivity and supervision models might be measured in terms of patient outcomes, although the challenges of such an approach have been well documented.[9,10] Thus, EPs' own assessments of the safety of their supervision and productivity can contribute to overall understanding.

Population Health Research Capsule

What do we already know about this issue?
Legislation on physician supervision of non-physician practitioners exists, but little data supports safe productivity and supervision standards.

What was the research question?
What are the current productivity and supervision practices among emergency physicians, and are they perceived as safe?

What was the major inding of the study?
Most emergency physicians treat 2.6 patients per hour. Direct supervision increases perceived safety (OR 5.41, 95% CI: 1.27-25.55), while CMG employment decreases it (OR 0.24, 95% CI: 0.10-0.60).

How does this improve population health?
Findings guide safer supervision policies, ensuring patient care quality by aligning legislation with actual emergency physician workload capacities.

Objectives

Given the evolution of emergency medicine (EM) and recent legislation impacting emergency care, there is a need for an assessment of current practice patterns. Our primary objective in this study was to determine the current productivity and supervision practices of practicing EPs. Secondarily, we aimed to assess the perceptions of those practices by the same EPs.

METHODS

Study Design and Setting

This was a cross-sectional observational study regarding EPs' perspectives on safe staffing and supervision models conducted from November–December 2023. This study was conducted on behalf of the American Academy of Emergency Medicine (AAEM). The survey was designed by a task force of the AAEM Workforce and Operations Management committees, which developed the questions and responses and incorporated committee revisions prior to distribution. It consisted of 14 questions examining different variables affecting supervision and productivity. The survey (Appendix A) was distributed electronically to the AAEM listserv, which includes 4,044 EPs. One additional reminder email was sent to the listserv to encourage participation in the survey.

Variables and Measures

Independent variables included the following: 1) physician sex; 2) physician race; 3) physician ethnicity; 4) physician years out of residency; 5) employment model; 6) practice setting; 7) annual volume at primary practice setting (<20,000 patients annually, 20,001-50,000, 50,001-75,000, 75,001-100,000, more than 100,000); and 8) number of patients seen per hour at primary workplace under a direct, indirect, and unsupervised/retrospective chart review model. Physician years out of residency data was collected as a ratio variable and recoded as categorical for analyses. Listed employment models included the following: contract management group (CMG), for which Envision, TeamHealth, and SCP were listed as prototypes; democratic group; hospital employed; or military. Practice settings were community and academic.

For supervision models, direct supervision requires that the supervising physician see and evaluate every one of the supervisee's patients over the course of their ED visit. Indirect supervision requires that the supervising physician discuss each patient with the supervisee during the course of clinical care, with or without personally evaluating the patient.[11] Dependent variables were 1) EP assessment of the safety of patients per hour, reported as a binary (yes/no) variable, and 2) EP assessment of the safety of their workplace supervision model, also binary (yes/no). Supervision ratios were reported as attending EP:NPP or attending EP:resident physician.

Data Analysis

Descriptive statistics were calculated and presented with summary information for the variables of interest and measures of spread. We estimated multivariate logistic regression models for factors associated with safety assessments both of productivity and supervision model. Finally, density plots were generated to compare reported safe staffing ratios by supervision model. We performed all analyses in R (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Descriptive Statistics

A total of 196 EPs responded to our survey. Respondent characteristics are shown in Table 1. A plurality of respondents reported being fewer than 10 years out of residency, and most worked in EDs with mid-range annual patient visits. The overall mean patients per hour reported by EPs was 2.6, with a standard deviation of 1.7. Patients per hour were similar for physicians at different stages of their career, as well as across employment models, with the exception of hospital-employed community practice physicians, who saw 2.1 patients per hour. The self-reported patients per hour data was similar to recent data provided by the ED Benchmarking Alliance.[12]

On average, more than 80% of EPs felt that the number of patients they saw per hour was safe. This rate of safety assessment held for all subgroups except for community CMGs as an employer type and practice setting. Supervision models reported were direct, indirect, and retrospective chart review. Direct supervision represented 59% of total visits, and the majority of visits in all employment models with the exception of community CMGs. A minimum of 80% of physicians in all employment models felt that their supervision model was safe, again with the exception of community CMGs, in which fewer than two-thirds of physicians felt the supervision model was safe.

Main Results

Table 2 shows the results for the multivariate logistic regression of determinants of safety assessment (yes/no) of the patients-per-hour staffing model. Overall, there were no significant associations between physician years out of residency or annual ED volume and assessment of safety of patients per hour. While the direction of the estimates for employment with a CMG and total patients per hour seen were in the expected direction, neither of these were significant at α=0.05. Table 3 shows the results for the multivariate logistic regression of determinants of safety assessment (yes/no) of the supervision model. As in the data for patients per hour, we

Table 1. Characteristics of survey respondents and descriptive staffing variables.

Characteristics of survey respondents		Staffing and safety variables			
Characteristic	No. (%)	Patients per hour (SD)	Patients per hour safety assessment (%)	Supervision model % direct (SD)	Supervision model safety assessment (%)
Years out of residency					
Still in residency	0 (0%)	NA	NA	NA	NA
0-10	77 (39%)	2.5 (1.2)	63/77 (82%)	58 (33.1)	60/77 (78%)
11-20	50 (26%)	2.6 (1.0)	43/50 (86%)	63 (36.5)	43/50 (86%)
21-30	45 (23%)	2.6 (2.5)	35/45 (78%)	65 (31.9)	40/45 (89%)
>31	24 (12%)	3.2 (2.6)	22/24 (92%)	50 (33.1)	21/24 (88%)
Annual volume at primary practice setting					
<20,000	24 (12%)	1.5 (0.6)	23/24 (96%)	71 (41.8)	23/24 (96%)
20,001-50,000	54 (28%)	2.4 (0.8)	42/54 (78%)	49 (30.8)	39/54 (72%)
50,001-75,000	54 (28%)	3.2 (2.7)	47/54 (87%)	53 (33.3)	46/54 (85%)
75,001-100,000	45 (23%)	2.9 (1.3)	34/45 (76%)	70 (30.8)	40/45 (89%)
>100,000	19 (10%)	2.5 (1.1)	17/19 (89%)	71 (32.2)	16/19 (84%)
Employment type					
Hospital employed					
Academic	38 (19.4%)	2.9 (1.3)	31/38 (82%)	70 (29.4)	33/38 (87%)
Community	50 (25.5%)	2.1 (1.2)	43/50 (86%)	51 (35.4)	44/50 (88%)
Contract Management Group (Envision, Team Health, etc.)					
Academic	6 (3.1%)	2.8 (0.9	5/6 (83%)	71 (24.1)	6/6 (100%)
Community	40 (20.4%)	2.7 (1.8)	30/40 (75%)	45 (29.8)	25/40 (63%)
Democratic group					
Academic	5 (2.6%)	2.8 (0.9)	4/5 (80%)	87 (28.1)	5/5 (100%)
Community	52 (26.5%)	2.8 (2.4)	46/52 (88%)	64 (34.0)	47/52 (90%)
Military	5 (2.6%)	3.0 (1.0)	4/5 (80%)	67 (47.0)	4/5 (80%)
Total	196 (100%)	2.6 (1.7)	163/196 (83%)	59 (33.8)	164/196 (84%)

Table 2. Multivariate logistic regression results: safety of patients per hour.

Variable	Estimate (95% CI)	Odds ratio (95% CI)
Characteristics of survey respondent		
Years out of residency		
	0.00 [-0.03, 0.04]	1.00 [0.97, 1.04]
Annual ED volume (reference: 20,001-50,000 patient visits)		
<than 20,000	1.33 [-0.49, 4.30]	3.77 [0.61, 73.73]
50,001-75,000	0.86 [-0.22, 2.03]	2.36 [0.81, 7.58]
75,001-100,000	-0.21 [-1.27, 0.85]	0.81 [0.28, 2.34]
>100,000	1.49 [-0.32, 4.45]	4.42 [0.73, 85.45]
Employment type (reference: non-contract management group)		
Contract Management Group	-0.91 [-1.83, 0.02]	0.40 [0.16, 1.02]
Staffing and productivity		
Total patients per hour	-0.12 [-0.33, 0.10]	0.88 [0.72, 1.11]
Supervision		
% patients seen primarily by a physician or under direct supervision in workplace	0.41 [-0.93, 1.77]	1.51 [0.39, 5.86]

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

found no association between years of practice and likelihood to report that supervision model was safe. However, a higher percentage of patients seen under direct supervision was associated with a higher likelihood of reporting a safe supervision model (odds ratio [OR] 5.41, 1.27-25.55). Furthermore, employment with a CMG was associated with less favorable assessments of the safety of supervision practices (OR 0.24, 0.10-0.60). Patients per hour was not statistically associated with assessment of supervision model safety. Figure shows side-by-side bar plots of the staffing ratios that EPs felt were safe. Physicians reported that they could safely supervise more emergency resident physicians than NPPs, with the most common safe resident ratios reported as 2:1 or 3:1. The most commonly reported safe staffing ratio for NPPs was 1:1 when directly supervised. A plurality (60/196) of emergency physicians reported that there was no safe staffing ratio for indirect supervision.

DISCUSSION

Most survey respondents reported seeing an average of 2.6 patients per hour and practiced direct supervision with resident physicians and either direct or indirect supervision with NPPs. The majority of respondents felt that their productivity and supervision practices were safe. Those employed by community The CMGs were felt the least safe, comparatively, in terms of both productivity and supervision practices. Compared to other employment models, those who worked for CMGs practiced less direct supervision (27%).

To the best of our knowledge, this study is the only recent work reviewing EP productivity and supervision practices. Given the well-documented challenges with measuring safety and quality outcomes in EM,[10,13] we used physicians' own safety assessments of their practice model to evaluate trends. With respect to supervision ratios that EPs deemed to be safe, the response data approximated a normal distribution in which physicians felt that they could safely supervise 1-3 individuals at a time, with resident physicians considered to need less strict ratios than NPPs. Because our survey instrument did not include questions regarding the rationale for supervision ratios we were unable to determine with certainty the factors related to ratios considered safe. However, one hypothesis that might be considered in future work is that the level of training of the supervisee was a relevant factor in the safe ratio, with resident physicians having more formal training. Future work might also consider supervision ratios for newly graduated physician assistants and nurse practitioners relative to those with more experience.

Our findings raise two practical implications with respect to policymaking. First, it is essential that standards of care be established for the supervision of NPPs in the ED in the same manner that standards of care exist for the supervision of resident physicians. Supervision of resident physicians, as mandated by the Accreditation Council for Graduate Medical Education, must be a direct supervision model and adequate to provide individualized clinical instruction.[14,15] Once standards are determined, legislation and hospital policies must be updated to reflect safe standards of care. No physician, no matter how talented, can supervise an unlimited number of other clinicians, and legislation permitting this practice places patients at risk. While our work is preliminary and limited in scope, early findings suggest that most EPs feel that they can safely supervise only 1-2 other clinicians at one time. Legislative changes that reflect these safety assessments must occur in parallel with further research on this topic.

The second policymaking implication is that standards of care for supervision must be properly incentivized, and liability

Table 3. Multivariate logistic regression results: safety of supervision model.

Variable	Estimate (95% CI)	Odds ratio (95% CI)
Characteristics of survey respondent		
Years out of residency		
	0.03 [-0.01, 0.07]	1.03 [0.47, 5.21]
Annual ED volume (reference: 20,001-50,000 patient visits)		
<than 20,000	1.45 [-0.38, 4.42]	4.26 [0.68, 83.00]
50,001-75,000	1.05 [-0.02, 2.22]	2.87 [0.98, 9.18]
75,001-100,000	0.63 [-0.57, 1.94]	1.88 [0.56, 6.96]
>100,000	0.76 [-0.84, 2.78]	2.13 [0.43, 16.13]
Employment type (reference: non-contract management group)		
Contract Management Group	-1.42 [-2.35, -0.50]*	0.24 [0.10, 0.60]**
Staffing and productivity		
Total patients per hour	-0.12 [-0.33, 0.14]	0.89 [0.72, 1.16]
Supervision		
% patients seen primarily by a physician or under direct supervision in workplace	1.69 [0.24, 3.24]*	5.41 [1.27, 25.55]**

*95% confidence interval for estimate does not cross zero.
**95% confidence interval for odds ratio does not cross one.
CI, confidence interval; *ED*, emergency department.

for failure to meet standards must be properly assigned. Due to changes in the employment landscape in EM, emergency physicians themselves may have little control over productivity or supervision ratios. At the start of the specialty, most hospitals were owned in conjunction with medical schools, or by religiously affiliated nonprofit entities.[16,17] Today, within the United States, nearly 5,000 hospitals have EDs. Most are managed by for-profit companies, and equity-backed CMGs staff many of those EDs.[16] Of practicing EPs, just over 50% are employed while just under 30% have an ownership stake in their practice.[18] In cases where substandard care results from unsafe productivity or supervision models, the unit of attribution for medico-legal purposes must be the party determining these models. In addition to the "stick" of liability, "carrots" of reimbursement tied to staffing ratios, similar to those in anesthesiology, might be considered. Anesthesiology has separate billing modifiers for services rendered by a physician vs a non-physician, in addition to modifiers for the number of procedures being supervised concurrently.[19]

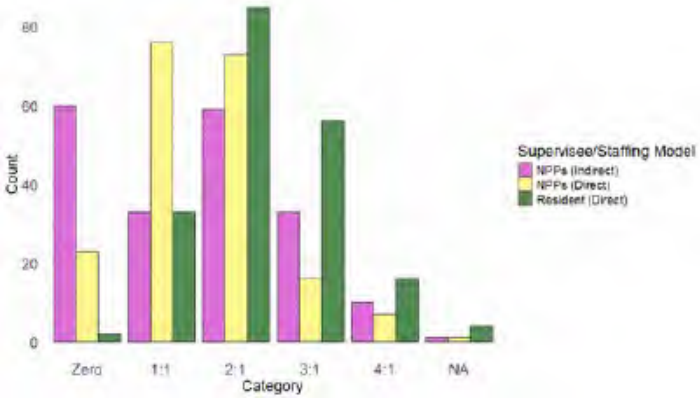

Figure. Safe supervision ratios for resident physicians and non-physician practitioners.
NPP, non-physician practitioner.

LIMITATIONS

Our study has several limitations. The first is that we had a limited number of survey respondents relative to total number of practicing EPs, and our sampling method did not have the capability to randomly select among practicing physicians. We elected to limit our sampling frame to AAEM membership to limit non-randomness of the sample, but this decision naturally limited the potential number of respondents. Future work should expand on sample size. A second limitation is that there is a great deal of variability both in staffing models and terminology regarding supervision, so some physicians may have interpreted terms such as indirect or direct in ways other than intended despite provided definitions.

More generally, while our survey was developed iteratively with feedback from stakeholders, the instrument has not been validated. We did not have a survey item related to the level of experience of NPPs or the training level of resident physicians and, thus, were unable to determine whether the experience and training of supervisees was a factor in safety assessments. Finally, no respondents reported being resident physicians. To the extent that some residents may supervise junior residents or students, our data may not represent the views of this population. Lack of participation

from resident physicians may be a result of our sampling strategy, a perception that the survey was directed more toward faculty physicians, or a lack of empowerment to raise concerns about NPP staffing, as noted in recent work.[20]

CONCLUSION

Our survey found that, on average, most emergency physicians treated 2.6 patients per hour and that productivity was similar across years of clinical experience, employment model, and supervision model. Most EPs felt that their productivity and supervision practices were safe, although EPs employed by community contract-management groups felt less safe with regard to both productivity and supervision compared to those in other employment models. Our assessment of EP productivity and supervision practices should be considered when developing future guidelines, policies, and legislation that impact emergency care. Furthermore, clear standards of care with respect to supervision must be established and could be linked to reimbursement in the future.

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Evaluating the Implementation of a "COVID-19 Test" Chief Concern in the Emergency Department

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Background: During the COVID-19 pandemic, rapid, at-home testing for severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) was inconsistently available. Consequently, for some patients, emergency departments (ED) became the preferred site to access COVID-19 testing. To improve operational efficiency, our ED implemented a "COVID-19 Test" chief concern (CC). Our primary objective in this analysis was to broadly assess the utilization of the new "COVID-19 Test" CC and associated clinical care.

Methods: We conducted a retrospective analysis of ED encounters from an academic ED and an affiliated, community-based ED of all patients after the establishment of a CC of "COVID-19 Test" from October 11, 2021–July 31, 2022. The data were extracted from the electronic health record. We calculated descriptive demographic statistics and ran a univariate and multivariate logistic regression with additional diagnostic or therapeutic interventions (binary) as the outcome variable to generate odds ratios (OR) and 95% confidence intervals (CI).

Results: A total of 320 patients were assigned a "COVID-19 Test" CC by a triage nurse. This was 0.5% of all ED encounters in this time frame. Of those, 45% were found to be SARS-CoV-2 positive. Admission or repeat ED visit at 72 hours occurred in 5.3% of patients. Nearly half (46.9%) of patients assigned a "COVID-19 Test" CC underwent additional ED interventions. Patients on Medicaid and those who self-identified as Black or Hispanic/Latino were disproportionately represented in the "COVID-19 Test" CC group as compared to the overall ED population. In multivariate analysis, an Emergency Severity Index of 1, 2 or 3 was associated with significantly higher odds of receiving additional interventions compared to ESI of 4 or 5 (adjusted OR: 46.85; 95% CI 13.28-165.26; P <0.001).

Conclusion: Patients assigned a chief concern of "COVID-19 Test" had a high COVID-19 positivity rate, often underwent additional ED interventions, and were at low risk of return ED visits or admission. Minoritized and low-income patients were disproportionately represented in the "COVID-19 Test" CC group, highlighting potential disparities in access to at-home COVID-19 testing and implementation of this CC. [West J Emerg Med. 2025;26(3)507–512.]

INTRODUCTION

Throughout the various phases of the COVID-19 pandemic, access to diagnostic testing evolved significantly. Even after rapid at-home tests were eventually approved, they were not always readily available for purchase.[1] Although insurance companies were required to cover the cost of eight tests per month during the public health emergency, this involved a burdensome reimbursement process.[1] Additionally, those without insurance had to rely on tests distributed by the federal government or pay out of pocket for these expensive tests.[1] Therefore, emergency departments (ED) became a site to access COVID-19 testing for some patients throughout the pandemic.

We implemented an operational intervention to rapidly identify and expedite care for patients presenting to the ED for the reported sole purpose of receiving COVID-19 testing. Better understanding of the characteristics and clinical course of patients who visit the ED only to receive a COVID-19 test could inform policies and procedures for future surges of COVID-19 and other respiratory pathogens. The primary objective of this analysis was to assess the uptake of this operational intervention and its performance in identifying the target population. Our secondary objective was to describe the demographic and clinical course of the ED patients assigned a chief concern (CC) of "COVID-19 Test," including a comparison between those who subsequently were discharged after solely receiving COVID-19 testing vs those who received additional diagnostic testing or therapeutics.

Population Health Research Capsule

What do we already know about this issue?
Early in the COVID-19 pandemic, reliable at-home testing was not widely available and EDs provided testing and developed new operational workflows.

What was the research question?
We sought to broadly assess the use of a "COVID-19 Test" chief concern and associated clinical care.

What was the major finding of the study?
Patients with this chief concern were disproportionally Black or Hispanic, and 45% tested positive. Emergency Severity Index 1-3 patients had higher odds of additional interventions (aOR: 43.28; 95% CI 12.45-150.43; P <0.001).

How does this improve population health?
Understanding impacts of assigning chief concerns in the ED can inform future operations and health disparities research.

METHODS

Setting and Intervention

On October 11, 2021, a health system in the Midwestern United States, a quaternary-care academic ED that sees approximately 60,000 visits per year and a community hospital-based ED with approximately 24,000 visits annually, added "COVID-19 Test" to the list of CC options eligible for selection by the ED triage nurse or designee. The CC selected is meant to identify the patient's primary reason for the ED visit. Triage nurses were informed of the addition of this CC and educated on its intended use prior to rollout at daily nursing huddles that occurred before each new shift. This quality improvement initiative assessment was deemed exempt based on institutional review board criteria, and informed consent was waived.

Data Source

We conducted a retrospective analysis of ED patient encounters from October 11, 2021–July 31, 2022 that had "COVID-19 Test" assigned as the CC and received a COVID-19 polymerase chain reaction test to detect severe respiratory syndrome coronavirus-2 (SARS-COV-2). Ending data collection in July allowed us to capture the first full respiratory season after the CC was implemented. Structured healthcare data were extracted from the electronic health record (Epic, Verona, WI) by DH, a department data analyst. We divided the sample into two groups: 1) COVID ONLY, for those who received only COVID-19 testing; and 2) COVID PLUS, for those patients who received additional diagnostic testing (any laboratory or imaging studies) or therapeutics (any medications or procedures).

We extracted information on patient demographics including age; age group (pediatric [<18], adult [18-64], and older adult [≥65]); sex (male or female); patient-reported race (American Indian or Alaska Native, Asian, Black, Native Hawaiian or Pacific Islander, White, or patient declined to answer); patient-reported Hispanic, Latino or Spanish ethnicity (yes, no, declined to answer); and insurance status (commercial, Medicaid, Medicare, or other (self-pay, workers compensation, or unknown insurance). We extracted information about the ED visit including disposition (admitted, discharged, left before treatment complete); COVID 19 test result (positive, negative); and Emergency Severity Index triage score (ESI). The ESI is meant to reflect a combination of patient acuity and intensity of resource requirement. It is assigned on a scale of 1-5, with one usually reserved for patients in need of emergent resuscitation and five usually indicating non-urgent patient presentation. Vitals sign data was captured using triage vitals, including temperature, heart rate, oxygen saturation, respiratory rate, and systolic and diastolic blood pressure. We classified patients as having abnormal temperature, heart rate, oxygen saturation, respiratory rate, and systolic or diastolic blood pressure, if the patient had a temperature >100.4°F; heart rate or pulse >100 beats per minute; oxygen saturation 92%; respirations >24

breaths per minute; systolic blood pressure <100 or >200 millimeters of mercury (mmHg); diastolic blood pressure >100 mmHg, respectively. We generated a summary variable that indicated whether the patient had any abnormal vital sign (yes/no). We also recorded whether participants had a return ED visit within 72 hours of initial ED discharge.

Analysis

We compared differences in demographic and clinical encounter variables between the COVID ONLY and COVID PLUS groups, using *t*-tests for continuous variables and independent chi-square test for categorical variables. We also compared demographic characteristics between the patient cohort flagged with the "COVID-19 Test" CC vs the entire ED population. We built a multivariable logistic regression model to describe the odds of receiving only a COVID test according to patient demographic and clinical encounter variables. We included variables in the model that prior literature (race, ethnicity, insurance status, age)[2-4] or clinical factors (COVID test result, ESI) suggested might be related to differences in ED utilization or care patterns. We excluded from the multivariate analysis 26 patients with missing values and seven patients who declined to answer demographic questions. Due to small numbers, the race ethnicity variable was included in the model as a dichotomous variable (White and non-Hispanic, Latino or Spanish origin; or non-White and/or Hispanic, Latino or Spanish origin). Alpha of 0.05 was prespecified as the threshold of statistical significance for all tests. We performed all data retrieval, cleaning, and analysis using R 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria).[5]

RESULTS

A total of 320 patients were assigned a CC of "COVID-19 Test," which represented 0.5% of the patient population during this period. Of those patients with a CC of "COVID-19 Test," 45.0% tested positive for COVID-19 (Table 1). The average age was 30.5 years old with a standard deviation of 19.6 years; 26.2% of patients were pediatric; and 6.9% were older adults. Overall, 39.7% of patients with a CC of "COVID-19 Test" identified as Black and 10.3% as Hispanic/Latino compared with the overall ED population from the study period of 11.8% and 7.9%, respectively. In terms of insurance status, 51.9% of "COVID-19 Test" CC patients were covered by Medicaid insurance compared with 22.0% of the general ED patient population. In the "COVID-19 Test" group, 2.2% of patients were admitted compared to 25% of the general ED population and 3.1% of patients had a return ED visit within 72 hours as compared to 0.9% in the general ED population. Use of the "COVID-19 Test" CC was highest in December 2021 and January 2022 (27.5% [88/320], and 35.6% [114/320]), respectively. The other eight months of the intervention had utilization that ranged from eight uses of the CC in March of 2022 to 25 uses in November 2021. This pattern corresponded to community rates of influenza-like illness, which surged in the winter of 2021-2022.

Approximately half (53.1%) of patients with a "COVID-19 Test" CC only received a PCR test for SARS-CoV-2 (COVID ONLY group), while the other 46.9% had PCR testing for SARS-CoV-2 plus additional ED interventions (COVID PLUS group). Within the COVID Plus group 74.7% (112/150) of patients had additional diagnostics and 70.7% (106/150) of patients were given additional therapeutics. Within therapeutics, 94.3% (100/106) of patients received at least one medication. Compared to the COVID PLUS group, the COVID ONLY group was significantly younger; more likely to identify as Black; more likely to identify as Hispanic or Latino, less likely to have Medicare; less likely to be admitted; less likely to have tested positive for COVID-19; less likely to have an abnormal vital sign; and more likely to have ESI scores of 4 or 5 (Table 1).

In the multivariable analysis, non-White patients or patients with Hispanic, Latino or Spanish ethnicity had 0.52 decreased odds of receiving additional interventions compared to White patients with non-Hispanic, Latino or Spanish ethnicity (95% confidence interval [CI] 0.29-0.93; P=0.03). Additionally, patients with Medicaid for insurance had 2.57 increased odds of receiving additional testing compared to privately insured patients (95% CI 1.08-3.98; P = 0.03). Patients who tested negative for COVID-19 had a statistically significant decreased odds of receiving additional interventions (adjusted odds ratio (aOR) 0.57; 95% CI 0.33-0.99; *P*=0.05) while controlling for other demographic and severity covariates (Table 2). Patients with an ESI of 1, 2 or 3 had significantly higher odds of receiving additional interventions compared to patients with an ESI of 4 or 5 (aOR 43.28; 95% CI 12.45-150.43; *P* <0.001) when controlling for age group, sex, race, ethnicity, insurance, and COVID-19 result.

DISCUSSION

This analysis uniquely evaluates the outcome of an operational intervention to identify patients presenting to the ED, reportedly, for the sole purpose of accessing COVID-19 testing. Post hoc analyses of operational improvement initiatives are critical in assessing impact and identifying unintended consequences. By embedding race and ethnicity in this process evaluation, our analysis aligns with the recently published quality framework to address racial and ethnic disparities in ED care.[6]

The "COVID-19 Test" CC did not consistently identify patients who would only need a SARS-CoV-2 PCR vs those whose presentation necessitated greater ED management, as nearly half of the patients assigned this CC received additional diagnostic evaluation or therapeutic interventions. Additionally, an ESI score 1, 2 or 3 and ≥1 abnormal vitals were present in approximately 1 of 4 patients, which suggests that many patients were determined by the treating clinician to require additional ED evaluation beyond COVID-19 testing based on triage ESI and vital signs. Given the ongoing national boarding crisis, expected seasonal resurgences in COVID-19, and seasonal influenza along with other infectious disease outbreaks, the ability to rapidly identify low-acuity patients presenting to the ED for infectious

Table 1. Description of patient demographic and clinical encounter variables overall and by COVID-19 lab only and additional intervention group, n (%).

	Overall (N=320)	COVID Only (n=170)	COVID Plus (n=150)	*P*-value*
Age (mean [SD])	30.5 (19.6)	25.3 (17.2)	36.5 (20.5)	<0.001
Age Group				<0.001
Pediatric (0-17)	84 (26.2)	59 (34.7)	25 (16.7)	
Adult (18-64)	214 (66.9)	107 (62.9)	107 (71.3)	
Older Adult (65+)	22 (6.9)	4 (2.4)	18 (12.0)	
Male	163 (47.1)	84 (49.4)	68 (45.3)	0.54
Race				0.01
American Indian or Alaska Native	9 (2.8)	6 (3.5)	3 (2.0)	
Asian	16 (5.0)	11 (6.5)	5 (3.3)	
Black	127 (39.7)	77 (45.3)	50 (33.3)	
Native Hawaiian or Pacific Islander	0 (0.0)	0 (0.0)	0 (0.0)	
White	161 (50.3)	70 (40.1)	91 (60.7)	
Patient declined to answer	7 (2.2)	6 (3.5)	2 (0.7)	
Patient Reported Ethnicity				0.02
Hispanic/Latino	33 (10.3)	24 (14.1)	9 (6.0)	
Not Hispanic or Latino	285 (89.1)	144 (84.7)	141 (94.0)	
Patient declined to answer	2 (0.6)	2 (1.2)	0 (0.0)	
Insurance Status				0.01
Commercial	107 (33.4)	64 (37.6)	43 (28.7)	
Medicaid	166 (51.9)	91 (53.5)	75 (50.0)	
Medicare	34 (10.6)	9 (5.3)	25 (16.7)	
Other coverage†	13 (4.1)	6 (3.5)	7 (4.7)	
Disposition				0.01
Admit	7 (2.2)	0 (0.0)	7 (4.7)	
Discharge	307 (95.9)	165 (97.1)	142 (94.7)	
Left before treatment complete	6 (1.9)	5 (2.9)	1 (0.7)	
COVID-19 Test Result				0.01
Positive	144 (45.0)	64 (37.6)	80 (53.3)	
Negative	176 (55.0)	106 (62.4)	70 (46.7)	
Emergency Severity Index				<0.001
1	0 (0.0)	0 (0.0)	0 (0.0)	
2	8 (2.5)	0 (0.0)	8 (5.3)	
3	68 (21.2)	3 (1.8)	65 (43.3)	
4	182 (56.9)	112 (65.9)	70 (46.7)	
5	62 (19.4)	55 (32.4)	7 (4.7)	
Any abnormal vital signs	87 (27.2)	37 (21.8)	50 (30.3)	0.03
Return ED visit within 72 hours	10 (3.1)	3 (1.8)	7 (4.7)	0.24

COVID-19, coronavirus 2019.
*Comparison of group that had COVID-19 test only vs. additional workup, using chi-square to test differences across categorical variables and *t*-test for differences in mean for age.
†Other coverage included self-pay, workers' compensation, and other insurance.

Table 2. Unadjusted and adjusted odds of receiving additional interventions by demographic and clinical encounter variables (n=313).

	Unadjusted Odds Ratio	Adjusted Odds Ratio	95% Confidence Interval; *P*- value
Age (years)			
<18	0.42*	0.63	0.33 - 1.29; 0.15
18 to 65	ref	ref	ref
≥65	4.50*	0.49	0.08 – 3.15; 0.45
Male	0.85	0.98	0.56 - 1.71; 0.94
Non-White race or LatinX ethnicity	0.36**	0.52*	0.29-0.93; 0.03
Insurance			
Commercial	ref	ref	ref
Medicaid	1.23	2.08*	1.08-3.98; 0.03
Medicare	4.13*	2.57	0.74 - 8.91; 0.14
Other Coverage	1..74	2.63	0.65 – 10.66; 0.18
COVID-19 negative	0.53	0.57*	0.33 – 0.99; 0.05
ESI Level			
1, 2 or 3	52.77**	43.28**	12.45 – 150.43; <0.001
4 or 5	ref	ref	ref

COVID-19, coronavirus 2019; *ESI,* Emergency Severity Index triage score.
**P* <0.05; ***P* <0.001

disease testing only will be an increasingly important operational goal. One important refinement to this operational intervention would be to do additional training of triage staff on optimal assignment and/or limiting its use only to patients with the lowest acuity triage scores (ESI 4 and 5).

The COVID-19 positive rate for the study population was over four-fold higher than the reported community positivity rates (45% vs 10%).[7] This implies that these patients did not view the ED as a simple alternative to testing at home or at another clinical site. Rather, sufficient barriers to using alternative testing sites exist for this group such that they generally present to the ED when they feel sufficiently ill or perceive a higher likelihood of COVID-19 (eg, close contact with confirmed infection). The high positivity rate indicates that anyone identified in triage as reportedly seeking only COVID-19 testing should be presumed positive until proven otherwise as it pertains to infection control measures. Thus, while the operational intervention failed to identify a low-acuity, low-resource-requiring patient subgroup, it did identify a group of patients at substantially greater risk for infection than the general population. Grouping patients into high, intermediate or low-risk groups has been suggested previously[8] and may still be a worthy outcome to pursue in future COVID-19 surges.

While there was a high positivity rate in this sample, over half of the patients (55%) tested negative for COVID-19. Among the patients who tested negative, three of five received no additional interventions. These findings do indicate that for some patients the ED may have served as a place to get COVID-19 testing. This suggests that there is utility in refining operational interventions such as this one to identify low-acuity patients.

Regarding the study's secondary objective, we observed differences in racial and ethnic demographics and care patterns in patients assigned the "COVID-19 Test" CC. Specifically, patients identifying as Black were represented in the study group at 3.5 times the general ED population. Patients with Medicaid insurance were represented twice as much in this study population compared to the general ED population. Such representation of Medicaid patients in our study population is in line with a recent Agency for Healthcare Research and Quality report noting higher rates of ED visits due to COVID-19 among poor or near-poor individuals.[9] This raises important concerns about barriers to reliable COVID-19 testing and non-ED care for both minoritized and low-income patient groups, for which there is substantial demographic overlap.[10] Our findings found a similar unequal availability of COVID-19 testing as described in New York City.[11] The disproportionate representation of Medicaid patients assigned this CC indicates a potential missed opportunity to improve access to on-demand COVID-19 testing in non-ED settings among this managed population.

Patients who identified as White were more likely to undergo additional diagnostic testing compared to non-White ethnicities. This is consistent with previous studies that have demonstrated disparities in ED testing and treatment in these groups including for acute pain management[12] and long bone fractures.[13] Additionally, the ESI score functioned as intended and drove additional interventions. Specifically, the COVID ONLY subgroup had only three patients (1.8%) assigned ESI 1, 2, or 3 compared to 73 patients (48.6%) in

the COVID PLUS group. Thus, any intentional or unintentional under-triage of minority and marginalized populations would substantially alter the access to clinical care and resources for this population.[14] Recent work by Essa et al observed cognitive bias in ESI score assignment across all levels of severity, which were most pronounced for lower acuity patients (ESI 3-5).[15] This marks a potential limitation for our study and underscores the need to consider de-biasing strategies when implementing new care pathways initiated in triage.

LIMITATIONS

This was a retrospective analysis, and it is possible that unmeasured variables might have contributed to our observations. Further, this project was conducted in a single healthcare system, and the results may not be generalizable to other settings. Finally, due to small sample sizes we were not able to compare outcomes between sites.

CONCLUSION

A retrospective analysis of patients assigned a "COVID-19 Test" chief concern demonstrated that these patients had a high COVID-19 positivity rate and often underwent additional ED interventions. Demographic differences between the overall ED population and those assigned the "COVID-19 Test" CC suggest patients from historically marginalized and low-income groups may more likely be classified under this CC and/or experience disproportionate barriers to accessing COVID-19 testing. Differential ED interventions for these groups also highlight the need for further consideration of disparities related to COVID-19 evaluation and treatment in the ED.

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Risk Factors for Hospital Admissions Among Emergency Department Patients: From Triage to Admission

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Introduction: Healthcare systems typically provide multiple channels to access acute inpatient care, with the emergency department (ED) as the main route of access. The ED faces multifaceted demand and supply challenges, which implicate resource allocation and patient flow. In this study we aimed to identify factors associated with hospital admissions among ED patients in a Singapore tertiary-care hospital.

Methods: Using a retrospective cohort study of all eligible visits to a Singapore ED between January 1–December 31, 2019, we conducted a multivariable, mixed-effect logistic regression model to study the factors associated with hospital admissions. The model accounted for patients' demographics; triage category; arrival mode; referral source; time of ED visit; discharge diagnosis; and ED occupancy levels.

Results: In 2019, there were 141,719 visits to the ED, with 42,238 (29.8%) of these visits resulting in hospital admissions. Factors associated with increased odds of hospital admissions included increasing age, being male, ethnicity (Malay vs Chinese), higher patient acuity, non-self-referred patients (vs self-referred), patient being conveyed by ambulances (vs walk-in), and category of disease. Our model demonstrated that the highest odds of inpatient admissions were attributed to the patient's acuity (highest vs lowest acuity: odds ratio [OR] 326, 95% confidence interval [CI] 292-363), followed by patients' age (70 and above vs 30 and below: OR 13.8, 95% CI 12.8-14.8). The ORs for all other factors with significantly increased odds of admissions were modest, ranging from 1.12-4.18. Although the ED occupancy levels at the hour of the patient's disposition decision, the hour of the ED visit, and the month of the ED visit were significantly associated with hospital admissions, changes in the probabilities of hospital admissions across the possible range of values of these factors were marginal.

Conclusion: Our study revealed several factors significantly associated with hospital admissions, with patient acuity and age as the most important factors. Moreover, emergency physicians' decisions to admit patients were clinically consistent and only marginally influenced by the degree of ED crowding. These findings offer invaluable insights into follow-up studies that will be crucial in shaping new policies or designing new interventions to enhance current preventive health or healthcare delivery systems to curtail the growth in inpatient-bed demand among ED patients over time. [West J Emerg Med. 2025;26(3)513–522.]

INTRODUCTION

Well-developed healthcare systems typically provide multiple channels to access acute inpatient care, with the emergency department (ED) as the main route of access.[1] The ED faces multifaceted demand and supply challenges, which implicate resource allocation, patient safety, and patient flow.[2]

Studies found that factors attributing to the increased demand for ED services include the ageing population and behavioural changes to healthcare services decisions.[3] Amidst global ED crowding, understanding the effect of ED and inpatient-bed occupancy rates on the rate of hospital admissions is vital, given their potential negative impact on patient outcomes and department functionality.[4-6]

Singapore is a rapidly ageing country with an increasing number of older adults in the last decade, and this trend is expected to persist in the next decade.[7] The ageing demographics contributed to a visible proportion of ED visits and increased the demand for many healthcare services.[8] Local public hospital EDs see a daily attendance ranging from 250-450 patients[9] attributed to factors such as free ambulance services,[10] a low triage rejection rate, and the public perception associating non-acute concerns with necessary specialist care.

Changi General Hospital (CGH) is a public, tertiary-care hospital located in the eastern part of Singapore, serving the regions with the highest proportion of older adults.[11,12] Its ED is also one of the busiest in the country, with at least 35% of 2019 having a high load of daily attendances of >400 patients. Over the last few years, while attendance at CGH ED observed a relatively consistent trend, the hospital admission rate among ED patients had increased from 22.6% in financial year (FY) 2012 to 30.2% in FY 2019. Research has shown that admission from the ED is dependent on several factors such as patient profile, acuity levels, diagnosis, and arrival patterns.[1,2] While much is known about the factors associated with hospital admissions in Western countries for specific groups of patients,[13-17] little is known about what affects admissions in a densely populated Asian country like Singapore, which faces the challenge of a swelling geriatric population. In this study, therefore, we aimed to identify the factors associated with hospital admissions in CGH. Considering the shift in the rate of hospital admission, it is imperative to understand and identify the factors associated with hospital admissions. These findings can offer insights that can potentially enhance the current healthcare systems in hospitals so that the demand for inpatient beds can be better managed in the future.

In this study we accounted for several factors that were less commonly explored in the existing literature, where reviews of the association with hospital admissions were mixed and inconclusive. In addition to patient demographics, ED diagnoses and arrival modes, we also studied the effect of ED occupancy levels and the timing of patient arrival at the ED.

Population Health Research Capsule

What do we already know about this issue?
Patient profiles and arrival traits affect emergency department (ED) admissions in Western countries, but the impact of ED patient volume is mixed.

What was the research question?
We sought to identify factors associated with hospital admissions among ED patients in Singapore.

What was the major finding of the study?
Hospital admissions via the ED (29.8% of all ED patients) were associated with increasing age and higher clinical acuity, but were marginally affected by ED patient volume.

How does this improve population health?
These findings could help shape policies and interventions to improve healthcare delivery systems and reduce inpatient bed demand among ED patients over time.

METHODS

Study Design, Setting and Participants

This was a retrospective study of visits that took place at the ED of CGH between January 1–December 31, 2019. We obtained data from the administrative databases of the hospital ED.

Data Sources and Variables

The outcome of the study, hospital admission, defined as the inpatient admission that follows an ED attendance, was obtained from the patient's discharge type. In our dataset, patients' discharge type was categorised into many categories (eg, treated and discharged, admitted to the ward, referred to general practitioners). Hospital admission was defined as an outcome if the ED patient was subsequently admitted to an inpatient ward (excluding short-stay units [SSU] in the hospital, where the SSU is a ward within the ED for observation of ED patients with specific clinical conditions and do not require inpatient admissions for up to 23 hours).

We identified independent variables from published studies and discussions with domain experts within the hospital. We included patient characteristics (age, sex, ethnicity), discharge diagnosis based on the International Classification of Diseases Revision 10 (ICD-10) codes, triage level based on acuity, arrival characteristics (mode of arrival, source of referral to the ED, hour of arrival, day of the week, and month of the year of ED visit), as well as ED occupancy level.

For this study we grouped patients by age as follows: ≤30 year of age; ≥71; and age groups of 10-year intervals between ages 31-70. (Results for a separate model where age was modelled non-lineary is presented in the appendix. The patients' sex was categorised as male or female, and ethnicity was categorised as Chinese, Malay, Indian, or other. The patients' mode of arrival to the ED was characterised

as walk-in or arrival by any type of ambulance. Patients could be referred to the ED by themselves (self-referral), intermediate and long-term care (ILTC) service professionals (eg, community hospitals, nursing homes), primary care physicians, government agencies (eg, police station or prison), or other. The patients' three-character ICD-10 codes were grouped into 10 broad ICD categories following the ICD-10 2019. [18] We extracted the 22 overarching categories from the ICD-10 and identified our hospital's nine most commonly diagnosed ICD-10 codes. The ICD-10 codes (apart from the nine identified) were grouped under "other" due to their lower frequencies. Acuity levels were categorised into P1, P2, and P3 where P1 represents the highest acuity for trauma patients with life-threatening conditions and P3 for patients with the lowest acuity, without urgent treatments or procedures required.[19] As there was no P4 acuity presented in the year of study, we excluded P4. We obtained ED arrival times by the hour, day of the week, and month of the year from patients' admission timestamps recorded when patients registered upon arrival.

The ED occupancy (or census) level was used as a representation of the degree of crowding in the ED. This variable represents the number of patients being cared in by the ED (inclusive of patients in the waiting room), also known as the number of patients in the ED at any time point in the study period, and it was derived using the respective times of arrival to discharge times of all patients. To understand the impact of the degree of crowding on admission decisions, the number of patients in the ED was matched to the hour of the emergency physician's final disposition decision regarding the patient (ie, to admit or discharge the patient) after reviewing relevant results. This variable serves as a proxy to gauge the ED occupancy level to perceive the crowded conditions on the floor.

Statistical Methods

We summarised characteristics of patients and their visits in our study population with mean and standard deviation or frequency with percentage for continuous and categorical variables, respectively. We conducted a comparison of these characteristics among these patients, with and without the outcome, using a two-sample *t*-test and chi-square test for continuous and categorical variables, respectively.

As patients could visit the ED more than once in 2019, we conducted a multivariable, mixed-effects logistic regression with random intercepts by patients to study the factors associated with urgent admission from the ED.[20] We fitted an unstructured covariance structure to account for the correlation between repeat patients in the dataset.[21] Candidate factors were identified from published studies and discussions with domain experts. We chose the final model presented in this study based on likelihood ratio tests.[22] Factors in the final model were either non-linear variables (ED occupancy levels, hour of admission to the ED, and the month of year) or categorical variables (all others).

We studied non-linear variables using restricted cubic splines (RCS) with a suitable number of knots placed at relevant quantiles, as recommended by Harrell.[22] For the month of arrival, we fitted a 3-knot RCS at the 10th, 50th, and 90th quantile of the data. For the ED occupancy levels and the hour of the day, we fitted a 4-knot RCS at the 5th, 35th, 65th, and 95th quantile of the data.[22] We assessed associations between the non-linear variables and the outcome using a likelihood ratio test of a model with and without the RCS. [22]

We present the odds ratio (OR) with a 95% confidence interval (CI) for the association between categorical variables with the outcome. Reference categories for variables were selected based on their descriptive distributions (choosing categories with the largest proportion for nominal data or those with the lowest likelihood of outcome for ordinal data) or based on clinical judgement (wherein clinicians identified the most appropriate reference category for comparisons). While RCS models are flexible and better suited for modelling non-linear data, the regression coefficients are hard to interpret. Therefore, for non-linear variables, we illustrated the relationship with the outcome by predicting the probability of hospital admission for each non-linear variable on an exemplar patient. The exemplar patient was defined based on values of each factor that had the highest proportion of hospital admission and was characterised by its 95% prediction intervals.

Statistical significance for this study was set at a 5% level. All data processing and statistical analysis were conducted in R version 4.1.1. (R Foundation for Statistical Computing, Vienna, Austria).[23] We used the packages lme4 [24] and rms [25] to build the mixed effect model and the model the restricted cubic splines respectively. The respective functions were glmer and rcs. To strengthen the report of our study, we adhered to the items in the STROBE statement checklist. [26]

Ethics Approval

This study was reviewed by the SingHealth Centralized Institutional Review Board, which determined that this study did not require further ethical deliberation because it was a service evaluation project aiming to study factors associated with hospital admissions from ED.

RESULTS

Participants

In 2019 there was a total of 144,136 visits from 99,700 patients. We excluded from the study 422 visits without discharge outcomes (0.3%), two with undefined sex (0.0%), and 1,975 (1.4%) with incomplete timestamps, resulting in 141,719 visits from 98,558 participants to analyze.

Outcome Data and Overall Descriptive Data

Amongst the 141,719 visits to the ED, 30% resulted in hospital admissions in 2019 (Table 1). Half of the visits were made by patients >50 years old, and a significantly higher

Table 1. Overall characteristics of patients and their visits included in the study.

		Hospital admission		
	Overall (N=141,719)	Yes (n=42,238, 29.8%)	No (n=99,481, 70.2%)	P-value[1]
Age (continuous), mean (SD)	49.3 (22.0)	64.1 (19.3)	43.0 (20.0)	<0.001
Age (categorical), N (%)				
≤30	38,219 (27%)	3,139 (7%)	35,080 (35%)	<0.001
31 to 40	19,615 (14%)	2,817 (7%)	16,798 (17%)	
41 to 50	15,823 (11%)	3,647 (9%)	12,176 (12%)	
51 to 60	19,759 (14%)	6,531 (15%)	13,228 (13%)	
61 to 70	19,745 (14%)	8,332 (20%)	11,413 (11%)	
≥71	28,558 (20%)	17,772 (42%)	10,786 (11%)	
Sex, N (%)				
Female	57,985 (41%)	18,511 (44%)	39,474 (40%)	<0.001
Male	83,734 (59%)	23,727 (56%)	60,007 (60%)	
Ethnicity, N (%)				
Chinese	74,344 (52%)	24,555 (58%)	49,789 (50%)	<0.001
Malay	30,469 (21%)	88,94 (21%)	21,575 (22%)	
Indian	16,634 (12%)	3,901 (9%)	12,733 (13%)	
Other	20,272 (14%)	4,888 (12%)	15,384 (15%)	
ICD-10 categories, N (%)				
Certain infectious and parasitic diseases	11,969 (8%)	2,980 (7%)	8,989 (9%)	<0.001
Diseases of the circulatory system	7,911 (6%)	5,481 (13%)	2,430 (2%)	
Diseases of the digestive system	8,305 (6%)	3,683 (9%)	4,622 (5%)	
Diseases of the genitourinary system	6,206 (4%)	2,144 (5%)	4,062 (4%)	
Diseases of the musculoskeletal system and connective tissue	13,468 (10%)	1,417 (3%)	12,051 (12%)	
Diseases of the respiratory system	15,179 (11%)	4,794 (11%)	10,385 (10%)	
Diseases of the skin and subcutaneous tissue	6,172 (4%)	2,550 (6%)	3,622 (4%)	
Injury, poisoning and certain other consequences of external causes	24,059 (17%)	2,838 (7%)	21,221 (21%)	
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	29,966 (21%)	10,635 (25%)	19,331 (19%)	
Others	18,484 (13%)	5,716 (14%)	12,768 (13%)	
Patient acuity, N (%)				
P1 (highest acuity)	18,823 (13%)	15,248 (36%)	3,575 (4%)	<0.001
P2	68,962 (49%)	26,133 (62%)	42,829 (43%)	
P3 (lowest acuity)	53,934 (38%)	857 (2%)	53,077 (53%)	
Mode of arrival, N (%)				
Walk-in	114,609 (81%)	24,970 (59%)	89,639 (90%)	<0.001
By ambulance	27,110 (19%)	17,268 (41%)	9,842 (10%)	
Source of referral, N (%)				
Self-referral	104,855 (74%)	30,090 (71%)	74,765 (75%)	<0.001
Primary care	28,806 (20%)	7,797 (18%)	21,009 (21%)	
ILTC[2]	1,993 (1%)	1,632 (4%)	361 (0%)	

[1]Comparisons between two groups were done using a chi-square test for categorical variables.
[2]Intermediate and long-term care (ILTC) providers (eg, community hospitals and nursing homes).
ILTC, intermediate and long-term care; *ICD-10,* International Classification of Diseases, 10th Rev.

Table 1. Continued.

		Hospital admission		
	Overall (N=141,719)	Yes (n=42,238, 29.8%)	No (n=99,481, 70.2%)	P-value[1]
Government agency[3]	4,673 (3%)	1,828 (4%)	2,845 (3%)	
Others	1,392 (1%)	891 (2%)	501 (1%)	
Arrival hour, N (%)				
07:00-12:00	46,077 (33%)	13,838 (33%)	32,239 (32%)	<0.001
13:00-21:00	67,617 (48%)	20,837 (49%)	46,780 (47%)	
22:00-06:00	28,025 (20%)	7,563 (18%)	20,462 (21%)	
Number of patients in the ED, mean (SD)	105 (39.1)	107 (39.1)	104 (39.1)	

[3]Government agency (e.g., police station or prison).
ED, emergency department; *SD,* standard deviation.

proportion of hospital admissions was seen in the older age groups; 59% of the patients were male, with a higher proportion of admission seen amongst males compared to females; and 52% of the patients were Chinese, followed by Malays (21%), other (14%), and Indian (12%). There was a higher proportion of Chinese who were admitted compared to those who were not. The largest proportion of ICD-10 diagnoses presented at the ED were symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified (21%). Furthermore, 49% of patients were classified as P2, and 38% as P3, while 81% of patients walked into the ED. There was a higher proportion of hospital admission amongst those arriving by ambulance. The proportion of visits on various days of the week was slightly higher on Mondays (17%) and Tuesdays (15%), and there was a similar proportion of visits across different months of the year (8-9%).

Main Results

The multivariable, logistic mixed-model results showed that older patients had increasing odds of hospital admissions (Table 2). Patients 31-40 year of age had 1.28 times (95% CI 1.19-1.38) while those ≥71 years of age had 13.8 times (95% CI 12.8-14.8) higher odds of hospital admissions as compared to patients <30. As compared to males, females had significantly lower odds of hospital admissions by 0.949 times (95% CI 0.914-0.986). We also found that Malays (OR 1.12, 95% CI 1.07-1.18) and other races (OR 1.19, 95% CI 1.12-1.26) had significantly higher odds of hospital admission compared to Chinese patients.

We observed that the days of the week did not affect the odds of hospital admission (compared to Wednesdays). Patients who arrived by ambulance had significantly higher odds of hospital admission by 1.64 times (95% CI 1.57-1.72) compared to those who walked into the ED. Patients who were referred to the ED by any form of referral source (government agency (OR 1.15, 95% CI 1.04-1.28), ILTC professionals (OR 1.79, 95% CI 1.50-2.12), primary care physicians (OR 1.85, 95% CI 1.76-1.94]), and others (OR 4.18, 95% CI 3.55-4.93]) also had significantly higher odds of hospital admission compared to self-referral. As compared to patients with the lowest acuity (P3), those with higher acuities had significantly higher odds of hospital admission. As compared to patients with diseases of the respiratory system, those with diseases of the circulatory system (OR 2.01, 95% CI 1.83-2.20), diseases of the digestive system (OR 2.17, 95 CI 1.98-2.37), and diseases of the skin and subcutaneous tissue (OR 2.14, 95% CI 1.94-2.36) had significantly higher odds of hospital admission, while those with diseases of the musculoskeletal system and connective tissue (OR 0.428, 95% CI 0.388-0.472), "injury, poisoning and certain other consequences of external causes" (OR 0.238; 95% CI 0.219-0.258), "symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified" (OR 0.866, 95% CI 0.806-0.93), and other ICD-10 categories (OR 0.729, 95% CI 0.674-0.789]) had significantly lower odds of hospital admission.

We studied the relationship between non-linear variables and hospital admission by illustrating the probability of hospital admission for an exemplary patient; we predicted the probabilities for the range of the variable in the dataset. Specifically, we predicted probabilities for a male, Chinese patient >70 years of age, who walked into the ED by himself. The patient presented with an acuity of P2 and was diagnosed with ICD-10 code "symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified." The patient came on a Monday in July at 10 AM when the number of patients in the ED was 100.

Figure 1 illustrates the relationship between the adjusted probability of hospital admission and the non-linear variables. At different ED occupancy levels (Figure 1A), the lowest probability of hospital admission (63%) was at levels of fewer than 48 ED patients in the ED. Between 48-174 patients in the ED, the probability of admission was around 65%, before increasing to 71% when the number of patients in the ED was above 174 (P = 0.04). At different hours of arrival to the ED (Figure 1B), the probability of hospital admission varied marginally over a range of 62-69%, with the highest probability of admission at 20 hours, and the lowest at 0 hours (P <0.05). At different months of the year (Figure 1C), there was a marginal increase from January to

Table 2. Odds ratio with 95% confidence intervals from mixed-effect, multivariable logistic regression[1] for factors associated with hospital admission.

Variables	Categories	OR [95% CI]	P-value
Age group (reference ≤30)	31 to 40	1.28 [1.19, 1.38]*	<0.01
	41 to 50	1.94 [1.81, 2.08]*	<0.01
	51 to 60	2.68 [2.51, 2.87]*	<0.01
	61 to 70	3.71 [3.47, 3.96]*	<0.01
	≥71	13.8 [12.8, 14.8]*	<0.01
Sex (reference male)	Female	0.949 [0.914, 0.986]*	<0.01
Ethnicity (reference Chinese)	Malay	1.12 [1.07, 1.18]*	<0.01
	Indian	0.958 [0.9, 1.02]	0.184
	Others	1.19 [1.12, 1.26]*	<0.01
Day of ED visit (reference Wednesday)	Monday	1.04 [0.972, 1.11]	0.261
	Tuesday	1.02 [0.954, 1.09]	0.569
	Thursday	0.956 [0.895, 1.02]	0.176
	Friday	0.978 [0.915, 1.05]	0.507
	Saturday	0.997 [0.927, 1.07]	0.945
	Sunday	1.03 [0.96, 1.11]	0.401
Arrival mode (reference walk-in)	By ambulance	1.64 [1.57, 1.72]*	<0.01
Source of referral (reference self-referral)	Government agency	1.15 [1.04, 1.28]*	<0.01
	ILTC	1.79 [1.5, 2.12]*	<0.01
	Primary care	1.85 [1.76, 1.94]*	<0.01
	Others	4.18 [3.55, 4.93]*	<0.01
Acuity [reference P3 (lowest acuity)]	P1 (Highest acuity)	326 [292, 363]*	<0.01
	P2	54.8 [50.2, 59.7]*	<0.01
CD-10 categories	Certain infectious and parasitic diseases	1.06 [0.972, 1.17]	0.176
(reference diseases of the respiratory system)	Diseases of the circulatory system	2.01 [1.83, 2.2]*	<0.01
	Diseases of the digestive system	2.17 [1.98, 2.37]*	<0.01
	Diseases of the genitourinary system	0.932 [0.843, 1.03]	0.164
	Diseases of the musculoskeletal system and connective tissue	0.428 [0.388, 0.472]*	<0.01
	Diseases of the skin and subcutaneous tissue	2.14 [1.94, 2.36]*	<0.01
	Injury, poisoning and certain other consequences of external causes	0.238 [0.219, 0.258]*	<0.01
	Others	0.866 [0.806, 0.93]*	<0.01
	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified	0.729 [0.674, 0.789]*	<0.01

[1]Multivariable mixed-effect logistic regression with random intercepts by patients and an unstructured covariance structure to account for the correlation beween repeated patients in the dataset.
CI, confidence interval; *ED,* emergency department; *ILTC,* intermediate and long-term care; *ICD-10,* International Classification of Diseases, 10th Rev.

December where the probability of hospital admission ranged from 66-71% (P <0.05).

DISCUSSION

Key Results

Our study identified several factors associated with higher odds of hospital admission. We found that older patients; males; Malay patients and those of other ethnicity (compared to Chinese); patients with diseases of the circulatory system, diseases of the digestive system, diseases of the skin and subcutaneous tissues (as compared to diseases of the respiratory system); higher acuity categories; non-self-referral (compared to self-referral); and arrival by ambulance (compared to walk-ins) had significantly higher odds of urgent admission.

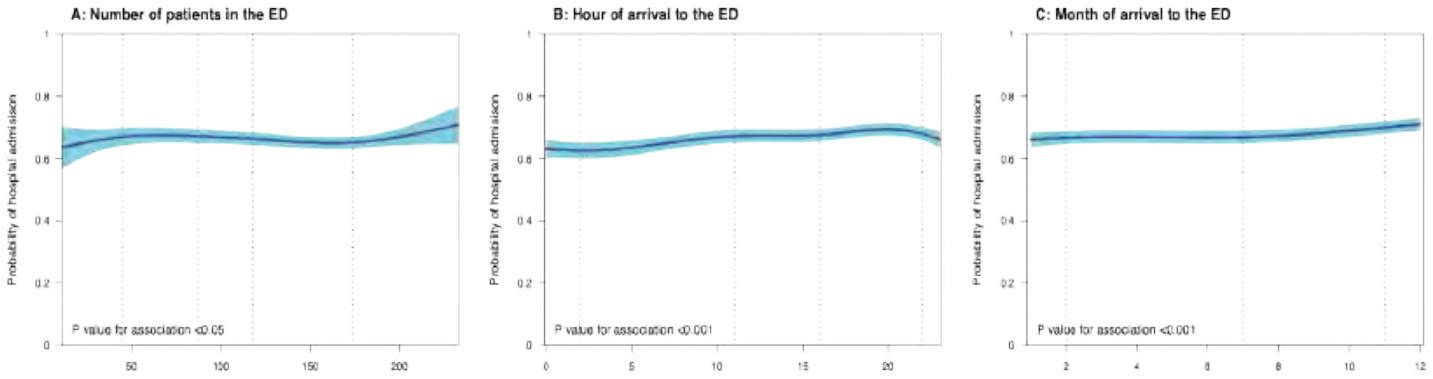

Figure. Probability of hospital admission for non-linear variables.
Predicted probability of hospital admission for an exemplary patient; a male, Chinese patient > 70 years of age, who walked into the ED by himself. The patient presented with an acuity of P2 and was diagnosed with ICD-10 code "Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified." The patient came on a Monday of the month of July at 10 AM when the number of patients in the ED was 100. The P-value for association was tested with a likelihood ratio test of a model with and without the spline function. Vertical dotted lines of each plot represent the knots placed at relevant quantiles, with 4 knots fitted at the 5th-, 35th, 65th, and 95th-quantile of the data for the ED occupancy levels and a 3 knots fitted at the 10th-, 50th- and 90th-quantile of the data for the hour of arrival to the ED and the month of arrival to the ED. The blue-shaded regions represent the 95% predicted intervals, and the P-value for the association tested with a likelihood ratio test.

Although the ED occupancy levels at the hour of the patient's disposition decision, hour of ED visit, and month of ED visit were significantly associated with hospital admission, the changes in the probability of hospital admission were marginal. A slightly higher probability of hospital admission was noted at a higher number of patients in the ED, post-evening hours, and at the end of the year.

Interpretation

We found that the factors affecting patient admissions were consistent with the findings of a larger study conducted across 19 EDs.[27] Older males with a higher number of comorbid conditions and patients presenting during the evening or night shifts were significantly more likely to be admitted. These factors were similar to the results of our study. Another study in the United States revealed that ED visits on a Monday were associated with a longer duration of ED length of stay (LOS).[28] The authors hypothesised that the nation's EDs might be experiencing a resource shortage on typical Mondays, whereby demand outweighs supply, contributing to longer ED stays. Using ED LOS as a proxy for the volume of ED patients, it was hypothesized that longer ED LOS and a higher patient load in the ED would result in higher odds of admission, particularly on a Monday.

Contrary to these findings, we found that the odds of admission were not influenced by the day of the week. This could be due to several admission-avoidance strategies, including the setup of a SSU ward in ED for observation (up to 23 hours) of ED patients who have specific clinical conditions and do not require inpatient admission; the practice of observational medicine[29] among ED staff; accessibility of primary care physicians even on weekends; and availability of fast-track specialist clinics for eligible ED patients. Additionally, the CGH ED uses a demand-driven optimal staffing approach to manage patient influx.[30] Specifically, the ED allocates more manpower on Mondays and Tuesdays compared to the rest of the week since the likelihood of recalling or activating off-duty personnel when unforeseen circumstances occur on Mondays and Tuesdays is higher. This maintains adequate staffing support in the ED to handle the patient load without compromising admission decisions.

We also found ED occupancy levels to be only marginally associated with admissions. We observed marginally higher odds of admission when a greater number of patients were present in the ED. One plausible rationale for this relationship is the indirect reflection of physician workload.[4] In a crowded ED, emergency clinicians face a heavier workload. Workup for safe discharge can be time-consuming and resource-intensive. Given these constraints, physicians might opt for a more conservative approach by admitting an ED patient whenever there is doubt about the patient's condition. A retrospective analysis by Wyatt et al provided differing perspectives as to how the non-clinical factors in their ED environment affected the rate of admission.[5] As the ED occupancy level increases, the staff-to-patient ratio decreases and the time taken to care for each patient in turn becomes longer. As the LOS of these patients extends, fortunately, they are still within the ED when the results of their diagnostic tests become available. This allows for a more comprehensive assessment of their condition, potentially leading to the conclusion that they are safe for discharge. Additionally, in some cases, the nature of their symptoms may spontaneously improve, reducing the need for hospitalization.

In a qualitative study conducted by Pope et al they interviewed ED and inpatient staff to identify other key factors

affecting hospital admissions among ED patients.[31] They found a significant influence on departmental culture and the personality of the physician in charge. These aspects set the risk appetite and create benchmarks for admission vs discharge decisions for the patients who present to the ED during a particular shift. Additionally, some physicians are more inclined to admit patients as a response to patients' preferences and expectations when there might not be clinical indications for doing so. Although such nuances are difficult to capture in quantitative studies, these findings underscore the complexity of the decision-making process in the ED, where physicians must balance patient expectations with adherence to clinical best practices when making hospital admission decisions.

Many studies have looked at the factors associated with hospital admissions focused on a specific group of patients with certain characteristics or medical conditions, with the proportions of admissions to hospitals from the ED general patient population not widely reported publicly in many countries.[13,14,16,32,33] However, amongst a few countries with such statistics, we saw that in 2021 it was reported that 13.1% of emergency visits in the United States resulted in hospital admission, a lower percentage compared to our study. [34] Despite the difference in proportion, the US researchers found that visits from older patients and those from nursing homes, or who arrived by ambulance and those with higher triage categories had higher percentages of admissions, similar to our findings. Another large study done in 1,375 EDs in the US reported admission rates varying from 9.8-25.8% and found that higher ED admission rates were linked with more Medicare or uninsured patients, more beds, lower ED volume, for-profit ownership, trauma center status, and higher occupancy rates.[35]

While the reasons driving these differences are complex, some of the possible reasons for discrepancies in hospital admission rates could arise from differences in healthcare systems. For example, the prerequisite that an ED visit in Denmark has to be initiated through a general practitioner's referral may potentially reduce the number of ED visits and subsequent hospital admissions.[36] Other contributing factors include variations in payment structures, such as subsidized fees or charges associated with emergency care services. Other possible reasons could also include admission criteria, patient population and demographics, and access to primary care, as well as public awareness and education regarding when to seek emergency advice.

Knowing the diseases, ethnicities, diseases and age groups with an increased chance of hospital admission can inform and tailor preventive health-related interventions to target specific populations in the region at the primary care level. Local initiatives that tap community-based clinicians to manage some acute conditions, empowering general practitioners (GP) and encouraging patients to follow up on chronic conditions with their primary care physicians have been useful in improving patient flow. Supplementing these initiatives can help curtail the rising inpatient bed demand in the future if conditions are managed at the community level. An example of such initiative is the GPFirst programme, introduced in CGH in 2014, where patients were given S$50 subsidies for their ED attendance if they were referred to the CGH ED by participating GPs.[37] This program encourages patients to visit their GPs first instead of going to the ED if their conditions are non-urgent or mild. Our analyses provide insights to direct the expansion of these programs by identifying the factors associated with increased hospital admission.

Strengths

There are several strengths to our study. Firstly, the sample size was large. This allowed the study team to focus on the effect size of the factors associated with the outcome as statistical significance was readily achieved. We obtained data from administrative databases that were not subjected to recall or observation bias, which we believe enhanced the quality of the study. We were, thus, able to control for several factors due to the quality of our administrative dataset. In this study, we reviewed less impactful factors such as ED occupancy levels at the hour of the patient's disposition decision, triage level, diagnosis, arrival mode, and referral sources.

LIMITATIONS

As a single-centre, retrospective study, our findings may not apply to other local hospitals serving a different patient demographic. We used data from 2019 before COVID-19 impacted and altered the systems and dynamics of healthcare services in hospitals. Future research from 2022 should be considered when the situation in EDs has stabilised from the impact of the pandemic. We used ICD-10 diagnoses according to the ED visit, which may differ at the point of inpatient discharge. Due to data limitations, we did not account for socioeconomic factors and behaviours associated with hospital admission[17]; nor were we able to explore how a physician's behaviour during the patient's deposition decision affects outcomes. Lastly, although there could be a possible interplay between hospital admission and inpatient units, which could be explored by looking at the inpatient bed occupancy rate (as discussed by Wyatt et al[5]), it was not feasible in this study to analyze this dynamic due to data constraints.

CONCLUSION

To the best of our knowledge, this is the first study in Singapore to identify factors associated with hospital admissions. We saw that the strongest association with hospital admission was patient acuity and age. Overall, emergency physicians' decisions to admit patients were clinically consistent and only marginally influenced by the degree of ED crowding. These findings offer invaluable insights into possible follow-up studies that will be crucial in shaping new policies or designing new interventions that aim to enhance preventive health or healthcare delivery systems,

so that the growth in demand for inpatient beds for ED patients can be curtailed over time.

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Case Study of How Alleviating "Pebbles in the Shoe" Improves Operations in the Emergency Department

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Objectives: Addressing minor yet significant frustrations, or "pebbles," in the workplace can reduce physician burnout, as noted by the American Medical Association. These "pebbles" are small workflow issues that are relatively easy to fix but can significantly improve the workday when resolved. This quality improvement project aimed to enhance clinician well-being in an emergency department (ED) affiliated with an academic institution through human-centered design by actively engaging clinicians to identify these "pebbles" and for a dedicated team to address them.

Methods: A task force comprised of three emergency physicians collaborating with emergency medicine leadership was established. After educating clinicians about "pebbles," clinicians were able to anonymously submit pebbles based on recall of frustrations in a baseline survey at the start of the project, as well as submit pebbles in real time by a QR code that was placed in easily noticeable areas. The task force met bimonthly to categorize, prioritize, and assign ownership of the pebbles. Progress was communicated to staff via a monthly "stop light" report. An anonymous survey assessed the impact on clinician well-being among 68 emergency clinicians within seven months of starting the project.

Results: Over seven months, 284 pebbles were submitted (approximately 40 per month). The feasibility of addressing pebbles was characterized by a color scale: green (easy to fix): 149 (53%); yellow (more complex): 111 (39%); and red (not feasible, "boulder"): 24 (8%). Categories of pebbles included the following: equipment/supply: 115 (40%); nursing/clinical: 86 (30%); process: 64 (23%); and information technology/technology: 19 (7%). A total of 214 pebbles (75%) were completed. Among 51 respondents (75% response rate), the self-reported impact on well-being of having pebbles addressed was as follows: extremely effective: 16 (31%); very effective: 25 (49%); moderately effective: 8 (16%); slightly effective: 2 (4%); and not effective 0 (0%).

Conclusion: In addition to improving personal resilience, improving well-being in the ED involves addressing efficiency of practice. This project highlights the positive impact of resolving small, feasible issues identified by clinicians, which resulted in 80% of respondents rating the project as very to extremely effective in improving their well-being. Most pebbles were related to equipment and easily fixed, while issues involving human interactions (eg, communications between consultants and EM) were more challenging. Regular meetings and accountability facilitated progress. This approach is replicable across medical specialties and practice settings, offering a low-cost method to enhance clinician work environments and well-being. [West J Emerg Med. 2025;26(3)523–527.]

INTRODUCTION

Physician burnout is one of the most discussed topics in emergency medicine (EM).[1–3] It can be exacerbated by the buildup of minor workflow problems. Small yet significant issues can create substantial inefficiencies, workforce dissatisfaction, and potentially lead to medical errors.[4] The American Medical Association mentioned in an editorial article that these "pebbles in the shoe" should be addressed to reduced burnout and promote organizational change.[5,6] In one example, leaders at Wisconsin's Marshfield Clinic Health System solved about 30% of their pebbles by systematically listening to team members and prioritizing issues based on feasibility and impact.

Much of a physician's well-being at work is rooted in the work environment.[7] Many studies have advocated for systems-level improvements, rather than just targeting the individual physician.[8, 9] The Stanford Model of Professional Fulfillment incorporates three different key drivers of professional fulfillment: culture of wellness; efficiency of practice; and personal resilience.[10] Culture of wellness involves leadership support, infrastructure, and resources to promote well-being. Efficiency of practice refers to systems that ensure quality, safety, and effectiveness, with physician involvement in redesigning inefficient processes being crucial.[11] Solving "pebbles in shoe" addresses both the culture of wellness and efficiency of practice. Addressing minor problems quickly can minimize burnout and increase efficiency.[5,10, 11]

Our objective was to allow clinicians to identify their operational frustrations at work and convey this information to the ED leaders that could fix them and to show the impact this project had on clinician well-being.

Population Health Research Capsule

What do we already know about this issue?
Minor workflow frustrations—what we define as "pebbles"—contribute significantly to physician burnout and inefficiencies in the ED.

What was the research question?
We aimed to evaluate how systematically addressing these minor workflow issues could enhance clinician well-being in an ED setting and reduce physician burnout.

What was the major finding of the study?
Of 284 "pebbles" submitted, 75% were resolved. Most were related to equipment and supply (40%). 80% of clinicians rated this project as very to extremely effective.

How does this improve population health?
This approach can indirectly enhance clinician well-being and workforce retention while increasing efficiency.

METHODS

Setting and Participants

The study was conducted in an academic emergency department (ED) at a tertiary care center with over 80,000 annual visits. Participants included 68 clinicians (32 attending physicians, 6 emergency medicine residents, and 30 advanced practice practitioners [APP]).

Intervention

A "pebbles task force" was formed, consisting of two lead emergency physicians; EM leadership, including the department chair; department administrator; nursing administrator; director of pediatric EM; and director of supply chain. The objective was to address minor workflow issues impacting clinician satisfaction. By streamlining information from frontline physicians and leadership, the process aimed to save time and create efficiency. A baseline pebbles survey was distributed to identify existing workplace frustrations, and a QR code system was implemented to collect real-time pebble submissions. QR codes labeled "real-time pebbles" were placed near computer workstations in easily noticeable areas so clinicians could easily scan them without having to search for them. Of note, clinicians had to scan the QR code on their own accord; they were not emailed or prompted to do so during their shift.

Study of the Interventions

We collected pebbles using Qualtrics software (Qualtrics International Inc, Provo, UT). The baseline pebble survey asked participants to recall minor frustrations encountered while working clinically. A prospective pebble survey, used in real time via QR code was sent to all attendings, APPs, and residents. It included three questions: "What frustrated you just now?"; "What area of the ED are you working in?"; and "What is your role?." Submissions were kept anonymous to allow for free expression of frustrations; however, there was a suggestion to include medical record numbers for clinical issues and/or the individual's name if they wanted to be contacted about this issue, as well as a prompt to escalate the issue in real time to the nurse manager or supply team.

Pebbles were entered into a database (REDCap hosted at http://openredcap.nyumc.org/) and categorized at the discretion of the task force in two ways: by type (eg, equipment/supply, IT/technology) and area of the ED (eg, critical care, peds ED) and by perceived feasibility based on the initial submission (green = easy to fix, ≤3 months; yellow = can be fixed but more complex and would take >3 months; red = cannot be fixed). Key stakeholders from the task force were assigned responsibility for follow-

up on each pebble based on suitability. For example, when clinicians mentioned needing otoscopes and ophthalmoscopes, the director of supply chain ordered and installed the equipment. For more complex issues, our department administrator or nursing manager would work with other departments or units but assume responsibility for reporting back to the task force on progress.

The pebbles task force met bimonthly to review submissions and prioritize based on feasibility and potential impact. Progress was communicated via a monthly "stop light" report, indicating the status of issues as green (completed), yellow (in process), or red (not feasible, "boulder"). Explanations for unfeasible items, such as regulatory issues preventing rapid strep swabs in certain areas, were also provided. " were made to complete the pebbles within three months.

If a pebble was submitted multiple times, a full review was conducted to determine why the problem was recurring. For example, for repeat supply issues, a new initiative, "Inventory Chat," was created to address broken or missing equipment through a messaging system on work iPhones, delivering real-time communication to inventory staff.

Outcome Measures

The primary outcome measures included the number and characteristics of pebbles submitted, the feasibility of addressing each pebble, and the self-reported impact on clinician well-being. The predicted feasibility of each pebble was categorized as green (easy to fix within three months), yellow (more complex and take >3 months to fix), or red (not feasible, "boulder"). A secondary outcome measure of well-being impact was assessed via an emailed anonymous survey after seven months that simply asked clinicians, "How effective is the "Pebbles in Shoe" project in improving your personal sense of wellbeing?" on a five-point Likert Scale.

Analysis

We conducted a quantitative analysis on the number and characteristics of pebble submissions, their completion rates, and feasibility. The impact on clinician well-being was assessed through qualitative analysis of responses from a single-question survey, focusing on the perceived effectiveness of the intervention in improving work conditions and reducing burnout.

RESULTS

Description of Pebble Submissions

Over the seven-month period, 284 pebbles were submitted, averaging approximately 40 submissions per month. The majority of pebbles, 74%, were submitted by physicians (residents and faculty), as compared to 26% by APPs. The distribution of types of pebbles across categories is shown in Table 1. The predicted feasibility of addressing the submitted pebbles is shown in Table 2, relative to all pebbles submitted.

Table 1. Distribution of pebble categories by frequency.

Pebble categories	Number of pebbles (%)
Equipment/Supply	115 (40%)
IT/Technology	19 (7%)
Nursing/Clinical	86 (30%)
Process	64 (23%)

IT, Information technology.

Table 2. Distribution of predicted pebble feasibility and progress of solving the problem.

Predicted feasibility of pebble problems	Number of ebbles (% of all pebbles)
Green (easy to fix)	149 (53%)
Yellow (more complex)	111 (39%)
Red (not feasible, "boulder")	24 (8%)

Overall, 214 pebbles (75%) were completed, indicating a high rate of feasible solutions within the identified issues. This high completion rate underscores the effectiveness of the task force in addressing and resolving minor workflow issues promptly. Figure 1 shows an example of a "traffic stoplight" report for the Winter Quarter that demonstrates the progress of the Pebbles Project to clinicians.

Impact on Well-being

An anonymous survey with a 75% response rate showed that 80% of clinicians rated the project as very to extremely effective in improving well-being. (See Table 3 for details.) Additionally, 80% of clinicians rated the project as very or extremely effective in improving well-being.

DISCUSSION

Summary

This project highlights the positive impact of resolving small, feasible issues identified by clinicians, which resulted in 80% of respondents rating the project as very to extremely effective in improving their well-being. The task force successfully addressed many minor issues; the most frequent "green" pebbles were related to equipment and supply, which were generally easier to resolve. For instance, a frustrating manual stapler was replaced with an electric one. Human interaction issues, like nursing/clinical problems, were categorized as being "yellow pebbles" and were more challenging but addressed effectively by our nursing leadership. For example, one of the first successful pebbles involved COVID-19 nasal swabs. After multiple submissions, the task force collaborated to shift this responsibility from clinicians to nursing staff. Several submissions also led to a shift-restructuring pilot to address inequities in patient distributions for clinician teams. While it is important to

Figure 1. "Pebbles in shoe" project traffic stoplight report Winter Quarter 2024.
CC, critical care; *ASU,* Ambulator Surgical Unit; *US,* ultrasound; IV, intravenous; *ED,* emergency department; *Ortho,* orthopedic; *FY,* fiscal year; *hCG,* human chorionic gonadotropin.

address the "green," easy-to-fix pebbles to keep clinicians engaged with the project by celebrating small wins, taking the time to fix the "yellow/red" pebbles was equally important, as they had a greater impact.

Interpretation

This project demonstrates that systematic, clinician-driven identification and resolution of workflow issues, or "pebbles," can enhance their clinical work environment and well-being. Engaging frontline staff gave clinicians a greater sense of autonomy, while collaboration between departmental leadership and ED stakeholders ensured success. The high completion rate underscores the effectiveness of the approach. Regular meetings and accountability were key to the project's success. The project has become so successful that "pebble" has become a verb in the department.

Comparison with Existing Literature

The findings align with existing literature emphasizing the importance of addressing everyday frustrations to reduce burnout. Previous literature has shown that reducing unnecessary stressors can significantly enhance job satisfaction and reduce turnover rates.[11-13] At Marshfield Clinic, a similar "pebble" initiative resulted in a 30% completion rate, while our sustained efforts led to a 75% completion rate.[6]

LIMITATIONS

This study was performed in a single center with a highly motivated team. Without dedicated individuals, replicating the project elsewhere may be challenging. Managing the databases, preparing reports, and tracking progress required significant effort. While the project fell within the existing budget, an estimated 0.1 FTE should be allocated to lead clinicians. While not a trivial cost, this financial investment has the potential to improve the work experience, thereby decreasing burnout and improving retention, as it is well known that replacing physicians is very costly. Reliance on self-reported data may introduce bias, and future studies should consider validated survey tools. Additionally, surveying well-being pre-/post-intervention may offer stronger evidence for this project to enhance clinician well-being. Expanding to other departments or multiple sites could help validate the findings.

CONCLUSION

Regularly addressing small workflow issues through clinician feedback can enhance work environments and well-being. This method is low cost and replicable across various medical settings, providing a practical approach to reducing physician burnout. It is already being incorporated into other departments within our hospital as well as a nearby affiliated emergency department.

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Epidemiology of 911 Calls for Opioid Overdose in Nogales, Arizona

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Objective: Drug overdose is the leading cause of unintentional death in the United States, and individuals identifying as BIPOC (Black, indigenous and people of color) and those of low socioeconomic status are over-represented in this statistic. The US-Mexico border faces several unique challenges when it comes to healthcare and the drug overdose crisis, due in large part to health inequities. Although the US Centers for Disease Control and Prevention recommends that overdose prevention programs address health inequities, little is known about opioid overdoses in this rural, primarily Spanish-speaking region. As emergency medical services (EMS) records collect countywide data, they represent a high-quality source for epidemiologic surveillance.

Methods: We conducted a retrospective chart review based on a local quality assurance program in which two years of EMS records were reviewed with the primary objective of characterizing patients receiving prehospital care for opioid overdoses in a rural, borderland community, and the secondary objective of characterizing EMS's fidelity to a naloxone distribution protocol. We included electronic patient care records for analysis if they included the EMS clinician's impression of overdose, opiate abuse, or opiate-related disorder from November 1, 2020–October 31,2022. The following data points were abstracted: date; patient initials/gender/age; police presence; response location; bystanders on scene; naloxone administration prior to EMS arrival; distribution of naloxone kit (yes/no); substance reported; and disposition. We analyzed descriptive statistics.

Results: A total of 74 cases met inclusion criteria over two years with the majority of cases involving men (82%) with a median age of 28. Almost half of overdoses occurred at private residences (46%), and slightly more than half (57%) reported fentanyl use prior to overdose. Family or friends were usually (64%) on scene, and law enforcement was often (77%) the first 911 to arrive. Naloxone was administered on scene in almost all cases (91%), usually by EMS (44%) or law enforcement (43%). The EMS clinicians distributed naloxone kits at 61% of calls.

Conclusion: Opioid overdoses along the US-Mexico border occurred primarily among young men using illicit fentanyl in private residences. Although family/friends were often present, they rarely administered naloxone. Law enforcement was often the first 911 responder to arrive. Emergency medical services is a suitable setting for naloxone distribution programs. [West J Emerg Med. 2025;26(3)528–534.]

INTRODUCTION

Although modern emergency medical services (EMS) systems were largely developed to respond to motor vehicle collisions (MVC), opioid overdoses have since surpassed MVCs as the leading cause of accidental death. Yet beyond protocols delineating how to reverse an acute opioid overdose with naloxone, many EMS agencies do not offer prevention or treatment for people who use opioids

chaotically. Fortunately, more and more agencies are beginning to initiate buprenorphine and offer a wide spectrum of harm reduction services.

Additionally, EMS is uniquely situated to reach a large population of people who use drugs. In one study of 218 individuals who died from unintentional opioid overdose, 30% had used EMS within the year preceding their death.[1] Furthermore, EMS may have been these patients' only point of contact with the healthcare system. One study demonstrated that approximately one third of patients who received prehospital naloxone subsequently refused transport to the emergency department (ED).[2,3] This trend is alarming, as this is a high-risk population with roughly 10% dying in the year following an overdose-reversal by EMS.[16] Emergency medical services is uniquely positioned to both gather uncaptured epidemiologic data about the opioid epidemic and provide effective prehospital interventions for chaotic opioid use.

One role for EMS in stemming the opioid epidemic includes opioid education and naloxone distribution (OEND), an intervention in which laypeople learn how to recognize an opioid overdose and administer naloxone and are given a naloxone kit. As 95% of people who could benefit from substance use disorder (SUD) treatment (buprenorphine or methadone) do not think they need it, ubiquitous naloxone distribution as a form of harm reduction is paramount.[4] Additionally, even people in recovery occasionally relapse.

As community nonprofits were the first organizations to implement OEND programs, they are the most studied, showing a reduction in overdose deaths and increased entry into treatment for opioid use disorder (OUD).[5,6] It is likely that these positive outcomes can be extrapolated to healthcare-based OEND programs if clinicians are willing to distribute the naloxone. Unfortunately, one ED OEND study showed that only 30.9% of eligible patient encounters resulted in naloxone provision, suggesting that there may be other barriers to consider in healthcare-based OEND initiatives.[7]

While the feasibility of prehospital naloxone distribution programs in urban communities[8] has been studied, little is known about unique rural populations such as those in the borderlands, where additional binational, social, and demographic challenges may affect persons with OUD and the EMS services that serve them. Our study setting, Nogales, AZ, is the largest city in Santa Cruz County and shares an international border with the larger city of Nogales, Sonora, Mexico. Nogales, AZ, has a population of almost 20,000 residents, with nearly 95% identifying as Hispanic/Latino, 90% speaking a language other than English at home, and 41.3% born abroad.[9] The median household income is $31,997, and 29.8% live below the poverty line.

Rural borderland communities face unique health inequities regarding risk for substance use disorder (SUD) and negative health outcomes, and they have less access to treatment. These communities have several of the characteristics listed by the US Centers for Disease Control and Prevention (CDC) as ones disproportionately affected by the drug overdose crisis: reduced economic stability; limited access to healthcare; limited access to SUD treatment; non-English speaking populations; rural density; and racial/ethnic minority groups.[10] Although the CDC recommends incorporating targeted prevention strategies that address key drivers of health inequities into overdose prevention programs, first we must better understand these communities. As EMS records collect countywide data, they represent a high-quality source for providing epidemiologic surveillance data[11,12] that can be used to create targeted prevention strategies.

Our fire department-based EMS agency developed a protocol in 2020 by which patients deemed at risk of opioid overdose could receive EMS-driven education around opioid use, information about addiction treatment facilities in the region, linkage to peer support, and a naloxone kit. As part of a quality assurance program, the medical director reviewed the electronic patient care records (ePCR) for all 911 overdose responses from 2020-2022 to better understand this patient population, identify issues with the protocol, and offer feedback to involved crew.

Our primary objective was to better describe the patients who are cared for by EMS in our rural, borderland community

Population Health Research Capsule

What do we already know about this issue?
The US-Mexico border faces unique challenges in the opioid epidemic. Although EMS reach a large population that uses drugs, few patients receive naloxone kits.

What was the research question?
In the borderlands, what is the epidemiology of patients whose overdose is reversed by EMS? Will EMS clinicians distribute layperson naloxone?

What was the major finding of the study?
Family or friends were usually (64%) on scene yet infrequently administered naloxone. Law enforcement was often (77%) the first 911 responder to arrive. EMS clinicians distributed naloxone kits during 61% of their calls for overdose.

How does this improve population health?
In rural, borderland communities, we should increase overdose recognition and reversal training to laypeople. Law enforcement involvement should be further studied. EMS is a suitable setting for naloxone distribution programs.

after a suspected opioid overdose to gain additional epidemiologic data that can subsequently be used to improve prehospital harm reduction and addiction treatment initiatives in this unique population. Our secondary objective was to characterize fidelity to the naloxone distribution component of our agency's prehospital protocol by calculating the percentage of eligible patients who received a take-home naloxone kit.

METHODS

Setting

There is one hospital in the city of Nogales and Santa Cruz County, AZ, and at the time of data collection it did not have buprenorphine on formulary or offer naloxone distribution. Similarly, there is only one opioid treatment program (OTP) offering methadone and buprenorphine, and one federally qualified health center that functions as an office-based opioid treatment (OBOT) program that offers buprenorphine for its patients. There are no harm reduction nonprofits based in the county, although a statewide nonprofit provides intermittent outreach. As of 2018, Arizona state regulations authorize law enforcement officers (LEO) to administer naloxone, and intranasal naloxone is carried by some trained LEOs.

At the time of data collection, 911 dispatch was provided by the Santa Cruz County Sheriff's Office, which did not use medical protocols or pre-arrival instructions such as those used by the Medical Priority Dispatch System. When someone calls 911 for an overdose, law enforcement is often dispatched along with fire/EMS. The Nogales Fire Department (NFD) is the exclusive 911 EMS provider for the city, with an annual call volume of 3,678 in 2021. All firefighters are certified as either an emergency medical technician or a paramedic.

In September 2020, all EMS personnel at the NFD received 2.0 hours of continuing education on OUD, naloxone/harm reduction, medications for OUD, community referrals, and their OEND protocol. The training included virtual and in-person components taught by their EMS medical director who is board-certified in both EMS and addiction medicine, the local OTP, OBOT professionals, and a peer support specialist (PSS). Medical director involvement and in-person elements were designed to convey the clinical value of such an intervention and foster community-wide, interdisciplinary collaboration across the healthcare system.

In October 2020, the OEND protocol was initiated. Those eligible for the OEND protocol (Figure) included any person at risk of an opioid overdose and bystander witnesses of an overdose. The EMS clinicians provided a naloxone kit (intramuscular or intranasal), taught participants how to recognize an overdose and administer naloxone, and explained local treatment options. If EMS clinicians administered naloxone for an acute overdose, they were instructed to call HOPE, Inc, a nonprofit that provides outpatient treatment for mental illness and SUD, for a warm handoff by a PSS. Although the PSS worked traditional office hours, they had a HIPAA-compliant voicemail. To increase the likelihood of a patient being linked to a PSS, the call was an opt-out process. If it were opt in, patients who were unable to have a significant conversation due to sedation or precipitated to withdrawal might be less likely to receive this linkage to care. Even patients transported to an ED were supposed to be linked to PSS, as they provide additional services not found in most EDs.

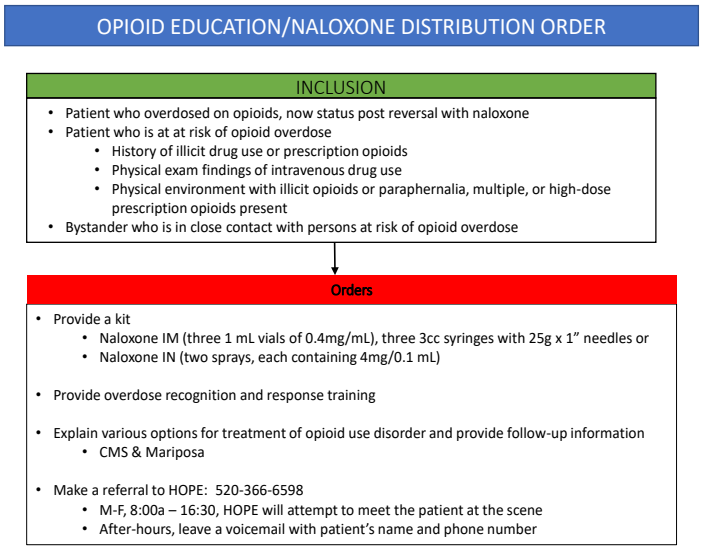

Figure. Opioid education and naloxone distribution protocol. *CMS, Community Medical Services; IM*, intramuscular; *IN*, intranasal; *IVDU*, intravenous drug use; *Mariposa*, Mariposa Community Health Center; *s/p*, status post.

Selection of Participants and Outcomes

The prehospital coordinator queried all NFD ePCRs to find patients treated by NFD with a primary or secondary impression from the prehospital clinician of "overdose," "opiate abuse," or "opiate related disorder" from November 1, 2020–October 31, 2022 with the objective of identifying all charts related to a non-fatal opioid overdose, as these are the most high-risk patients among those with chaotic opioid use. All included ePCRs were then reviewed by the EMS medical director who placed the following data in a spreadsheet: date of call; patient initials; patient gender; patient age; police presence on scene; location of the overdose/response; type of bystanders on scene (if any); naloxone administration prior to EMS arrival and by whom; whether a naloxone kit was left with the patient; substance used (per patient/bystander report or response to naloxone administration); and patient disposition. Much of this information was obtained from the narrative section of the ePCR.

In some cases, patients denied drug use or declined to state what they had used. In those cases, the spO_2, respiratory rate, Glasgow Coma Scale, and the ePCR narrative were reviewed by the medical director to look for signs of opioid

exposure, such as a clinical response to naloxone (nausea/vomiting or increased GCS, RR, SpO_2), the presence of drug paraphernalia such as the presence of the foil/lighter used to smoke fentanyl, or history/signs of drug use (such as track marks). Records were excluded if the medical director determined they were not likely related to illicit drug ingestion (for example, an acetaminophen overdose as a suicide attempt would be excluded) or if they were pronounced dead on scene (such as a cardiac arrest). Each week, the medical director sent specific feedback to the involved crew for quality assurance. To evaluate our secondary objective of characterizing the fidelity to the naloxone distribution component of the protocol, we calculated the rate of naloxone distribution among our included ePCRs.

We extracted data from the ePCR as noted above and entered it into an Excel spreadsheet v16.71 (Microsoft Corporation, Redmond, WA). Fentanyl use was classified through subject or EMS clinicians noting use of fentanyl or M30, the street name for illicitly fabricated fentanyl pills in the area. Subject drug use was classified as non-fentanyl opioids if the subject or EMS clinicians noted use of a different opioid or if paraphernalia of IV heroin use were found on scene; and drug use was classified as unknown if subjects denied using opioids or endorsed using non-opioid illicit substances but had a clinical response to naloxone. Location of EMS call was classified as residential; commercial if at a business; public if in a parking lot or at a public facility such as a park; vehicle if called to a parked vehicle; at a healthcare facility if at a community health center such as a pharmacy; or in custody if the subject was in custody of the Nogales Police Department, Department of Corrections, or detained by US Customs and Border Protection.

Analysis

We performed statistical analysis using Stata statistical software version 16.1 (StataCorp, College Station, TX). Subject characteristics are reported with descriptive statistics presented as medians with measures of dispersion for continuous variables and proportions for categorical data. We compared the incidence of leave-behind naloxone administration among groups using relative risk (RR) and 95% confidence intervals (CI) calculated using the Fisher exact test. The study received human subjects review exemption from the institutional review board of the University of Arizona Human Subjects Protection Program.

RESULTS

Of 82 records with the target primary/secondary impressions, 74 records met inclusion criteria. The median age of patients was 28 (interquartile range 22-35), and 13 (18%) were female. The majority (57%) reported the use of fentanyl prior to their overdose, 12% endorsed using a non-fentanyl opioid, and 31% used unknown substances or denied substance use (Table 1).

Overdoses most commonly occurred at a private residence (46%) with family members or friends on scene 64% of the time calling 911 (Table 2). Law enforcement officers were frequently the first dispatched responder on scene, representing 77% of study cases. In almost all (91%) of the recorded EMS calls, patients were administered naloxone for suspected overdose reversal. Of those receiving naloxone, 12 (18%) were administered naloxone by multiple parties, whether bystanders, LEOS, or EMS. The median number of naloxone doses was two (range 0-10), with 31% of patients requiring only a single dose. When naloxone was administered, it was administered primarily by EMS (44%) and LEOs (43%), including Nogales Police Department, Department of Corrections, or Customs and Border Protection, and by family/bystanders in 10% of cases. In our study, 19% of patients refused subsequent transport to the ED, which is consistent with refusal rates observed in the literature.[3] Leave-behind naloxone was provided in 61% of overdose calls, including those in which naloxone was not administered in the field.

Subjects who refused EMS transport to the hospital were 1.74 (RR) times as likely to receive leave-behind naloxone from EMS as those who were transported to the hospital (95% CI 1.32-2.3). Subjects who had family or friends on scene

Table 1. Demographics of emergency medical services calls with primary or secondary impression of opioid overdose in Nogales, Arizona, October 2021-2022.

Variable	No (%)
Age, median (IQR), y	28 (22-35)
Gender	
Female	13 (17.6)
Male	61 (82.4)
Opioid	
Fentanyl	42 (56.8)
Other opioid	9 (12.2)
Unknown	23 (31)
Law enforcement presence on scene	
Yes	57 (77)
No	17 (23)
Naloxone administration	
Yes	67 (90.5)
No	7 (9.5)
EMS disposition	
Hospital transport	60 (81.1)
Transport refusal	14 (18.9)
Naloxone kit distributed	
Yes	45 (60.8)
No	29 (39.2)

IQR, interquartile range.

Table 2. Scene characteristics and by whom naloxone was administered on scene for emergency medical services calls with primary or secondary impression of opioid overdose in Nogales, AZ, October 2021-2022.

Variable	No (%)
Primary bystander on scene at EMS arrival	
Family/significant other	37 (50)
Law enforcement	15 (20.3)
Friend	10 (13.5)
Employee of business	2 (2.7)
Unknown	6 (8.1)
Healthcare worker	1 (1.3)
None	3 (4.1)
Overdose location	
Private residence	34 (46)
Private vehicle	10 (13.5)
In custody	12 (16.2)
Public	8 (10.8)
Commercial	7 (9.5)
Healthcare facility	3 (4)
Naloxone administration	
EMS	35 (44.3)
NPD	31 (39.2)
Family	8 (10.1)
CBP	1 (1.3)
Department of Corrections	2 (2.5)
Self	1 (1.3)
Healthcare worker	1 (1.3)

EMS, emergency nedical services; NPD, Nogales Police Department; *CBP*, Customs and Border Protection.

with EMS were 2.29 times as likely to be given leave-behind naloxone as those who did not (95% CI 1.31-3.40).

DISCUSSION

The patients in our study frequently used at home around family, yet family and friends administered naloxone at relatively low rates compared to professionals who arrived later. This highlights the importance of training family members regarding overdose recognition/reversal and providing them with naloxone to prevent future overdose deaths. Additionally, we found that patients who were not transported to the emergency department following overdose were almost twice as likely to receive a leave-behind naloxone kit, which illustrates the impact that prehospital clinicians may have on patients who do not interact with the healthcare system further. To address these needs, the NFD has become an active member of a countywide substance use consortium and increased its community outreach, with large placards outside the fire stations highlighting that they are Safe Stations; radio advertisements welcoming people to pick up free naloxone; and tabling at overdose prevention events. In positioning itself as a key player in combating the opioid epidemic in the community, NFD aims to reduce the stigma that many persons who use drugs (PWUD) face when accessing healthcare and enhance the trust between them and EMS. This is especially important given the number of patients that decline transport after high-risk overdose events. Further studies could evaluate family and friends' beliefs and behaviors around layperson naloxone in rural, borderland communities like ours.

Our study also showed that LEOs often arrived on scene before EMS and played a substantial role in overdose recognition and naloxone administration in our community. To better understand the clinical significance of law enforcement's actions, it would be useful to know just how much sooner they arrived. If it were several minutes, it would suggest that LEOs should receive enhanced training on the medical model of substance use, harm reduction, and overdose recognition/reversal. However, if it were less than a minute, perhaps the automatic dual dispatch to overdose calls should be reconsidered, as one minute may not confer enough clinical benefit to justify the cost of the increased trainings and law enforcement response. Instead, perhaps a community's financial resources would be better spent on training bystanders.

Additionally, removing law enforcement from overdose calls might reduce existing anxieties of PWUD about calling 911, especially in a region where citizenship and residency concerns are also prevalent.[14] Although many states have tried to reduce this barrier by implementing Good Samaritan laws that provide limited criminal immunity to people who request help for an overdose, their effectiveness has been mixed.[14] As their specific provisions vary by state, some offer more protections than others and many PWUD are still hesitant to call 911. This is unfortunate, as EMS can both save a life from a specific overdose event and potentially offer education, harm reduction, treatment, and further linkage to care.[15]

Future initiatives could include expanding the role of EMS in harm reduction for opioid overdoses, such as the distribution of fentanyl and xylazine test strips and safe use supplies, staffing overdose prevention centers, referral to harm reduction specialists, the use of alternate destinations to overdose prevention centers, and expanding the role of EMS in addiction treatment with buprenorphine induction and the use of alternate destinations to opioid treatment programs. Future prehospital addiction research should evaluate what interventions interest prehospital patients (perhaps patients who have suffered a prehospital overdose are more interested in SUD treatment than the 5% identified by the National Survey on Drug Use and Health among the general using population)[5] and the short- and long-term outcomes of patients who received EMS intervention and/or referral for suspected OUD.

Our findings also suggests that EMS can be a suitable environment for naloxone distribution programs, as 61% of our system's overdose calls resulted in the provision of naloxone. Compared to the ED-based study[7] in which only 30.9% of eligible patients received a naloxone kit, this seems like a success. Although we hoped this number would be closer to 100%, there were some situations that made naloxone distribution difficult. For example, for the four patients who experienced an overdose while in the county detention facility/jail, it was not clear whether EMS could leave naloxone with them, and so they did not. Further research could evaluate EMS clinicians perspectives regarding OEND programs; training elements that increase fidelity to OEND protocols; whether EMS-based OEND programs shift EMS clinician opinions about PWUD and overdose calls, and whether fidelity to an OEND protocol decreases as the time from training increases.

LIMITATIONS

This study has several limitations. This was a descriptive, retrospective study with a small sample size. It is possible that some patients who experienced an opioid overdose were missed due to a different impression documented by the EMS clinician, although due to education provided, this number is likely to be very small. Additionally, not all patients who received the primary/secondary impression of "overdose" actually experienced an overdose; that is, not all had respiratory or central nervous system depression to the extent that they required naloxone. However, all included patients did experience some history or symptoms suggestive of opioid ingestion.

Additionally, there was variability in the manner in which EMS clinicians classified locations and bystanders within the ePCR, as this was not a prospective study with explicit training on classification; much of this information was found within the narrative. Similarly, there may have been bystanders present on scene, but if they were not mentioned in the ePCR narrative, this would not have been captured. Intoxicant drugs were not tested to confirm the underlying substance, and there may be inaccuracies in subject reporting of what was used. Finally, this information may not be generalizable to all rural communities in the borderlands, as Tucson and the University of Arizona are nearby and support several social service programs in the area. Although our department was able to receive free training and naloxone, cost may be more of a barrier for other agencies.

CONCLUSION

In this rural community along the US-Mexico border, opioid overdoses occurred primarily among young men using illicit fentanyl in private residences. Even though family was often present, they rarely administered naloxone. In our community, law enforcement officers often arrived first on scene and played a substantial role in overdose recognition and reversal. With 61% of eligible patients receiving naloxone kits from EMS, the prehospital setting is well suited for such an opioid education and naloxone distribution protocol.

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Development and Evaluation of a Novel Curriculum for Whole Blood Transfusion by Paramedics in the Prehospital Environment

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Introduction: Resuscitation with low-titer O+ whole blood improves the outcomes of patients with hemorrhagic shock. Recently, some emergency medical services (EMS) agencies have started to carry blood in the field. However, there exists no standardized training program to teach paramedics the fundamentals of blood administration. This study describes one EMS system's experience with implementing a novel, whole blood educational curriculum.

Methods: We used Kern's six-step framework to develop a novel curriculum to provide paramedics the requisite knowledge to safely administer blood in the field. The course included an asynchronous component as well as an in-person, skills competency verification. The asynchronous portion was open to any paramedic, but only paramedic supervisors were eligible for the in-person skills check as they are the ones tasked with administering blood in the field. The course was evaluated through survey and performance outcome measurements.

Results: Fifty-three (26.5%) of 200 total paramedics at a combined career and volunteer fire department enrolled in the asynchronous course, and 31 (58.5%) completed the pre- and post-course survey. Of participating paramedic supervisors, 20 of 20 (100%) finished both portions of the course. Survey answers were based on a 5-point Likert scale. We reported results as a mean, with 5 corresponding to "strongly comfortable" or "strongly agree." There was a statistically significant increase in the number of respondents who felt overall comfortable in administering blood from 3.51 to 4.16 (P = 0.003). Additionally, there was an increase in the number of paramedics who reported feeling comfortable performing the procedure of a blood transfusion from 3.11 to 4.13 (P = <0.001). Nearly all participants (30/31) would recommend the course to someone else. In the first three months of carrying blood in the field, there were 12 units of blood transfused and no protocol deviations or safety events.

Conclusion: This study provides a model for the successful creation and implementation of a prehospital blood transfusion educational program using Kern's framework. The curriculum was implemented in a single EMS system with senior paramedics, which may limit generalizability. [West J Emerg Med. 2025;26(3)535–540.]

INTRODUCTION

Early resuscitation of hemorrhagic shock with blood products improves patient outcomes.[1-6] In 2017, two Texas emergency medical service (EMS) agencies became the first civilian ground EMS systems in the United States to carry low-titer O+ whole blood (LTO+WB).[7] The success of these

programs and others across the country demonstrated the value of a prehospital whole blood program.[8] As of August 2023, there are over 112 active ground-based EMS whole blood programs.[9]

Emergency medical services clinicians are trained to recognize hemorrhagic shock and initiate life-saving measures, such as a tourniquet or wound packing.[10,11] Blood administration, however, is not currently a mandatory topic in initial paramedic training.[10] As paramedics are increasingly tasked with transfusing blood in the field, there is a need for standardized supplementary training to ensure competency in initiating a blood transfusion and managing potential complications.

In September 2023 the Howard County Department of Fire and Rescue Services (HCDFRS) became Maryland's first EMS ground agency to carry LTO+WB. In this paper, we describe the development of a curriculum to teach paramedics the key components of prehospital whole blood transfusion. Our goal was to provide a framework for other EMS agencies that are creating a whole blood education program.

METHODS

Study Design

This is a descriptive study of the curriculum development process and a retrospective review of survey data obtained from course participants as a part of evaluation and feedback. The Johns Hopkins University School of Medicine Institutional Review Board approved this study as exempt research.

Study Setting and Population

We conducted this study at HCDFRS in Howard County, Maryland. The department responds to over 30,000 calls annually and has approximately 200 paramedics. At any given time, three medical duty officers (MDO) are stationed in the county. The MDO is an experienced paramedic with at least five years of EMS experience, including a minimum of two years as an Advanced Life Support (ALS) responder. An MDO is dispatched to all high-acuity calls and provides advanced capabilities such as rapid sequence intubation and whole blood administration. A minimum of one unit of LTO+WB is carried in each MDO vehicle. There are 20 MDOs in the department, all of whom were required to take the blood administration training course.

Curriculum development

The HCDFRS LTO+WB curriculum was created in part as a capstone project for the EMS Educator's Collaborative, sponsored by the National Association of EMS Physicians and the National Association of EMS Educators. We used Kern's six-step framework for this project.

I. *Problem identification and general needs assessment*

No ground EMS service in the state of Maryland was carrying blood products at the time that the HCDFRS whole blood program was created; therefore, no educational programs existed that incorporated the specifics of the Maryland state protocol and unique challenges of ground EMS. Thus, there was an essential need to develop a novel curriculum to ensure HCDFRS paramedics could transfuse blood safely and appropriately to patients in hemorrhagic shock.

II. *Targeted needs assessment*

Knowledge of blood transfusion complications and maintaining a blood transfusion are expected competencies in the 2021 National EMS Education Standards and the 2019 National EMS Scope of Practice, respectively.[10,11] However, neither document refers to initiating a blood transfusion. Knowledge of the indications and contraindications for LTO+WB is essential and is not routinely covered in the paramedic curriculum. Additionally, the MDOs in our study averaged a decade since initial paramedic schooling and had no bedside experience in blood transfusion. A literature review revealed only one publicly available comprehensive training curriculum whose target audience included paramedics. This program, created by the Trauma Hemostasis and Oxygenation Research Network, provides an excellent overview but does not provide the depth of content necessary to cover all objectives nor does it address the nuances of specific state and departmental protocols.[12] Thus, the creation of a robust training program, novel due to its focus specifically on prehospital care, was necessary.

III. *Goals and objectives*

The goal of the curriculum was for paramedics to demonstrate the key components of prehospital blood transfusion and possess competency in the requisite knowledge to administer blood to a critically ill patient in the prehospital environment. We created objectives using Bloom's taxonomy framework (Table 1). Consensus on the goals and objectives was obtained from board-certified EMS physicians at HCDFRS, departmental leadership, professional paramedic educators, and the Maryland State EMS medical director.

IV. *Educational strategies*

To ensure flexibility and maximize efficiency, a portion of the curriculum was delivered asynchronously using the department's online learning management system. Competency was assessed during an in-person skills check.

V. *Implementation*

Two EMS physicians (EG, ML), a doctorate-prepared EMS educator (RM), and a HCDFRS EMS captain (EC), created nine, narrated PowerPoint modules spanning 134 minutes (Table 1). Each module contained a brief formative assessment to ensure understanding. The in-person component included a review of the asynchronous content followed by a skills check. This was scheduled for three hours with a group of up to 10 learners (Table 1). The EMS physicians and an EC performed the review and skill checks. Completion of the online portion was required before attending the in-person session.

Development of the course, plus implementation of the asynchronous content, required approximately 80 hours of

work. Half of this time was from EMS physicians, and the other half was from EMS educators. Four in-person were held, each of which were three hours in length. The in-person classes included a physician and EMS educator. Although exact numbers are difficult to obtain and costs will vary substantially between departments, we estimate the total cost for HCDFRS of designing, implementing, and executing this program was ≈$14,960.

V1. *Evaluation*

Before- and after-surveys were distributed to assess reaction level data. Program effectiveness is measured at the behavior and outcome levels through review of every blood administration in the field. Protocol compliance and patient outcomes are determined for each blood transfusion event through 100% case review by an EMS physician medical director. This review includes a debrief with the treating paramedic within 24 hours of the call, review of the prehospital patient care report, and chart review of the hospital course.

Semi-annually a report is generated to identify any patients who met vital sign criteria for blood. Review of the narratives by the EMS physician medical director is performed to determine whether any patient was a candidate for blood but was not transfused.

All protocol deviations and patient complications are

Table 1. Objectives of course in prehospital whole blood transfusion.

Course Objectives by Module
I. Module 1 *(Introduction and Blood Physiology, 35 minutes)*
a. Review the research on the need for whole blood in the prehospital setting
b. Review data of EMS agencies that are currently using whole blood
c. Explain blood type and Rh factor physiology
d. Explain the components of low-titer O+ (LTO+) whole blood (WB)
e. Explain the importance of prehospital blood transfusion
II. Module 2 *(Management of the Severely Injured Trauma Patient, 22 minutes)*
a. Compare how management of the trauma patient has changed from the 1990s to today
b. Explain the lethal diamond and the role that LTO+WB has in this patient
c. Review the Multiple Severe Trauma Protocol
d. Review the use of air transport and when it should be activated
III. Module 3 *(Indications and Protocol, 22 minutes)*
a. List the indications for administration of LTO+WB
b. List the contraindications for administration of LTO+WB
c. Explain shock index and demonstrate how to calculate it
d. Explain the management of a patient who is having a transfusion reaction
IV. Module 4 *(Blood Transfusion in the Medical Patient, 8 minutes)*
a. Review situation in which medical patients may benefit from blood
b. Discuss risk factors that can increase the likelihood of developing hemorrhagic shock
V. Module 5 *(Management of the Patient Receiving Blood, 12 minutes)*
a. Explain the safety profile for the use of whole blood in the field
b. Describe the set-up that is needed for the administration of LTO+WB
c. Understand the importance of administration of tranexamic acid and calcium when their administration is appropriate
VI. Module 6 *(Ethical Considerations and Consent, 4 minutes)*
a. Review the consent process, including implied consent
b. Discuss patients who may refuse to receive blood products
VII. Module 7 *(Special Populations, 8 minutes)*
a. Discuss blood transfusion in pediatrics and women of childbearing age
b. Review management of postpartum hemorrhage
VIII. Module 8 *(Cold Chain and Administration, 15 minutes)*
a. Review the equipment needed for cold-chain storage
b. Review the cold-chain storage workflow
IX. Module 9 *(Review, 8 minutes)*
a. Review key components of whole blood administration in the field
X. In Person Skills Check *(2 hours)*
a. Demonstrate the process of administering blood
b. Assess situations where blood transfusion is appropriate
c. Manage a patient with a transfusion reaction
d. Obtain consent from a patient

EMS, emergency medical services.; *LTO+WB*, low-titer O+ whole blood.

documented and handled per departmental policy. All calls involving the use of blood are reviewed during a monthly MDO meeting. The session is led by an EMS physician medical director with input from the MDO who administered the blood.

RESULTS

The online course was available to all HCDFRS paramedics and mandatory for MDOs. Fifty-three paramedics enrolled in the online course, including the pre-course survey. Thirty-one completed the post-course survey, which was embedded within the online course. All 20 HCDFRS MDOs completed the asynchronous component and attended the hands-on skills session.

We calculated the mean with 95% confidence intervals. Statistical significance was calculated using a two-sample Wilcoxon rank-sum test. Data is reported on a 1-5 scale, with 1 corresponding to "very uncomfortable" or "strongly disagree" and 5 representing "very" comfortable or "strongly agree." A mean of three correlates to neither comfortable nor uncomfortable or neither agree nor disagree.

Table 2 details the survey results. Among those who took the pre-course survey, 94.3% (50/53) had never administered blood in the field. Most students entered the course strongly agreeing that carrying blood in the field is important (mean 4.21) and safe (mean 4.08), which increased to a mean of 4.45 (P = 0.236) and 4.39 (P = 0.064), respectively. The comfort level of administering blood increased from a mean of 3.51 to 4.16 (P = 0.003). Comfort with the knowledge of the indications (mean = 3.53) and contraindications (mean = 3.19) increased significantly to 4.19 (P = 0.001) and 4.16 (P = <0.001). Confidence in performing the procedure was neutral before the course (mean = 3.11) and increased afterward (mean = 4.13, P = <0.001). Respondents initially felt neutral with pediatric blood transfusion (mean = 3.04) and increased to 3.97 (P = <0.001).

Obtaining verbal consent for blood transfusion was initially a comfort level of 3.77 and increased to 4.19 (P = 0.045). Comfort with handling a situation in which the patient refused blood due to religious beliefs was 3.77 to 4.19 (P =

Table 2. Survey responses.

Survey Question	Pre-Course [n=53]	Post-Course [n=31]	*P*-Value
Have you ever administered blood in the field? [Yes/No]	Yes 5.6% [3/53] No 94.3% [50/53]	---	---
Do you think that carrying blood in the field is important?	Mean 4.21 CI 3.98-4.44	Mean 4.45 CI 4.21-4.70	0.24
Do you think that prehospital blood administration is safe?	Mean 4.08 CI 3.87-4.28	Mean 4.39 CI 4.13-4.64	0.06
Overall, how comfortable are you with whole blood administration in the field?	Mean 3.51 CI 3.22-3.79	Mean 4.16 CI 3.80-4.52	0.003
How comfortable are you knowing the indications for prehospital administration of whole blood?	Mean 3.53 CI 3.27-3.80	Mean 4.19 CI 3.84-4.54	0.001
How comfortable are you knowing the contraindications for prehospital administration of whole blood?	Mean 3.19 CI 2.89-3.49	Mean 4.16 CI 3.77-4.55	<0.001
How comfortable are you with the procedure to administer whole blood in the field?	Mean 3.11 CI 2.82-3.41	Mean 4.13 CI 3.75-4.51	<0.001
How comfortable are you with prehospital blood administration in pediatrics?	Mean 3.04 CI 2.73-3.34	Mean 3.97 CI 3.58-4.35	<0.001
How comfortable are you with obtaining verbal consent from a patient for whole blood administration? Assume the patient has capacity.	Mean 3.85 CI 3.60-4.10	Mean 4.35 CI 3.98-4.73	0.007
How comfortable would you be handling a situation in which a trauma patient meets the criteria for blood but refuses due to their religious beliefs?	Mean 3.77 CI 3.49-4.10	Mean 4.19 CI 3.82-4.57	0.05
How easy do you think it will be to integrate whole blood administration into your typical care of a patient in hemorrhagic shock?	Mean 3.60 CI 3.39-3.82	Mean 3.94 CI 3.62-4.25	0.07
Was this course too long, just right, or too short?	---	Too long = 3 (9.7%) Just right = 28 (90.3%) Too short = 0 (0.0%)	---
Would you recommend this course to someone else?	---	Yes 96.8% [30/31] No 3.2% [1/31]	---

CI, confidence interval.

0.045). Finally, integrating whole blood into the typical care of a patient with hemorrhagic shock was 3.60 followed by 3.94 ($P = 0.072$). The majority (90%, 28/31) felt the course length was just right, and 97% (30/31) would recommend the course.

Ten patients were transfused a total of 12 units of blood in the first six months of the LTO+WB program, which is approximately two patients per month. No protocol deviations or adverse reactions occurred. All patients eligible for blood during this time were correctly identified and transfused. Among the patients who received blood, 60% (6/10) were alive at emergency department arrival and 50% (5/10) were alive at 24 hours. The majority (8/10) were patients with hemorrhagic shock secondary to trauma.

DISCUSSION

As out-of-hospital transfusion of blood continues to gain popularity across the United States, there is an emerging need to provide paramedics with the knowledge of when and how to initiate a transfusion. Although there are publications regarding best practices of whole blood transfusion in other clinical environments, none exist that focus on blood transfusion by paramedics.[13,14] We aimed to share our experience creating a curriculum to address the needs of an EMS system, with the understanding that many systems across the country share the same barriers.

Kern's framework ensured training was created that was targeted toward our system's needs and appropriately accomplished our learning objectives. The hybrid model of using asynchronous narrated lectures plus an in-person skills check allowed for maximal flexibility and limited the need for additional staffing. Further, it has the advantage of being easily distributed to other EMS clinicians within the department and other organizations.

The survey data results suggest that the course successfully achieved its goals, as the mean response to feeling confident that they could identify the correct patient and perform the procedure was 4.19 and 4.13, which corresponds to "agree" on the Likert scale. Notably, this was a statistically significant increase from the pre-course survey. This confidence aligns with our performance data, which demonstrated 100% protocol compliance over the first three months and no safety events. The survey area with the lowest post-course confidence was pediatric blood transfusions (mean = 3.97), which is an area that may need additional explanation in future iterations.

As educators and EMS leaders consider the future of prehospital care, there must be a continued emphasis on development of educational programs that teach paramedics new skills not covered in initial training programs. More departments will likely expect their paramedics to administer blood in the field. This study creates a blueprint and foundation for future learning objectives and educational strategies in developing new curricula for paramedics using the Kern framework.

LIMITATIONS

This program fulfilled the needs of a specific EMS agency, which limits generalizability. However, many aspects of this program are universal to all patients in hemorrhagic shock. Additionally, the audience for this program was senior paramedic supervisors. The course may need modification for novice EMS responders. Not all participants finished the final survey, which adds potential bias. No complications or protocol deviations occurred; however, the number of patients treated was small, which limits our ability to make any firm conclusions. Finally, further research is required to determine the degree of knowledge retention using this educational approach.

CONCLUSION

This study describes the creation of a prehospital blood transfusion educational curriculum targeted at paramedic supervisors. Confidence increased in all categories that were surveyed, and no safety events occurred after blood was deployed in the field, although this result was limited by the small sample size. As more EMS agencies carry blood in the field, there will be an increasing demand for this type of content. This curriculum provides a framework for future educational programs.

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Variations in Out-of-Hospital Cardiac Arrest Resuscitation Performance and Outcomes in Ohio

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Introduction: Understanding characteristics of top-performing emergency medical service (EMS) agencies and hospitals can be an important tool for improving community out-of-hospital cardiac arrest (OHCA) care. We compared deidentified EMS and hospital-level variations in OHCA performance and outcomes in Ohio.

Methods: We analyzed adult OHCA data from the 2019 Ohio Cardiac Arrest Registry to Enhance Survival (Ohio CARES). We limited the analysis to EMS agencies and receiving hospitals with ≥10 OHCA episodes. The primary outcomes were return of spontaneous circulation (ROSC) and survival to hospital discharge. We compared OHCA outcomes between EMS agencies using linear mixed models, with EMS agency as a random effect and adjusting for Utstein variables. We repeated the analysis by receiving hospital. We compared EMS agency population demographics, response times, and resuscitation characteristics of the top 10% of agencies against remaining agencies using chi-squared tests.

Results: We included 2,841 OHCA among 44 EMS agencies in our analysis. The ROSC varied three-fold; mean 27.9%, range 15.8%-51.0%. Among 40 hospitals, survival varied two-fold; mean 12.9%, range 8.1%-19.0%. Top-performing EMS agencies included both medium- and large-sized agencies that tended to treat younger patients (59 vs 62 years, P<0.01) in public areas (15.7% vs 12.3%, P<0.01). There were no differences in bystander-witnessed arrest, bystander cardio-pulmonary resuscitation (CPR), or EMS response time. However, top-performing EMS agencies used less mechanical CPR (61.7% vs 76.0%, P<0.01) and were more successful in advanced airway placement (89.6% vs 74.8% P<0.01).

Conclusions: The ROSC and survival after out-of-hospital cardiac arrest varied across EMS agencies and hospitals in Ohio. Top-performing EMS agencies exhibited unique demographic characteristics, used less mechanical CPR, and were more successful in airway placement. These variations in OHCA care and outcomes can indicate opportunities for system improvement in Ohio. [West J Emerg Med. 2025;26(3)541–548.]

INTRODUCTION

Nearly 350,000 individuals suffer an out-of-hospital cardiac arrest (OHCA) annually in the United States.[1] To enhance survival, prehospital recommendations have focused on the importance of 9-1-1 activation, rapid bystander cardiopulmonary resuscitation (CPR), early defibrillation, and provision of high-quality CPR by emergency medical services (EMS).[2] Despite significant efforts to improve resuscitation performance, survival has remained poor.[3] Further, regional variability in OHCA outcomes has remained broad.[4]

Studies have described variations in the care and outcomes of life-threatening conditions such as myocardial infarction, stroke, and sepsis.[5-7] While often due to variations in the characteristics of the population,[8] these differences may also reflect disparities in the organization of care and the skill of care of paramedics and physicians, as well as limitations in institutional resources.[5] Despite standard professional and community approaches to optimizing OHCA resuscitation care being propagated for over two decades,[2] significant regional variability in OHCA care persist. [4,9] One study describing variations in OHCA care noted large variations in automated external defibrillator (AED) use and bystander CPR.[9] Further, national- and state-level evaluations of prehospital OHCA care suggest that rates of survival to hospital admission also vary across EMS agencies.[4,10] These variations in healthcare outcomes may exist within populations that should otherwise be receiving similar care.[5,11,12]

Surveillance and benchmarking, including identifying high- and low-performing EMS agencies, can potentially identify modifiable factors to optimize OHCA care and outcomes. The Cardiac Arrest Registry to Enhance Survival (CARES) is the nation's most widespread and durable OHCA registry.[13] In 2016 Ohio joined CARES as a statewide initiative to improve survival through the registry's provision for tracking and evaluating care. In this study, we sought to evaluate regional OHCA care variations in the state of Ohio to identify the characteristics that distinguish high-performing EMS agencies and hospitals.

Population Health Research Capsule

What do we already know about this issue?
Out-of-hospital cardiac arrest is a leading cause of death. Variations in resuscitation care can contribute to regional differences in outcomes from cardiac arrest.

What was the research question?
What are the variations in care and outcomes from cardiac arrest in Ohio?

What was the major finding of the study?
Return of Spontaneous circulation varied 3-fold across Ohio with mean 27.9% and range 15.8% to 51.0% of cardiac arrests.

How does this improve population health?
Variations in cardiac arrest outcomes can identify opportunities for systems improvements in resuscitation care across Ohio.

METHODS

Study Setting and Design

In accordance with guidelines,[14] we performed a retrospective analysis of data from Ohio CARES 2019 to evaluate the extent of regional OHCA prehospital care variability. We first evaluated the characteristics of OHCA in Ohio, followed by agency performance variability. Additionally, we evaluated characteristics of top-performing agencies in comparison to average performing agencies. As a national registry of OHCA events, CARES encompasses 2,300 EMS agencies in 46 US states. It obtains data through three resources: 9-1-1 dispatch centers; EMS professionals; and receiving hospitals. This national registry requires that participants achieve >99% data entry and accuracy to be included in the dataset.[15] In 2019, Ohio participation in CARES included 77 EMS agencies covering 33% of the total state population.[16] This study was approved by the Ohio CARES Data Sharing Committee and the Ohio State University Office of Responsible Research Practices.

Study Population

We included all adult (≥18 years) non-traumatic OHCA reported in the 2019 Ohio CARES registry. CARES only includes OHCA with resuscitation efforts, defined as EMS-performed CPR, and/or any defibrillation, including bystander AED use.[13,17] We excluded pediatric OHCA since the underlying etiologies of arrest and quality of resuscitation performance often differ from adults. We also excluded agencies with <10 OHCA episodes in 2019 to ensure a minimum sample size per agency.

Outcomes

The primary outcomes were return of spontaneous circulation (ROSC) and survival to hospital discharge determined at the EMS agency and receiving hospital level. We then used these outcomes to define high-performing agencies and hospitals.

Analysis

First, we described the baseline characteristics of the OHCA in the registry using standard summary statistics. We then compared OHCA outcomes between EMS agencies and receiving hospitals using linear mixed models with agency/receiving hospital as a random effect. We adjusted the model for pertinent covariates, including age, gender, race, witnessed status, bystander CPR, initial rhythm, and location.[18] Only complete cases were included for modeling, output (Appendix 1). For the comparison across EMS agencies or hospitals, we used a typical cardiac arrest patient: male; White race, age 60 with an unwitnessed cardiac arrest without bystander CPR in a home location.[19] We defined outliers as EMS agencies or hospitals with 95% confidence interval (CI) performance bands outside the cohort mean.

We used number of cardiac arrests in our cohort to define EMS agency size where median (25 OHCA annually) defined medium-sized agencies, and above the 75th percentile of OHCAs (40 OHCA annually) defined large-sized agencies. We compared EMS agency population demographics, response times, and resuscitation characteristics of the top 10% (rounded to next integer) of agencies outperforming the mean against remaining agencies using chi-squared tests. We performed all analyses using STATA IC version 17 (StataCorp LP, College Station, TX), and ARCGIS (Environmental Systems Research Institute, Redlands, CA).

RESULTS

During 2019, the registry contained 2,991 OHCA treated by 77 EMS agencies. Among 44 included EMS agencies, there were 2,841 OHCAs. Population characteristics were similar to national figures[19]: median age 61 years; male 60.3%; White race 65.9%; witnessed arrests 48.7%; and arrest at home residence 68.9% (Table 1). We determined rates of ROSC and survival to discharge for each EMS agency. Rates of ROSC varied from 15.8%-51.0% (Figure 1). Five medium-to-large EMS agencies were in the top 10% of performance. No agencies exhibited performance below the mean ROSC rate. The EMS agency rates of OHCA survival to hospital discharge varied from 6.6%-11.9%. Only one agency outperformed the mean survival rate (9.1%). No agencies exhibited survival below the group mean (Figure 2). Among 40 included receiving hospitals, rates of survival varied from 8.1%-19.0%. Only one receiving hospital performed above the cohort mean (12.6%). There were no underperforming receiving hospitals. Neurologically intact survival ranged from 5.5%-8.6%, with no under or over the mean (7.0%) performing hospitals.

Table 1. Demographics of out of hospital cardiac arrest in Ohio 2019.

Characteristics	Frequency (%) N=2,841
Age mean (±SD)	61 (±17.2)
Sex n (%)	
Male	1,715 (60.3)
Race n (%)	
White	1,871 (65.9)
Black	829 (28.9)
Other	150 (5.3)
Location of arrest n (%)	
Home/residence	1,982 (68.9)
Nursing home	305 (10.7)
Public/commercial building	219 (7.7)
Healthcare facility	158 (5.7)
Street/highway	135 (4.8)
Industrial place	11 (0.4)
Transport center	1(0)
Witnessed status n (%)	
Unwitnessed	1,458 (51.3)
Bystander witnessed	918 (32.3)
EMS witnessed	465 (16.4)
Initial rhythm n (%)	
Shockable	507(17.9)
Non-shockable	2,334 (82.2)
Bystander CPR n(%)	1,002 (35.3%)
ROSC n (%)	911 (32)
Survival to hospital discharge n (%)	348 (12.3)
Survival with CPC score 1 or 2	242 (8.5)

1=Full recovery or mild disability; 2= Moderate disability but independent in activities of daily living
EMS, emergency medical service; *CPR,* cardiopulmonary resuscitation; *CPC,* Cerebral Performance Category; *ROSC,* return of spontaneous circulation.

Figure 1. Rate of return of spontaneous circulation (ROSC) across emergency medical service (EMS) agencies. Dots represent individual agency mean ROSC rate with associated standard deviation (bars). ROSC varied 3-fold across EMS agencies with a mean agency average ROSC rate of 27.9%, range 15.8%-51.0%. Five EMS agencies were top- performing agencies with ROSC rates above the mean EMS agency average (blue dots).

We compared characteristics of the top 10% of EMS agencies above the mean. When comparing OHCAs within agencies, top-performing EMS agencies tended to treat younger patients (59 vs 62 years, P <0.01) in public areas (15.7% vs 12.3%, P <0.01) (Table 2). Other distinguishing characteristics of top-performing EMS agencies included lower utilization of mechanical CPR (61.7% vs 76.0%, P <0.01) and higher rates of successful advanced airway placement (89.6% vs 74.8% P<0.01). There were no differences in bystander-witnessed arrest (30.5% vs 34.4%), bystander CPR (34.2% vs 36.9%), EMS response time (5 vs 5.1 minutes) (Table 2, Table 3). As there were minimal outliers from the mean and to avoid potential identification, we did not pursue further descriptive statistics for our survival analysis.

DISCUSSION

The statewide dissemination of CARES data provides the opportunity to compare performance between EMS agencies in their associated communities. In this statewide series from Ohio, we observed three-fold variations in ROSC and two-fold variations in survival to hospital discharge. We were also able to identify high-performing EMS agencies and some of their distinguishing characteristics. We believe

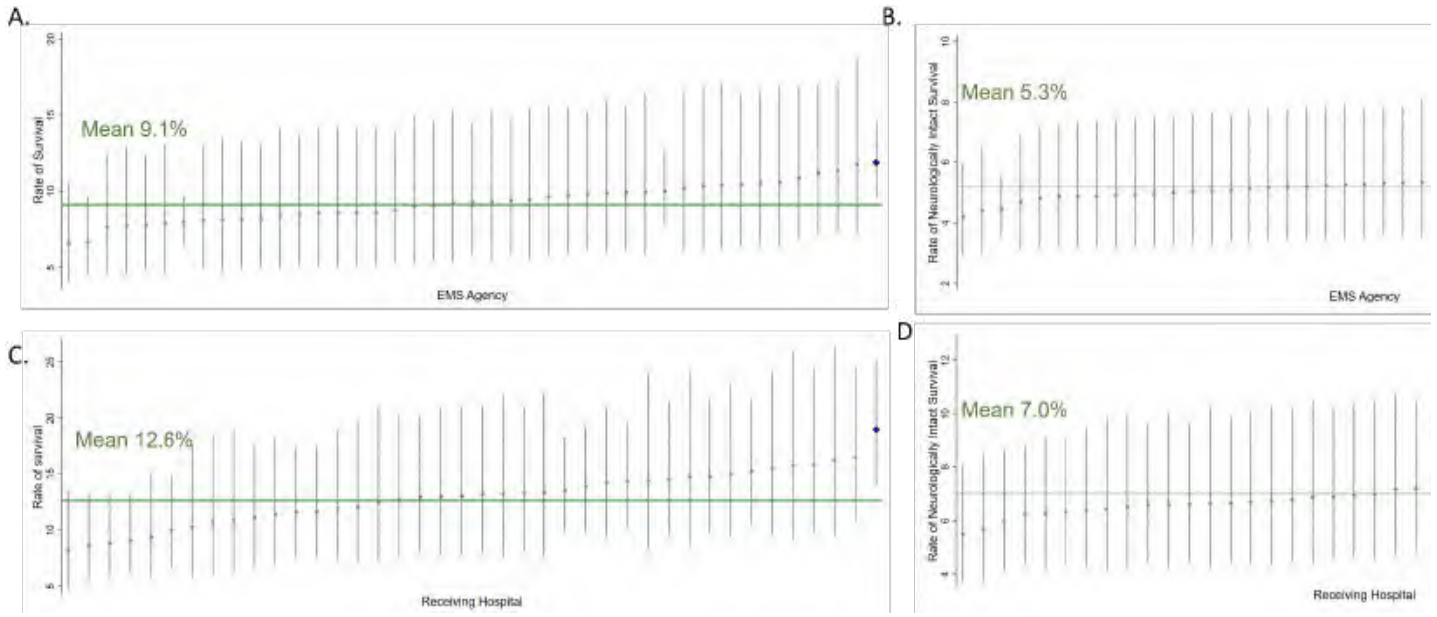

Figure 2. Rate of survival to hospital discharge (left graphs) and neurologically intact survival (right graphs) across emergency medical service (EMS) agencies (top row) and receiving hospitals (bottom row). Dots represent individual agency or hospital mean with associated standard deviation (bars). (A) Survival varied 2-fold across EMS agencies with an agency mean of 9.1%, range 6.6%-11.9%. One EMS agency had survival rates above the mean (blue dot). (B) Neuro-intact survival varied 1.5-fold across EMS agencies with a mean of 5.3%, range 4.2%-6.0%. (C) Survival varied 2-fold across receiving hospitals with a mean survival of 12.6%, range 8.1%-19.0%. One hospital had survival above the mean (blue dot). (D) Neuro-intact survival varied 1.5-fold across receiving hospitals with a mean of neuro-intact survival of 7.0%, range 5.5%-8.6%.

these findings illustrate the value of statewide registries for benchmarking OHCA care, because results are more relevant and actionable for state- and agency-level efforts compared to national reports.

Previous studies using CARES to characterize regional resuscitation performance and outcomes have also been performed but differ from the present analysis. Huebinger et al described approximately a two-fold difference in survival across 13 EMS agencies in Texas CARES.[9] Our sample includes a more diverse range of EMS agencies and higher survival and survival with good neurologic function (survival Ohio 13.1% vs Texas 9.1%; cerebral performance scale 1 or 2 Ohio 8.6% vs Texas 4.0%). Series from North Carolina and Alaska reported higher rates of survival (33.6% and 17.1%, respectively) compared to our study. North Carolina reported similar rates of good neurologic survival, Cerebral Performance Category 1 or 2 (9.7%).[20]

More importantly, the present analysis offers a novel analytic approach toward spotlighting the top-performing EMS agencies in the series to better understand the underlying causes of regional variation. Interestingly, we did not identify any below-average performing agencies, which suggests that variation is driven by the few high-performing agencies in Ohio. Benchmarking EMS agencies is a useful tool that can provide the foundation for community-based OHCA care improvement initiatives for the state rather than targeting individual EMS agency interventions.

Defining site-level variations has motivated practice change and improved outcomes across multiple critical illnesses.[6,7] For example, benchmarking stroke centers has allowed for equitable comparisons to identify modifiable quality improvement strategies.[21,22] Similarly, regional variability in sepsis outcomes highlighted targeted improvement strategies.[23,24] Variations in OHCA outcomes have previously been linked to population, community, and EMS agency factors.[25-28] The chain of survival for cardiac resuscitation focuses on individualized care[29] without focus on aligning practice patterns across regions. Identification of outcome variations provides opportunities to improve cardiac arrest care through using appropriate targeted community strategies within regions.[30] For example, the most recent study of variations in EMS resuscitation across the US found that agencies with faster response times were associated with improved survival.[4] Further, targeted interventions such as improving bystander CPR rates and EMS interventions improved survival.[20,31] Framed with the chain-of-survival ideology, leveraging EMS and community interventions to develop targeted strategies against regional variations, along with additional investigations that identify modifiable factors in high-quality receiving hospitals, can improve survival.

Our findings identified two areas for optimization: manual, high-quality CPR; and successful advanced airway

Table 2. Characteristics of out-of-hospital cardiac arrest patients in top 10% of performing EMS agencies in Ohio (A-E).

Agency ID	A	B	C	D	E	Top 10% agencies above mean (combined)	Other performing agencies
Age mean (IQR) *	61 (51-73)	57 (45-70)	66 (62-72)	68 (63-76)	60 (46-72)	59 (48-71)	63 (52-76)
Location (%) *						n (%)	n (%)
Home	65.9	68.9	45.0	69.0	74.5	904 (67.7)	1189 (71.8)
Nursing home/healthcare facility	20.6	13.5	40.0	20.7	12.8	222 (16.6)	262 (15.8)
In general public	13.4	17.5	15.0	10.3	12.8	209 (15.7)	204 (12.3)
Witnessed status (%)						n (%)	n (%)
Unwitnessed	56.5	52.3	35.0	34.5	42.6	706 (52.9)	831 (50.2)
Bystander witnessed	29.1	30.4	25.0	51.7	36.2	407 (30.5)	568 (34.3)
EMS witnessed	14.4	17.2	40.0	13.8	21.3	222 (16.6)	256 (15.5)
CPR initiated by (%)						n (%)	n (%)
EMS	64.9	65.5	55.0	69.0	83.0	879 (65.8)	1045 (63.1)
Bystander	35.1	34.5	45.0	31.0	17.0	455 (34.2)	610 (36.9)
Shockable rhythm (%)						n (%)	n (%)
Yes	21.0	17.8	20.0	34.5	12.8	256 (19.2)	284 (17.2)
No	79.0	82.2	80.0	65.5	87.2	1079 (80.8)	1371 (82.8)
ROSC	34.6	36.6	65.0	62.1	61.7	37.8	32.0
Survival	15.7	11.6	20.0	20.7	19.2	13.6	12.2

*P<0.01

EMS, emergency medical service; *IQR,* interquartile range; *CPR,* cardiopulmonary resuscitation; *ROSC,* return of spontaneous circulation.

Table 3. Emergency medical services interventions in top 10% performing EMS agencies (A-E).

Agency ID	A	B	C	D	E	Top 10% agencies above mean (combined)	Other performing agencies
EMS arrival time (minutes) mean (IQR)	-	5(3.6-6.1)	3.5(3-4.5)	4.3(3-5.1)	-	5.0(4.0-6.0)	5.1(4.9-5.4)
EMS time to CPR minutes mean (IQR)	-	0.8(0-2)	-	1.1(0-2)	-	1(0-2.9)	1.2(0-3)
Mechanical CPR (% yes)*	46.4	69.9	60.0	65.5	84.7	61.7	76.0
Advanced airway successfully placed (% yes) *	89.6	78.5	80	65.5	84.8	89.6	74.8
Supraglottic airway	32.3	35.6	0	0	2.4	32.3	30.9
Endotracheal tube	67.6	64.4	100	100	97.6	67.7	69.0

"-" = missing greater than 50% of values, *P<0.01.

EMS, emergency medical services; *IQR,* interquartile range; *CPR,* cardiopulmonary resuscitation.

management. Prior studies have shown heterogenous associations with mechanical CPR and advanced airway strategies in resuscitation. Observational studies have shown improved survival with mechanical CPR.[32-34] However, randomized trials and meta-analysis have shown worse neurologic survival with mechanical CPR.[34-41] Similarly, multiple studies have highlighted challenges in advanced airway management and shown both improved and reduced OHCA outcomes compared to bag-mask-ventilation.[42-47] Recent meta-analysis showed improved outcomes with advanced airway strategies.[48,49]

Our data revealed an association between manual, high-quality CPR and successful advanced airway placement with improved outcomes. Improvement strategies for advanced airway placement success can include more training, video-assisted laryngoscopy, or potentially placement of supraglottic

devices, which has increased in use.[50,51] Despite heterogeneous evidence, advanced airway strategies are used in the majority of OHCA resuscitations, and mechanical CPR utilization has significantly increased in the US.[47,52] Further qualitative studies should evaluate these high-performance agencies to determine whether mechanical CPR use and airway success are the only differences from average agencies.

These observations highlight important opportunities for improving community-wide OHCA care and outcomes through use of statewide registries. Identifying high-quality CPR, one of the initial links in the chain of survival, and ventilation quality metrics are the initial steps in improvement strategies. Validation of these associative quality metrics and outcomes is the next step in implementation. Further, improvement strategies must be applicable to regional barriers and culture. Providing statewide data to pertinent teams, such as statewide CARES teams, can allow for directed and culturally appropriate statewide initiatives to improve OHCA outcomes.[20,53] Targeting improvement strategies toward known weak links in the chain of survival is known to improve OHCA outcomes.[30,54]

LIMITATIONS

This analysis included only an estimated 5.9% of potential EMS agencies in Ohio, which covered 35% of the populus with an urban bias. Inclusion of a larger proportion of the populus and/or more rural agencies could have changed the variation in outcomes and potentially highlighted different factors associated with outcomes. Our study only identified one outlier in both EMS agency and receiving hospital survival. We did not pursue further descriptive statistics for our survival analysis. It is unclear whether directed quality initiatives would result in changes in survival. Lastly, missing data may alter results. The ROSC modeling was able to include >99% of all cases; however, destination hospital was missing in 743 cases, which may have significantly affected distribution predictions. Interventions such as EMS arrival time and start of CPR is not mandatory in CARES reporting. We were missing 2/5 of EMS agency arrival times, which may have altered our findings. We also omitted Agency C EMS CPR initiating time, as values were missing in greater than 50% of cases.

CONCLUSION

Significant variations in both return of spontaneous circulation and survival exist across EMS agencies in Ohio. Understanding regional variations in prehospital care can provide novel perspectives that can be leveraged to improve care.

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Dispatch Decisions and Emergency Medical Services Response in the Prehospital Care of Status Epilepticus

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Objective: Emergency medical dispatch is intended to ensure that emergency medical services (EMS) allocate appropriate resources for the treatment of patients with status epilepticus (SE). However, it is unclear whether dispatch algorithms accurately identify those patients having a seizure-related medical emergency and how dispatch algorithms influence what prehospital resources are allocated for the encounter.

Methods: We performed a cross-sectional analysis of prehospital encounters for SE using data from the 2019 ESO Data Collaborative. We included patients who were ≥18 years of age, had an EMS diagnostic impression of SE, and did not have a cardiac arrest. We examined the dispatch-determined complaint designated by the emergency medical dispatch (EMD) code, dispatch-determined level of acuity (A, B, C, D), ambulance response, and training level of the responding prehospital professional.

Results: Of the 18,515 patient encounters for SE with an EMD code, 8,279 (44.9%) were women, and the mean age was 40.0 years (SD 19.7). There were 13,829 (75%) encounters that received a dispatch code for seizures/convulsions and 4,686 (25%) with a dispatch code for a non-seizure-related condition. Among encounters for SE identified by dispatch as seizures/convulsions, 6,412 (46.4%) were designated high acuity, 6,626 (63.6%) were designated low acuity, and the majority received emergent ambulance responses (98.1% among those designated high acuity and 81.8% among those designated low acuity) and an Advanced Life Support-trained responder (93.7% among those designated high acuity and 92.7% among those designated low acuity). Median response times were similar for all acuity levels (9.1, 8.8, 9.1, and 8.3 minutes for A-D, respectively).

Conclusion: Approximately one-fourth of SE cases were categorized as a non-seizure related condition at dispatch, and fewer than half received the highest acuity determinant code. Despite this, dispatch-assigned acuity did not have a strong relationship with the ambulance response or training level of the EMS responder or response time, suggesting that use of dispatch algorithms might be further optimized and highlighting a potential area to improve quality of EMS care. [West J Emerg Med. 2025;26(3)549–555.]

INTRODUCTION

Status epilepticus (SE) is a neurologic emergency that relies on emergency medical services (EMS) for treatment outside the hospital setting, with high-quality evidence demonstrating that rapid EMS stabilization and treatment with a benzodiazepine improves SE outcome.[1] Prehospital data suggest that seizures prompt a substantial portion of calls to EMS in both pediatric and adult populations (≈6-8%) and that SE represents 6% of seizure-related emergency department visits, highlighting the magnitude of this problem.[2,3] Emergency medical dispatch (EMD) is the system responsible for fielding 9-1-1 requests and allocating resources using a preset algorithm. Thus, EMD serves a critical role in ensuring that patients with SE receive rapid, effective treatment.[4]

In an optimally functioning EMD system, high-acuity medical scenarios would be accurately identified and rapidly receive ambulance care delivered by personnel trained in Advanced Life Support (ALS) capable of providing an appropriate level of treatment (eg, delivery of certain medications, intubation for airway or breathing compromise). Conversely, low-acuity responses would receive less rapid ambulance care delivered by personnel with Basic Life Support (BLS) rather than ALS training.[5-11] However, there are likely large gaps in the ability to distinguish between low-acuity[12,13] and high-acuity scenarios.[14,15] The performance of EMD systems for patients with SE in particular is unclear. We, therefore, aimed to describe dispatch-related decisions for patients with SE using a national prehospital cohort. Our analysis focused on agencies that used the Medical Priority Dispatch System (MPDS) for assigning EMD codes. The MPDS is one of the most common systems used in the United States and internationally, whereby dispatch telecommunicators follow a rigid, predetermined algorithm to code prehospital encounters with a specific complaint (eg, seizure) and acuity level. Variability exists between EMS agencies with respect to how resources are allocated for determinant codes, although these are preset and not up to the telecommunicator to decide at the time of a 9-1-1 call.

Population Health Research Capsule

What do we already know about this issue?
Emergency medical dispatch (EMD) is critical for allocating resources for status epilepticus (SE), but its accuracy and impact on prehospital care are unclear.

What was the research question?
Does EMD classify SE as high acuity, and how does this influence ambulance response time and receipt of ALS-trained responders?

What was the major finding of the study?
Less than 50% of SE cases were designated high acuity. Median ambulance response times fell within 2 minutes of each other, and most cases received ALS responders (> 90% for both high and low acuity).

How does this improve population health?
Findings demonstrate gaps in dispatch algorithms and a path for improving EMS care for SE, potentially leading to better outcomes.

METHODS

Study Design and Data Source

This was a cross-sectional analysis of prehospital encounters for patients with SE using data from the ESO Data Collaborative from January 1–December 31, 2019. The collaborative, which compiles data from more than 3,000 EMS agencies, fire departments and hospitals, is the research arm of ESO Solutions, Inc (Austin, TX), a company that provides electronic medical record software to EMS agencies across the US. Deidentified data elements are available for research purposes. These include dispatch codes and clinical details for each prehospital encounter, which are compliant with National EMS Information System version 3. We used this data to examine dispatch decisions for patients with SE, determining whether patients were categorized as medical emergencies, the priority of the ambulance response, and the training level of the responding prehospital professional. Our primary outcome was ambulance response time. Our study protocol was approved by the Institutional Review Board of the University of California, San Francisco.

Study Population

Inclusion criteria included encounters for patients who were ≥18 years of age, evaluated for a 9-1-1 call, had an EMS primary or secondary primary diagnostic impression of SE, and received an EMD code that adhered to the MPDS. (We excluded agencies that used alternative EMD systems).[16] An EMS diagnostic impression for SE has been demonstrated to have high specificity and moderate sensitivity for identifying generalized convulsive SE; restricting encounters with an EMS diagnostic impression for SE to those that receive benzodiazepine results in only modest improvement to specificity, with a large reduction in sensitivity.[17] Emergency responders select impressions from a set of options that can vary across EMS agencies, which include seizure- or epilepsy-related impressions that indicate the presence or absence of SE (eg, "Seizure," "Seizure without SE," "Seizure with SE," "Epilepsy with SE," etc). These impressions did not specifically indicate whether convulsive activity had stopped, since SE may manifest with non-convulsive activity/persistent

altered mental status. We excluded from our analysis EMS agencies that did not use the MPDS, since these encounters were not recorded in the ESO database. Patients who received cardiopulmonary resuscitation were excluded given the assumption that cardiac arrest would be the main complaint identified by dispatch. We also excluded patients with no EMD code.

Measurements

We used the MPDS EMD code to determine the complaint and acuity level identified for each encounter. The MPDS EMD codes include a protocol number and letter (A [Alpha], B [Bravo], C [Charlie], or D [Delta]). Protocol number 12 designates seizures/convulsions. The letter specifies the acuity level in quasi-escalating priority (A = low priority, B = middle priority, C = possibly life-threatening, and D = life-threatening), with examples as follows:

- 12A: patient with seizures that have terminated, and breathing verified
- 12B: patient with seizures that have terminated but breathing not verified
- 12C: patient with seizures and a high-risk comorbidity (diabetes, heart disease, or pregnancy)
- 12D: patient with seizures who is not breathing, or ongoing seizure activity

We created a binary indicator of whether the EMD protocol number was 12, specifying the complaint as seizure/convulsion. We defined acuity level as a categorical variable (A, B, C, or D) and created a binary indicator of whether acuity level was low (A, B, or C) or high acuity (D). Patient characteristics included age, sex, race, and Hispanic ethnicity.

Characteristics of the prehospital response included whether the ambulance response was categorized as emergent vs non-emergent, whether the responders had ALS or BLS training, ambulance response time, total prehospital encounter time, whether the encounter occurred in a rural area (according to the US Census Bureau classification), and the EMS agency staffing structure and EMS agency governing structure. Advanced Life Support included ambulances with responders capable of providing specialty critical care services. Response time was defined as the number of minutes between dispatch receiving a 9-1-1 call and the ambulance arriving on scene. Staffing structure was categorized as an agency having paid personnel, volunteers, or a mix. Governing structure was categorized as agency overseen by a non-profit/community organization, hospital, fire department, governmental body, or a private entity.

Statistical Analysis

We examined patient and agency characteristics of all included encounters, comparing encounters that dispatch identified as seizures/convulsions vs not and among encounters identified as seizures/convulsions, comparing encounters that dispatch identified as high acuity vs low acuity.

For encounters with EMD code for seizures/convulsions we examined the relationship between the acuity assigned by dispatch and agency response in two ways. First, we examined differences in the proportion of encounters that had 1) ambulance response categorized as emergent vs non-emergent and 2) ALS- vs BLS-trained team of responders among encounters identified as high acuity vs low acuity. Second, we examined differences in the speed of the response by calculating the 25th, 50th, and 75th percentile response time and total prehospital encounter time for encounters within each acuity level (A, B, C, and D). We examined the adjusted difference in response time and total prehospital encounter time. Adjustment was derived by fitting multilevel mixed-effects linear regression models with agency as a random effect and with patient age and sex as fixed effects. We stratified these estimates by agency rurality to account for the longer distances required for travel in rural areas. We also compared the rate of emergent vs emergent and ALS vs BLS assignment among encounters with non-seizure/convulsion EMD vs non-seizure EMD codes.

We performed two sensitivity analyses. To address the fact that some encounters have multiple ambulances dispatched to responder care, we repeated our analyses only including encounters linked to the first responding ambulance. To increase the specificity of our definition for SE, we repeated our analyses including only encounters for patients who were diagnosed with SE and received a benzodiazepine.[17]

RESULTS

There were 18,515 prehospital encounters for patients with SE that met the inclusion criteria (Figure 1). Patients had a mean age of 40.0 years (SD 19.7), and 44.9% were identified as women. Most encounters occurred in urban locations and involved non-volunteer agencies (Table 1). Characteristics of the encounters excluded from our main analysis that had no EMD code are described in Appendix Table 1.

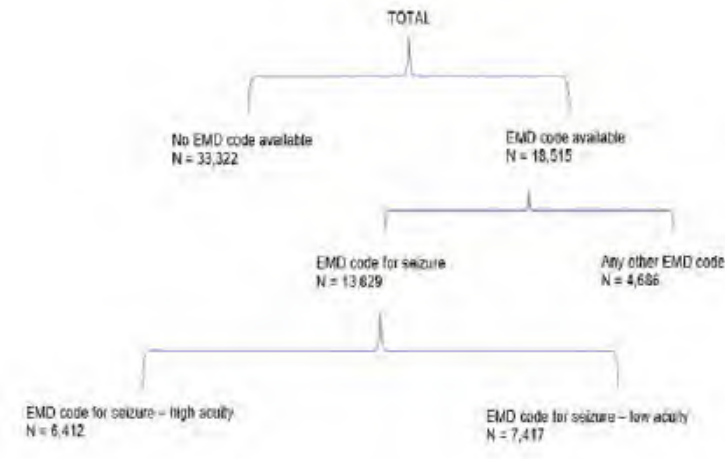

Figure 1. Number of patients with and without EMD codes in a study of dispatch acuity for status epilepticus calls.
EMD, emergency medical dispatch.

Table 1. Characteristics of prehospital encounters with status epilepticus with an emergency medical dispatch code (EMD) for seizure, or any other EMD code.

	EMD code for convulsions/ seizures	Any other EMD code	Seizure code, high-acuity level	Seizure code, low-acuity level
	N = 13,829	N = 4,686	N = 6,412	N = 7,417
Patient				
Age, mean (SD)	38.8 (19.1)	43.6 (20.9)	40.8 (19.0)	37.0 (18.9)
Female gender y/n	6,095 (44.2%)	2,184 (46.8%)	2,873 (44.9%)	3,222 (43.6%)
Race				
White	6,787 (49.1%)	2,738 (58.4%)	2,990 (46.6%)	3,797 (51.2%)
Black	5,749 (41.6%)	1,423 (30.4%)	2,806 (43.8%)	2,943 (39.7%)
Asian	71 (0.5%)	31 (0.7%)	25 (0.4%)	46 (0.6%)
Other	693 (5.0%)	238 (5.1%)	332 (5.2%)	361 (4.9%)
Unknown	529 (3.8%)	256 (5.5%)	259 (4.0%)	270 (3.6%)
Hispanic ethnicity y/n	939 (6.8%)	311 (6.6%)	457 (7.1%)	482 (6.5%)
Rural	387 (2.8%)	169 (3.6%)	158 (2.5%)	229 (3.1%)
Region				
Northeast	99 (0.7%)	47 (1.0%)	9 (0.1%)	90 (1.2%)
Midwest	2,568 (18.6%)	808 (17.3%)	1,128 (17.6%)	1,440 (19.4%)
South	9,256 (67.0%)	2,752 (58.8%)	4.510 (70.4%)	4,746 (64.1%)
West	1,891 (13.7%)	1,075 (23.0%)	758 (11.8%)	1,133 (15.3%)
Agency				
Status				
Mixed	1,914 (13.8%)	560 (12.0%)	858 (13.4%)	1,056 (14.2%)
Non-volunteer	11,916 (86.2%)	4,125 (88.0%)	5,554 (86.6%)	6,360 (85.7%)
Volunteer	1 (<1%)	1 (<1%)	0 (0.0%)	1 (<1%)
Type				
Community, non-profit	9,699 (70.1%)	2,922 (62.4%)	4,632 (72.2%)	5,067 (68.3%)
Fire department	1,014 (7.3%)	399 (8.5%)	443 (6.9%)	571 (7.7%)
Governmental, non-fire	2,623 (19.0%)	1,143 (24.4%)	1,135 (17.7%)	1,488 (20.1%)
Hospital	31 (0.2%)	13 (0.3%)	0 (0.0%)	31 (0.4%)
Private, non-hospital	462 (3.3%)	209 (4.5%)	202 (3.2%)	260 (3.5%)

EMD, emergency medical dispatch.

Among all encounters with an EMD code, 13,829 (75%) received a code for seizures/convulsions and 4,686 (25%) received a code for non-seizure-related conditions, of which 8.8% comprised a category of "other," which included a long list of labels that were not easily included in any existing category (Table 1, Appendix Table 2). Across the 13,829 encounters with an EMD code for seizures/convulsions, 2,651 (19.2 %) were assigned acuity level A, 1,059 (7.7%) acuity level B; 2,916 (21.1%) acuity level C; and 6,412 (46.4%) acuity level D. Compared to low- acuity encounters, encounters assigned a high acuity (acuity level D) had patients with lower Glasgow Coma Scale scores and no clinically meaningful differences in the initial heart rate, blood pressure or oxygen saturation (Appendix Table 3).

There were 6,291 (98.1%) encounters with an EMD for seizure assigned a high acuity that received an emergent ambulance response and 5,855 (91.3%) that received an ALS-trained prehospital responder. There were 5,421 (81.8%) encounters with EMD for seizure assigned a low acuity that received emergent ambulance response and 6,101 (92.1%) that received an ALS-trained prehospital responder. The rate of emergency response and ALS assignment for encounters with an EMD code for seizure/convulsion compared to encounters with a non-seizure EMD code was similar (Appendix Table 4). Median response times across encounters' associated acuity level fell within two minutes of each other (9.1, 8.8, 9.1 and 8.3 minutes for level A, B, C, and D, respectively). After adjustment, we found that the response times for 12B, C and D were faster than those for 12A (Table 2). Sensitivity analyses restricting to encounters involving the first

responding unit and encounters involving benzodiazepine administration did not change the results (Appendix: Tables 5, 6, and 7). The rate of receipt of a benzodiazepine was 15.2% for 12A encounters, 12.8% for 12B, 15.4% for 12C, and 25.9% for 12D. Within each category, midazolam was the benzodiazepine administered in >90% of encounters.

DISCUSSION

We found that 25% of patients with SE are not categorized as having a seizure by EMD and fewer than 50% receive the highest acuity determinant code. However, the ambulance response and training level of the responding prehospital professionals did not differ meaningfully between encounters identified as low vs high acuity.

Our finding that telecommunicator mis-categorization occurs frequently is consistent with the literature on other medical emergencies, including cardiac arrest[18,19] and stroke.[20-23] The extent to which this is explained by our reliance on bystanders to provide information or disease mimics is unclear. Our findings also suggest that dispatch codes have limited ability to distinguish acuity, but this does not substantially influence downstream EMS care for SE. Similar to prior work from a single city demonstrating that acuity level correlated poorly with benzodiazepine receipt for patients with seizure,[24] our analysis of a large EMS cohort found that the rate of benzodiazepine administration was ≤25% for all patients with SE regardless of dispatcher-assigned acuity level, consistent with literature demonstrating low rates of prehospital SE treatment overall.[25]

Although our findings provide reassurance that high-acuity resources are deployed consistently for a true emergency like SE, they may reflect a well-recognized tendency for prehospital dispatch systems to over-triage,[15,26] or in part may be explained by aspects of dispatch algorithms mediated at a local/agency level that could not be characterized in this analysis, representing a worthy focus of future investigation.

LIMITATIONS

This analysis was limited to agencies that use ESO and MPDS for prehospital medical documentation, limiting generalizability. We also did not account for MPDS versions used by various agencies or the policies employed at a local/agency level; both factors may dictate what resources are allocated for each determinant code and, thus, are likely to influence dispatch patterns. Dichotomization of the acuity-level variable in our analysis facilitated interpretation of trends in this population at the expense of capturing more nuanced information about why lower acuity determinant codes may trigger utilization of an emergent priority of ALS response. We were unable to explore these complexities using our analysis, which is a limitation and worthy topic of future investigation.

We relied on EMS diagnostic impressions to identify SE but were unable to confirm whether the patients were truly experiencing SE at the time when the dispatch telecommunicator was responding to the 9-1-1 call. An EMS diagnostic impression for SE has only moderate sensitivity;

Table 2. Prehospital encounters for EMS: response times*, and adjusted† differences in response times, stratified by emergency medical dispatch code acuity level (A, B, C, and D, with each successive letter implying increasing acuity), emergency designation, and service level of the unit dispatched to the scene.

	Response time (minutes)			Adjusted difference in response time (minutes)	
	25th percentile	Median	75th percentile	Coefficient	95% CI
EMD Code					
12A	6.6	9.1	12.9	Ref	
12B	6.6	8.8	11.7	-1.0	-1.3, -0.7
12C	6.8	9.1	12.0	-0.9	-1.1, -0.6
12D	6.2	8.3	11.1	-1.7	-1.9, -1.5
12-NOS	5.5	7.7	11.0	-2.0	-2.7, -1.3
Priority					
Not emergency	7.3	10.2	13.8	Ref	
Emergency	6.3	8.5	11.4	-2.0	-2.2, -1.7
Service Level of EMS Unit					
BLS	6.9	8.6	10.9	Ref	
ALS + Specialty Critical Care	6.4	8.6	11.7	-0.14	-0.6, 0.3

*Defined as the number of minutes between dispatch receiving an emergency call and the ambulance arriving on scene.
†Adjusted differences in response times were derived by fitting multilevel mixed-effects linear regression models with agency as a random effect, to estimate the difference in response time between acuity, priority, and service levels, adjusting for patient age and sex.
EMS, emergency medical services; *CI,* confidence interval; *EMD,* emergency medical dispatch; *NOS,* Not otherwise specified; *BLS,* Basic Life Support; *ALS,* Advanced Life Support.

therefore, we may have excluded some patients with true SE in our cohort from this analysis. We excluded encounters with no EMD code but were unable to verify the cause for these missing data, which may have included lack of data entry at an agency level, or that the dispatcher did not enter an EMD code for a specific encounter. For encounters with an ALS response, we were unable to verify whether a BLS response would have been sent if available. Similarly, we lacked information on the proportion of responders at each EMS agency who had ALS training and, thus, we were unable to determine whether the high proportion of encounters with an ALS-trained responder was merely reflective of agency staffing.

CONCLUSION

Our findings demonstrate that application of the current emergency medical dispatch system for patients with status epilepticus may not be optimized but does not lead to substandard allocation of resources. More investigation is needed to determine how dispatch algorithms can be better designed to improve the quality of prehospital care.

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Creation and Implementation of an EMS Elective for Final-Year Medical Students: A 5-year Evaluation

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Introduction: Emergency medical services (EMS) professionals interact with nearly every type of physician and are key stakeholders across the healthcare spectrum. However, no formal national recommendations exist for medical student education about EMS. When looking for institution-level resources to assist in writing the educational objectives and curricular content for an EMS elective for medical students, limited examples are available for guidance. We designed, implemented, and evaluated a two-week EMS elective for final-year medical students. A pragmatic description of how to create an EMS elective is detailed.

Methods: The EMS elective involves an introductory session, an operational orientation, and six ambulance shifts. Self-directed activities and checklists encourage interdisciplinary learning between calls. Additionally, students deliver a case presentation including an example for improved interdisciplinary communication. Before and after the elective, a voluntary anonymous survey is distributed, in addition to a formal standard course evaluation.

Results: From 2017–2022, 37 students participated in the elective. Thirty-four (92%) submitted the pre-elective survey, and 21 (57%) submitted the post-elective survey. Mann-Whitney U testing suggested an improved understanding of the capabilities of different EMS practitioner levels and of the different types of medical oversight after the elective (median pre=60%, median post=90%, U=118, P<0.001). Qualitatively, students described their experiences as “practical,” “hands-on,” and “eye-opening.”

Conclusion: An EMS elective using andragogy and intentional interdisciplinary communication seems useful in facilitating improved understanding of the fundamentals of EMS practice for final-year medical students. [West J Emerg Med. 2025;26(3)556–563.]

BACKGROUND

Emergency medical services (EMS) professionals, via their current roles within 9-1-1 emergency response, critical care interfacility transfers, and prescheduled movement of medically complicated patients in the outpatient setting, interact with nearly every physician specialty. With advances in mobile-integrated health and community paramedicine, EMS professionals are anticipated to become even more integrated within the healthcare spectrum, thereby strengthening these physician-EMS interactions.[1]

Given the importance of future physicians’ understanding of the fundamentals of contemporary EMS practice, regardless of their specialty or practice setting (eg, inpatient, outpatient, telehealth), offering medical students the opportunity to work directly with EMS professionals would seem to be an invaluable experience. However, despite ubiquitous

interactions between EMS professionals and physicians, no formal national recommendations currently exist about how to introduce medical students to EMS systems and the crucial role EMS plays within the healthcare system. National educational guidance related to educating physicians about EMS first appears at the resident physician level with the Accreditation Council for Graduate Medical Education requiring that emergency medicine (EM) residents "have experience in emergency medical services… includ[ing] ground unit runs and should include direct medical oversight."[2] A model EMS curriculum for EM residents has been proposed by the Society for Academic Emergency Medicine; however, it dates back to 1996.[3]

When looking for institution-level resources to assist in writing the educational objectives and curricular content for an EMS elective for medical students, limited examples are available for guidance. Superficial course descriptions can be found on individual medical school websites via internet search; however, concrete details about scheduling, learning materials, and assessment strategies are generally not readily available to the public. Although the value of medical student exposure to EMS through emergency medical responder courses, emergency medical technician courses, or advanced elective opportunities, have been referenced in retrievable literature, these opportunities are often limited to medical schools affiliated with university hospitals that have strong, well-established connections with EMS agencies.[4-10] For medical schools without robust pre-existing relationships with surrounding EMS agencies, descriptions about how to create and implement an EMS elective by way of offering ready-to-use resources and including pragmatic feedback on how to overcome operational challenges inherent to EMS to provide optimal medical student learning experiences, are nearly non-existent.

Population Health Research Capsule

What do we already know about this issue?
Although emergency medical service (EMS) professionals interact with nearly every physician specialty, no formal recommendations exist for what medical students should learn about EMS systems.

What was the research question?
We designed, implemented, and evaluated a curriculum for an EMS elective for final-year medical students.

What was the major finding of the study?
We found an improved understanding of EMS practitioner levels and medical oversight (pre score=60%, post score=90%, U=118, P<0.001).

How does this improve population health?
An EMS elective using andragogy and intentional interdisciplinary communication can improve medical student's understanding of the fundamentals of EMS practice.

OBJECTIVES

Our goal was to design, implement, evaluate, and disseminate a model curriculum for a two-week EMS elective for final-year medical students who have already completed their EM clerkship experience.

CURRICULAR DESIGN

Study Design

Prospective, observational data collection from the medical students taking the course was planned for during the initial development of the EMS elective to allow for dynamic curriculum changes to be made in response to student and faculty feedback. The proposed data collection plan was reviewed and approved by the Stony Brook University institutional review board.

Study Setting & Participants

The Renaissance School of Medicine (RSOM) at Stony Brook University is an allopathic state medical school with approximately 130 medical students per graduating class, located on Long Island. The primary clinical site for RSOM is Stony Brook University Hospital (SBUH), a suburban, academic, Level I trauma and tertiary care center with an annual emergency department census of approximately 110,000 patients. Stony Brook University Hospital Emergency Medical Services (SBUH EMS) is the hospital-based EMS agency, which employs approximately 100 paramedics and 50 emergency medical technicians. SBUH EMS has an annual call volume of approximately 15,000 requests for service, which is comprised of 9-1-1 and interfacility responses. The 9-1-1 response vehicles include multiple ground ambulances, mobile stroke units, and rotor-wing air ambulances.

Curriculum Developmental Process

The overarching goals of the EMS elective were to provide medical students with high-yield educational content that would be beneficial regardless of their future specialty, as well as to encourage a two-way learning opportunity between EMS professionals and medical students. Medical students may lament that at the end of their medical school experience, while they may feel more knowledgeable about anatomy, physiology, pathology, and the healthcare system, their understanding of practical medicine, such as how to turn on an oxygen tank, assemble a nebulizer mask, or apply 12-lead electrocardiogram electrodes, may be lacking. An EMS elective offers the opportunity for EMS professionals to

showcase their unique skillset for the future physicians with whom they will be interacting, while medical students are simultaneously encouraged to share with EMS professionals their newly learned understanding of anatomy, physiology, and pathology.

The initial curriculum for the elective was assembled based on the experience of the course director, LMM, a critical care paramedic and nationally certified EMS educator who went on to become a double board-certified emergency physician and EMS physician. To guide EMS-specific medical knowledge, the following course objectives were developed:

1. Describe an understanding of the components of EMS including educational requirements and scope of practice for different levels of EMS professionals, operations of the local EMS system, fundamentals of communication, and documentation requirements;
2. Appreciate the time, safety, personnel, and equipment constraints of prehospital care;
3. Discuss the different forms of medical direction;
4. Explain the importance of timely, precise interdisciplinary communication and safe patient-hand-off practices.

The educational activities (Table 1) composing the EMS elective were developed based on andragogy and incorporated self-directed and experiential learning theories (Appendix A or from the authors upon request). In addition to course objectives, the educational activities are linked with the Association of American Medical Colleges' Entrustable Professional Activities and Physician Competencies (Table 2).[11-12]

Course Structure

The EMS elective, offered bimonthly, is two weeks long and has 2-3 seats available per iteration. The elective begins with a one-hour operational orientation over Zoom. The course director reviews the course syllabus, discusses safe attire and equipment expectations, and orients the students to their schedules and locations of ambulances. Students then asynchronously watch a one-hour long introductory lecture pre-recorded by the course director. Clinically, medical students are scheduled for three 9-1-1 ambulance shifts, two critical care interfacility transport shifts, and one mobile stroke unit shift, totaling 64 clinical hours. (If critical care interfacility transport shifts and/or mobile stroke unit shifts are not available to a medical school, having all ride-along shifts on 9-1-1 ambulances would likely be an equally meaningful clinical experience.)

A student skill-tracking form is sent along with an introduction e-mail to orient paramedic preceptors to meaningful skills and valuable educational opportunities specific to medical students, as SBUH EMS paramedic preceptors often have multiple learner-types regularly joining them for ride-alongs. During the ride-along shifts, medical students complete the student skill-tracking form and a patient encounter log. During down time between calls, medical students complete an open-book protocol, review

Table 1. Components of two-week emergency medical services elective and the course objectives they meet.

Educational activity	Description	Course objective
Introductory lecture	One-hour, prerecorded, asynchronous, instructor-centered didactic session. Lecture begins with discussion of the history of EMS and then describes the fundamentals of modern EMS systems. A progressive disclosure case presentation takes medical students into the mind of a paramedic regarding scene safety, crew resource management, environmental and operational considerations, and spatiotemporal awareness.	1, 3
Ambulance ride-along	Experiential learning opportunity.	1–4
Student skill-tracking form	List of items to discuss, review, or perform during the ride-along time.	1, 2, 4
Patient encounter log	Form to track patient encounters to confirm robust clinical exposure.	1, 2, 4
Open-book protocol exam	Self-directed learning opportunity during down time on ride-alongs to become familiar with EMS medicine. A series of multiple-choice questions guide the student through the protocols, highlighting protocol structure, unique aspects of EMS medicine, and the scope of practice of different EMS professionals.	1 - 4
Scholarly articles	Self-directed learning opportunity during down time on ride-alongs to review EMS-related literature. One article on EMS- to-emergency-department hand-offs is mandatory; the student chooses two of the additional four articles provided to read based upon their interests. Students complete a corresponding worksheet for each article.	1, 4
Case presentation checklist	A case presentation guided by a checklist that includes a protocol review, a reference to a peer-reviewed article, and a description of at least one opportunity for improved interdisciplinary communication.	1 - 4

EMS, emergency medical services.

Table 2. A description of the AAMC* Entrustable Professional Activities and Physician Competencies linked to the educational activities that comprise the elective.

Entrustable Professional Activity[11]	Physician Competency reference set[12]	Educational activity
1. Gather a history and perform a physical examination.	PC2, ICS1, ICS7, P1, P3, P5, KP1	Patient encounter log Case presentation checklist
2. Prioritize a differential diagnosis following a clinical encounter.	PC2, KP3, ICS2, ICS3	Case presentation checklist
6. Provide an oral presentation of a clinical encounter.	PC2, PC3, PC4, PC5, PC6, ICS2, ICS3, PBLI1	Case presentation checklist
7. Form clinical questions and retrieve evidence to advance patient care.	KP3, PBLI1, PBLI3, PBLI6	Case presentation checklist
8. Give or receive a patient handover to transition care responsibly.	ICS2, ICS3, P3	Case presentation checklist Student skill-tracking form
9. Collaborate as a member of an interprofessional team.	IPC1, IPC2, IPC3, IPC4, SBP1, ICS2, ICS3, ICS7, PBLI8	Patient encounter log. Case presentation checklist Student skill-tracking form
10. Recognize a patient requiring urgent or emergent care and initiate evaluation and management.	PC1, PC2, PC4, PC5, PC6, IPC4, ICS2, ICS3	Case presentation checklist Open-book protocol exam
12. Perform general procedures of a physician.	PC1	Student skill-tracking form
13. Identify system failures and contribute to a culture of safety and improvement.	KP1, ICS2, SBP4, SPB5	Case presentation checklist

**AAMC,* Association of American Medical Colleges.

scholarly articles related to EMS, and complete a worksheet for each article.

On the final day, each medical student delivers a case presentation, which includes a protocol review, a reference to a peer-reviewed article, and a description of one opportunity for improved interdisciplinary communication. After the student submits their completed educational activities, the annotated answers to the open-book protocol exam and the scholarly article worksheets are sent to the students to ensure their correct understanding of the content.

Before and after the elective, a voluntary, anonymous survey containing demographic, opinion, and knowledge-based questions is distributed, which was reviewed by the SBU IRB. The post-elective survey is not sent until after the students' final grades are posted. These surveys were initially handed to students in paper form; however, during the pandemic, they were moved to an online format. Additionally, students complete formal standard course evaluations administered by the RSOM.

Course Implementation

In keeping with the axiom that "if you've seen one EMS system, you've seen one EMS system," we offer some pragmatic guidance for medical school faculty who may be interested in creating an EMS elective. When sending medical students for ambulance ride-along time, it is important to consider whether an affiliation agreement is needed to ensure appropriate medical malpractice coverage is in place, as well as to confirm what procedural skills medical students are allowed to participate in (ie, endotracheal intubation, intraosseous needle placement). Once the legal coverage is in place, it would be beneficial for the course director to establish a single point of contact within the EMS agency. This individual acts as the liaison with the department, helps orchestrate the scheduling, confirm staffing (location, shift times), troubleshoots real-time problems (eg, if a medical student were to arrive late due to car trouble and needs to rendezvous with the ambulance), and acts as a point of contact in the event of a workplace injury, occupational exposure, or motor vehicle collision.

It is also important to establish what equipment the medical student is expected to bring with them during the ride-alongs. For example, do the students need to bring their own high-visibility safety vest, personal protective equipment, helmet, and turnout gear, or is that provided by the EMS agency? Special attention must be paid to what clothing the medical students wear (closed-toe, supportive shoes are a must), and specific guidance should be given regarding wearing identification badges and branded clothing.

For course directors who may feel they do not have a strong background in EMS, it would be beneficial to consider involving a senior paramedic or supervisor when delivering the introductory lecture or operational orientation. Introductory lecture content material is well covered in general EM textbooks such as Tintanelli's or Rosen's.[13,14] For a deeper dive into content, textbooks used by most EMS fellowships could be considered.[15]

IMPACT/EFFECTIVENESS

Before and after the elective, we distributed a voluntary, anonymous survey (reviewed by the SBU IRB) containing demographic, opinion, and knowledge-based questions. Trends were elicited using descriptive statistics and Mann-Whitney U testing. Recurring themes were elicited from the open-response questions. After completing the elective, students are asked to complete a standardized formal course evaluation administered electronically by the RSOM. These results are provided as an anonymous, aggregated set annually to the course director.

From 2017–2022, 37 medical students participated in the elective, five of whom reported prior EMS experience. Anticipated residencies predominantly included EM (18), anesthesiology (5), and internal medicine (4). Other anticipated residencies included pediatrics, obstetrics and gynecology, neurology, neurosurgery, urology, and psychiatry.

Students averaged 12 patient encounters (range 5-21) during the elective. All students completed the skill-tracking form and delivered a case presentation at the end of the elective, demonstrating an understanding of the prehospital patient course, the protocols involved, and the initial workup in the emergency department. Each student recognized, described, and put into the context of patient safety and systems-based practice at least one opportunity for improved communication between medical professionals, and interpreted the call in the context of a scholarly article.

Thirty-four students (92%) submitted a pre-elective survey, and 21 (57%) submitted a post-elective survey; not all opinion prompts on the surveys were answered (Table 3). Mann-Whitney U testing suggested a significantly improved understanding of the capabilities of different EMS clinician levels and of the different types of medical oversight after the elective (median pre-elective score = 60%, median post-elective score = 90%, U = 118, $P<0.001$). Qualitatively, students repeatedly used the terms "practical," "involved," "included," "hands-on," and "eye-opening" when describing their experiences.

Over the five years, 33 of 37 medical students completed the standardized formal course evaluation administered electronically by the RSOM (Table 4).

An EMS elective based on andragogy and emphasizing intentional interdisciplinary communication, while being cognizant of faculty responsibilities, seems useful in facilitating an improved understanding of the fundamentals of EMS practice for final-year medical students and attracts students beyond those interested in emergency medicine. Quantitatively, students demonstrated an improved understanding of fundamental components of EMS, such as medical direction and scope of practice for different certification levels (Table 5).

Qualitatively, students were immersed in a world distinct from what they are used to in-hospital. Many of the procedures are novel, and those that are familiar now have unusual nuances, such as being performed in patients' homes. This affords the opportunity to obliterate perceptions of medical hierarchy as medical students and EMS professionals become equal partners in the exchange of information. Medical students offer knowledge from their clerkship activities. In return, the opportunity for EMS professionals to

Table 3. Medical student responses to post-elective anonymous course evaluations.

Prompt	Responses
Is there anything that stood out in your memory about the elective (e.g., an experience, an interaction)?	- During one of the 9-1-1 calls I was a part of, I remember how quickly but methodically the medic worked through all the tasks we needed to complete. One of my primary goals at the end of my training in EM is to be able to manage a super-unstable patient that well. - The rapport that the paramedics built with the patient during the transport - How integral a role EMS plays in patient care. I think this is unappreciated by medical professionals. - The amazing MSU system- every part of it. The organization, the skills, the teamwork, the technology, and the care.
If you were asked to give a lecture to a group of EMTs or paramedics, what topics would you speak about?	- The importance of communication - Cultural competency when taking care of LGBTQ+ patients - Managing a laboring patient - Tips for caring for newborns and young pediatric patients
If a paramedic were to give a lecture to a group of medical students, what topics would you like to hear about?	- Scene management - Some of the experiences prehospital providers go through on scene that hospital providers never see - Practical medicine (drug math, physically moving patients) - Clinical pearls about running codes in unconventional or uncontrolled settings - Thought process during initial interventions - Thought process during MCIs - How their HPI and exam can be limited due to patients' living conditions, initial location in the house, physical obstacles; and how to overcome those challenges

EMS, emergency medical services; *EMT,* emergency medical technician; *MCI,* mass casualty incident; *HPI,* history of present illness; *MSU,* mobile stroke unit; *EM,* emergency medicine; *LGBTQ,* Lesbian, Gay, Bi-sexual, Transgender, Queer, or Questioning.

Table 4. Aggregate results of five years of medical student responses to the standardized formal course evaluation administered electronically. Of the 37 students who took the elective, 33 completed the evaluation.

Prompt	Strongly disagree n (%)	Disagree n (%)	Indifferent n (%)	Agree n (%)	Strongly agree n (%)
This course had clear learning objectives.	1 (3%)			4 (12%)	28 (85%)
This course met its stated objectives.	1 (3%)			4 (12%)	28 (85%)
The teaching methods were appropriate for the stated objectives.	1 (3%)			4 (12%)	28 (85%)
The evaluation methods were clear.	1 (3%)			5 (15%)	27 (82%)
The evaluation methods were applied consistently and fairly.	1 (3%)			5 (15%)	27 (82%)
The course content was relevant and of sufficient detail.	1 (3%)			4 (12%)	28 (85%)
Adequate time was provided in this course to meet the learning objectives.	1 (3%)			5 (15%)	27 (82%)
There was good integration of basic science and clinical correlates in this course.	1 (3%)			5 (15%)	27 (82%)
The learning materials in this course were appropriate.	1 (3%)			5 (15%)	27 (82%)
Overall, this course was well structured.	1 (3%)			5 (15%)	27 (82%)
Overall, I am very satisfied with this course.	1 (3%)			4 (12%)	28 (85%)
I would recommend this elective to future students.	1 (3%)			4 (12%)	28 (85%)

Additional comments:
-Excellent opportunity for emergency medicine candidates and other students alike to gain exposure to pre-hospital medicine and what happens before patients get to the front door of the hospital. Would highly recommend this course as an experience for any medical student.
-Well organized, with the schedule of shifts sent to us in advance. Also, great opportunity to learn about the role of EMS, and the relationship between physicians and EMS.
-It was so much fun and such a great learning opportunity to get to work hands on with patients in highly acute situations. You learn so much about the prehospital and transport world that'll benefit me for years to come.
-This is a great course. It's very helpful to provide a better understanding of how EMS works and the challenges they face daily.
-This elective was one of the best structured with appropriate checklists and well thought-out learning points. Everyone involved was aware of incoming students and excited to teach.
-Working alongside extremely knowledgeable and friendly prehospital staff and learning practical life-saving skills.

impart their unique skill-set to individuals who will become the physicians receiving their patients builds camaraderie and mutual respect. This value in recognizing complementary strengths is especially evident with the student skill-tracking form as it offers medical students an opportunity in a low-stakes environment to ask what they may perceive to be "silly" questions, such as how to apply oxygen to a patient or even confirm that an oxygen tank does indeed have oxygen in it.

With this interdisciplinary immersion also comes the direct opportunity to experience how crucial effective, timely communication is and the consequences of poor communication. This is intentionally brought to their conscious thought when reading a mandatory scholarly article about handoffs and again when they deliver a case presentation at the end of the elective. Collectively, these experiences seem to have positively impacted medical student awareness of professionalism, interpersonal and communication skills, and systems-based practice. Finally, the open-ended questions on the post-elective survey encourages students to reflect on their role as both givers and receivers of information as they continue their career-long endeavor of practice-based learning and improvement.

In response to student feedback, the ratios of different ride-along types have been adjusted. Before the COVID-19 pandemic, students spent more time on interfacility, critical care transport ambulances, spent a shift in the medical control office for the county, and had the opportunity to ride in an SUV first-responder fly car. Due to physical distancing requirements when the elective resumed following the peak of the pandemic, medical control and the fly cars were removed; prior student feedback also suggested these were the least productive of their experiences. Additionally, the department has seen a change in types of requests for service, with more call volume coming from 9-1-1 ambulances and less call volume coming for critical care interfacility transportation. Therefore, students now spend more time on 9-1-1 ambulances and the mobile stroke unit and less time with the critical care transport teams.

Acknowledging medical student expectations of the course load of an elective, we have considered adding an introduction to disaster management and incident command via FEMA IS-100.C. We have also considered adding interdisciplinary

Table 5. Aggregate results of five years of medical student responses to medical knowledge questions on pre- and post-course surveys as analyzed by Mann-Whitney U testing.

Question	Students Answering Correctly n (%) Pre n = 34	Post n = 21	U value, P-value
In NY, the highest level of 9-1-1 prehospital care is provided by: (paramedic)	16(47%)	16(76%)	U=253, P=0.04
In NY, EMT-Basics are allowed to administer all the following medications except: (morphine)	27(79%)	13(62%)	U=295, P=0.16
In NY, EMT-Basics are allowed to perform all the following skills except: (IV insertion)	21(62%)	17(81%)	U=289, P=0.14
In Suffolk County, [9-1-1] paramedics are allowed to administer all the following medications except: (propofol)	21(62%)	19(90%)	U=255, P=0.02
In Suffolk County, paramedics are allowed to perform all the following skills except: (pericardiocentesis)	31(91%)	17(81%)	U=321, P=0.27
Prehospital care professionals work under the medical license of: (their medical director)	28(82%)	21(100%)	U=294, P=0.04
In NY, a paramedic's initial education is at least how many hours: (1,000)	18(53%)	20(95%)	U=206, P=0.001
In NY, an EMT-Basic's initial education is at least how many hours: (150)	16(47%)	14(67%)	U=287, P=0.16
When a paramedic provides an intervention to a patient without calling a physician, they are using: (standing orders)	12(35%)	17(81%)	U=194, P=0.001
When a paramedic is on scene and wants to perform an intervention not specifically mentioned in their protocols, they must: (call the medical control physician)	20(59%)	19(90%)	U=244, P=0.01

simulation cases to reduce experiential gaps caused by the unpredictable nature of 9-1-1 calls. It also deserves specific mention that the engagement and interest of paramedic preceptors is crucial for students' positive experiences. Timely, appreciative feedback is provided to preceptors with inclusion of agency leadership, and quotes from students are included in annual EMS weekly emails to the department in recognition of their efforts.

LIMITATIONS

The most significant limitation of this study is the quantitative feedback that was received. After the elective resumed following the initial COVID-19 pandemic peak, the voluntary, anonymous pre- and post-course evaluations were moved to an online format, which reduced response rate. Despite specialty unit involvement, the content and focus of the elective as far as skills, knowledge, and interpersonal skills have stayed true to the central tenants of EMS medicine. Thus, we believe our educational resources can be implemented in other settings with a reasonable degree of adaptation to meet their local needs.

CONCLUSION

An EMS elective using andragogy and intentional interdisciplinary communication seems useful in facilitating an improved understanding of the fundamentals of EMS practice for final-year medical students. Given limited, if any, guidance on how to educate future physicians about the most crucial aspects of emergency medical services, we offer a pragmatic description about how to start an EMS elective, including course objectives tied to national medical school education competencies, sample syllabi and educational activity templates, and recommendations on how to overcome operational challenges inherent to EMS such as scheduling, liability, and communication, to encourage an optimal medical student learning experience.

APPENDICES

A. Supplementary Course Material.

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Harnessing Residents' Practice-based Inquiries to Enhance Research Literacy: The Thoughtful Reading of Evidence into Clinical Settings (T-RECS) Initiative

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Introduction: Research literacy is an important competency for all clinicians, but developing resident enthusiasm for it is difficult. At one academic emergency medicine (EM) residency program, we designed an innovative program to help residents improve literacy skills within a community of practice and use research literature to address clinical problems.

Methods: A six-member faculty core team surveyed residents to assess their baseline experience with evidence-based medicine (EBM) and level of engagement with the medical literature. Interested residents joined an iterative curriculum development process that drew on previous EBM pedagogical experience and literacy theory. We developed a semi-structured approach that prioritizes using the reference frame of clinical applicability rather than research methodology. We held 90-120 minute sessions three times a year as part of the regular residency didactic conference; post-session evaluations with quantitative and qualitative elements were used to adjust subsequent didactics to refine the approach.

Results: An average of 48 residents were in the EM training program during the nine sessions conducted during the study period. At baseline, residents had a high degree of exposure to EBM during medical school (94% of respondents) but low confidence in reading the medical literature (25%) or applying research to practice (10%). In contrast, they reported the novel program equipped them with skills to interpret literature and led to collective practice improvement. We found engagement was highest when residents led sessions based on inquiries that emerged out of their own training experience. Other positive factors included well-facilitated discussions between residents, relating questions to data-driven review of local practice patterns and addressing findings from free open access medical education (FOAMed) sources. The initial stages required significant team effort to design the pilot sessions, but later sessions were developed following the trajectory of resident inquiries using a minimally structured faculty consensus process and required less than 12 total faculty hours of commitment.

Conclusion: An innovative program centered on residents' practice-based queries of research literature appears to enhance learner enthusiasm for development of research literacy. Further development is needed to validate the overall effectiveness and generalizability of this approach. [West J Emerg Med. 2025;26(3)564–568.]

INTRODUCTION

Understanding the medical literature has always been an important skill for healthcare professionals, including physicians in clinical practice. Physicians are expected to stay abreast of emerging knowledge about new diseases, diagnostic approaches, and treatments to advance the care they provide to their patients. Facility with reading literature is crucial to properly applying it to local practice environments and individual patient needs.

The volume of medical literature has grown exponentially in recent years.[1] Accordingly, entire ecosystems of resources have emerged that provide pre-appraisal and interpretation of research, including the collection of sources known as free open access medical education (FOAMed).[2] Residents now need to know how to interpret and use both primary and secondary sources. However, the traditional methods of teaching research evaluation, such as critical appraisal checklists and statistical lectures, are of questionable benefit to clinically oriented learners and do not apply to FOAMed sources.[3,4]

We sought to develop a new approach to developing literacy, one that would foster a community of practice that engaged the medical literature in the context of resident experience. To distinguish this effort from traditional ones and emphasize our intended focus on application to practice, we named it "Thoughtful Reading of Evidence into Clinical Settings," or "T-RECS."

METHODS

Setting

This educational innovation was developed in an emergency medicine residency program affiliated with two urban, academic medical centers within one hospital system. This 48-trainee, four-year program during the study period was staffed with 12 residents per class, who covered emergency department (ED) sites treating more than 250,000 patient visits annually. Approval by the institutional review board was not sought as this was an educational initiative conducted entirely within the context of the standing didactic program, and individual subjects were not enrolled. Residents participated in the sessions as part of their weekly general didactic conference; the T-RECS organizing group did not influence which residents attended or took part.

Initial Curricular Development

A core group of six faculty assembled to design and implement a new approach to teaching what has traditionally been called evidence-based medicine (EBM). The team included a residency assistant program director, departmental operations and quality improvement leaders, the director of clinical pathway development, and other faculty with experience in teaching EBM.

We developed a needs assessment survey (Supplement Material 1) to gauge baseline exposure to and facility with EBM, typical sources of medical literature, and related practice behavior. The survey was distributed electronically over the residency mailing list and completed anonymously by respondents via Qualtrics (Qualtrics International Inc, Provo, UT). Two residents were recruited into the curricular development team based on their responses to the survey. We considered various approaches to curriculum development, but there was clear consensus on making our focus the clinical application and contextualization of primary and secondary research reports. We also decided that maximizing learner engagement would take priority above an attempt to comprehensively cover concepts related to research design and statistical methodology.

Pilot Session Planning

The resident participants shared clinical questions they had encountered during their practice and identified sources of information they had accessed to address those topics. Choosing a few topics that seemed promising from the perspective of engagement and available evidence, our group surveyed attending physicians on their personal practice in those subject areas to create linkage to local context. The core team then met to identify potential points of emphasis ranging from methodological and statistical to clinical applicability; we designed a 90-minute, Zoom-based pilot session incorporating the above that we hoped would stimulate rich, resident-led discussion. Residents were broken into small groups, each with a faculty facilitator. Group leaders led semi-structured discussion along the pre-specified points of emphasis, prioritizing dialogue rather than completion of the planned material. (Supplemental Material)

Iteration and Refinement

After a positive response to the first session, T-RECS was scheduled three times a year as part of the regular weekly residency conference series. Subsequent sessions varied in length from 90-120 minutes. Initially, sessions were held virtually because of the COVID-19 pandemic but are now in person.

The approach was refined based on quantitative and qualitative feedback from post-session participant assessments and the observations of the leadership team. After each session, a short evaluation survey was distributed to the participants using a direct link to an anonymous survey. Results of these evaluations helped inform subsequent refinements to our protocol. Different variations were trialed, including covering different topics or papers in each small group, sharing results of faculty practice surveys, review of electronic health record data, and invitation of extra-departmental faculty to contextualize discussions. Enthusiasm for T-RECS has allowed continual recruitment of interested residents who can drive subsequent sessions.

RESULTS

Nine T-RECS sessions have been held. Approximately half of the 48 residents were present at any given conference; over the course of the academic year all residents attend at least one session. In the baseline survey of trainees, nearly all (94%) respondents reported having education on EBM during medical school, with half of those recalling attending more than six lectures on the subject. Yet only 25% of respondents felt "very comfortable" interpreting research studies, and only 10% were confident in their ability to judge the applicability of a study to their own clinical practice.

On the other hand, post-session evaluations conducted after conference have revealed consistent positive sentiment toward T-RECS. Compiled results from post-session evaluations after the first five sessions are reported below in the Table. While subsequent sessions did not evaluate the same questions, there has been continued high satisfaction the overall approach and level of emphasis on statistical concepts. Qualitative feedback from residents have revealed clear themes. Clinical relevance is seen as a major positive, as are small-group discussions, effective faculty facilitation, a pivot away from statistics, and the use of resident-discovered resources. The feedback received from the pilot session are reported in full in the Supplemental Materials as a sample of the comments received. Feedback from faculty leadership reported similar findings, with emphasis on the observation that engagement was best when topic selection was driven by spontaneous resident inquiries into issues and decisions that they had found frustrating in clinical practice.

Current Framework of T-RECS Sessions

While emphasis on formal critical appraisal tools is of little interest to our residents, the need for some basic shared framework for group reading and discussion became clear. The PICO formulation (patients, intervention, comparison, outcomes) emerged as an ideal structure for this purpose. Originally developed as a tool to guide systematic evidence reviews, PICO is usually used as a framework for formulating clinical research questions.[6,7] We use the acronym as a guide to identifying the fundamental points of comparison between reported research results and clinical practice. Active identification of the PICO components while reading creates a scaffold by which the applicability to practice can be integrated into each reader's own medical knowledge and context.

Present Approach to T-RECS Session Planning

Preparation time for each conference has significantly shortened with experience and now averages less than 12 faculty hours per session between 2-3 faculty members. This translates to an approximate faculty salary cost of $2,400 per session, or $7,200 per academic year to maintain the program. Session planning begins by soliciting clinical topics from residents based on actual searches they have recently independently conducted and the sources they had used. Faculty identify the potential teaching points available in the primary research reports, secondary appraisals, and the search process. These considerations are condensed into a set of prompts and discussion points that are used to facilitate small-group conversation.

Table. Results of voluntary post-evaluation survey results. Responses were collected as Likert-type items, from 1 (most negative) to 5 (most positive) and are reported as mean and standard deviation, except for "emphasis on statistical concepts," which was collected as a 3-choice response: "too little"; "too much"; or "just right (reported as percentage response.)

	N	"The session increased my ability to evaluate the relevance of research to clinical practice"	"Discussion of collective clinical practice enhanced the session"	"The facilitation was effective"	"The emphasis on statistical concepts was 'just right'"	"The *additional element improved the session"	*Additional element
Session 1	13	3.9 (1.1)	3.9 (1.1)	4.2 (0.9)	46.2%	4.4 (0.8)	FOAMed piece
Session 2	13	3.8 (0.8)	3.8 (1.2)	4.2 (0.9)	92.3%	3.9 (1.0)	FOAMed piece
Session 3	13	3.3 (1.2)	3.9 (1.0)	3.7 (1.4)	53.8%	3.2 (1.1)	Outside content expert
Session 4	13	4.1 (1.0)	4.5 (0.9)	4.5 (0.8)	76.9%	4.1 (1.1)	Survey of faculty opinion
Session 5	29	4.5 (0.7)	4.7 (0.5)	4.8 (0.4)	96.6%	4.5 (0.6)	Faculty vs faculty debate

FOAMed, free open access medical education

DISCUSSION

Nurturing emergency physicians to be adept at informing practice through research enhances patient care. Such clinicians are better equipped to navigate the dynamic landscape of medicine. But teaching research literacy is difficult. Prior attempts at our institution to address this using various educational formats were less successful.[8] They relied on traditional EBM methods that skewed heavily toward methodology and statistics and reflected the "educational prescription" model that had been promoted in early EBM literature.[7] In those models, residents are required to formulate research questions and conduct quasi-systematic reviews. Residents find such exercises artificial and disconnected from their clinical education.[9]

The T-RECS approach instead seeks to enhance "literacy." Rather than try to teach biostatistical methods to aspiring clinicians, T-RECS draws on the activities and realities in which the learners are actually immersed. It fosters the ability to integrate information from the research literature with knowledge from personal and shared practice experience. It constitutes a program for resident empowerment akin to the literacy methods developed by the Brazilian educator Paulo Freire, using the advantages conferred by team-based, small-group learning.[10, 11]

The T-RECS approach coheres with the Accreditation Council for Graduate Medical Education practice-based learning and improvement (PBLI) competency, particularly as the EM milestones call for literature review in relationship to practice issues encountered by residents.[12] The PBLI competency conceives such review as a core aspect of reflective practice.[13, 14] On the other hand, T-RECS is distinct from journal club. In most programs, journal club is held outside clinical or educational hours, which emphasizes its social function.[15] It can serve as a means of keeping up with the literature and acquisition of critical appraisal skills, but it is typically expert-led and responds to what is important to publishers of medical journals.[16] In contrast, T-RECS is resident-driven and focuses on inquiries arising from their actual practice experience. Although a curricular approach has been advocated for journal clubs,[17] we avoided imposing any such framework in T-RECS to maximize the immediacy of resident-driven topics and literature.

Therefore, we worked with organically emerging topics, while being mindful to expose learners to a breadth of concepts and skills. Further details on sessions are available in the online Supplement. The FOAMed resources are often cited and heavily influence their perspectives, and our survey confirmed that they are used more frequently than primary sources in connection with practice-based inquiries. We drew on them to frame the T-RECS session alongside primary sources they are based on.

LIMITATIONS

There are some limitations to this approach and our findings thus far. Substantial faculty time and effort were required to initiate the program, although this has diminished significantly over time. We benefited from an established emphasis on facilitated small-group learning within the program, which may not be available in all settings. The T-RECS approach also relies on meaningful resident engagement; while participation has been robust, maintenance of a community of practice, a culture of shared inquiry and practice transformation, is critical for the sustainability of the program. Finally, T-RECS is aimed at the clinically oriented trainee. Although most residents in our program fit this profile, systems with a higher percentage of research-oriented learners may desire more emphasis on methodology and statistics.

CONCLUSION

A resident-driven approach to enhancement of literature reading skills that emphasizes applicability to practice and context over statistics and research methodology has resulted in a positive learner response. Further development and exploration of its applicability to other EM programs appear warranted.

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Descriptive Analysis of Resources Used to Learn About Residency Programs Since Transition to Virtual Interviews

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Introduction: The transition to virtual interviews over the past four years has been associated with changes to the ways that applicants collect information on residency programs.

Methods: Our program collected free-response data from questionnaires completed by applicants prior to their virtual interview days over the course of four recruitment cycles. We performed a descriptive analysis of these responses to identify the frequency with which students have been accessing various resources to learn about programs, and to learn how that has changed over time.

Results: Our findings over four years and 322 applicants (of 391 surveyed, response rate 82%) indicated that the three most common sources of information were individual program websites, the Emergency Medicine Resident's Association (EMRA) Match website, and Instagram. These sources were reported more frequently than personal experience, word of mouth, and advice from mentors. Other online resources were rarely used.

Conclusion: These findings may help program leaders to direct their limited time and attention towards marketing their programs through online resources most commonly used by applicants. [West J Emerg Med. 2025;26(3)569–572.]

INTRODUCTION

Since the onset of the pandemic in 2020, residency application and interview processes have changed dramatically. The transition from in-person to virtual interviews and the decreased availability of visiting rotations has created challenges for students in assessing programs and experiencing their unique elements.[1–3] With the rise in use of social media and various online platforms for sharing information and interacting with programs, medical students may place greater value on these web-based resources than advisor recommendations, word-of-mouth, and official websites endorsed by national organizations. An awareness of applicants' level of engagement with various resources exploring residency programs could help program leaders direct their time and attention toward those resources most commonly used by applicants. We aimed to provide a descriptive analysis of the resources used by applicants to our program, and how their use has evolved over the last four years, to better inform program leaders in their ongoing recruitment efforts.

METHODS

We conducted this study at our three-year, academic program in the Northeast. The emergency medicine (EM) residency program began in 2019 and accepts six residents each year. Over the course of four consecutive academic years (2020-2024), our program coordinator sent a brief electronic questionnaire to each applicant prior to their interview day. In addition to asking (1) why applicants were interested in our program and (2) whether they were interested in any specialty areas of emergency medicine, our survey also asked (3) "What resources have you used to learn more about our program?" Responses to the first

two questions were provided to interviewers to make our short virtual interviews more efficient. Free-text responses to the third question were reviewed in aggregate by our selection committee at the end of each interview season in an effort to best inform our future program recruitment efforts. After recognizing trends over the past four years, we decided to perform a descriptive analysis to share our findings.

All responses were deidentified, and this project was found to be exempt from institutional review board review. To measure the frequency of reported resources used from our free-text responses, we used the Linguistic Inquiry and Word Count (LIWC) (https://www.liwc.app) program. This validated text analysis software program analyzes text files and compares words within a text document to predefined word dictionaries, customized by the study team. For example, the category "Conference" included the words: fair, meeting, conference, American College of Emergency physicians (ACEP), and Society of Academic Emergency Medicine (SAEM). In creating the dictionary for each category of resources, two investigators reviewed the responses to reach agreement. (See Appendix for customized dictionary)

Population Health Research Capsule

What do we already know about this issue?
The transition to virtual interviews over the past four years has been associated with changes in ways that applicants collect information on residency programs.

What was the research question?
We identified the frequency with which students access information about programs from various resources.

What was the major finding of the study?
With a response rate of 82%, we found that the three most common resources were individual program websites, the Emergency Medicine Resident's Association (EMRA) Match website, and Instagram.

How does this improve population health?
These findings might help program leaders to direct their efforts towards those resources that might have the greatest impact on recruitment.

RESULTS

Over four years, our pre-interview survey was sent to 391 medical student applicants selected to interview at our program and we collected responses from 322 (response rate 82%). Figure 1 shows the proportion of applicants that reported using various resources for learning about our program.

The residency program's website continues to be the most frequently used resource. The Emergency Medicine Residents Association (EMRA) Match website has been a close second but seems to be decreasing in the proportion of applicants that use this site. Instagram use appears to be rising slightly each year. All three of these resources (program website, EMRA Match website, and Instagram) were reported to be used more frequently than personal experience, word of mouth, conversations with peers, and advising from mentors. Other sites including Residency Explorer, National Resident Matching ProgramRMP, Doximity, Association of American Medical CollegesAAMC, Fellowship and Residency Electronic Interactive Datase (FREIDA), Twitter, and Reddit were used by a small minority of applicants.

DISCUSSION

Since the pandemic, the shift to virtual interviews has been viewed favorably by medical students, with advantages including decreased costs, fewer scheduling conflicts, decreased carbon footprint, and the opportunity to easily interview with programs across geographically distant locations.[4] However, various challenges have arisen, particularly regarding residency programs' ability to attract highly qualified candidates in the absence of in-person experiences. Residency applicants have expressed that the inability to personally experience programs and their cities is a significant drawback in virtual interviews.[3] One strategy to address these challenges has been an increased reliance on web-based resources such as program websites and social media platforms as a way for residency programs to market their programs and interact with potential applicants.[5] Our findings indicate that these online platforms have supplanted other resources including medical school advisors, word-of-mouth recommendations, and informational websites such as the American Medical Association FREIDA database. As our program grew from newly established in 2019, to two years of graduates in 2023, these findings did not appreciably change.

Prior work has described the factors influencing residency selection, although fewer studies have described resources that students use when determining which programs to apply to.[6,7] Medical students have relied on residency program websites for over two decades, making them one of the longest-standing available resources. Various studies from 2002–2005 surveying applicants to emergency medicine and anesthesia reported that the program website was an important factor in their decisions to both apply to and rank programs.[8–10]

The rise of social media use by medical students over the past decade has created an additional tool for the dissemination of information by residency programs when recruiting potential applicants.[11,12] Medical students are increasingly using social media, in addition to program websites and other resources, to gather information from residency programs. In a 2020 study of medical students applying to anesthesia programs, the most used resources when researching residency programs included program

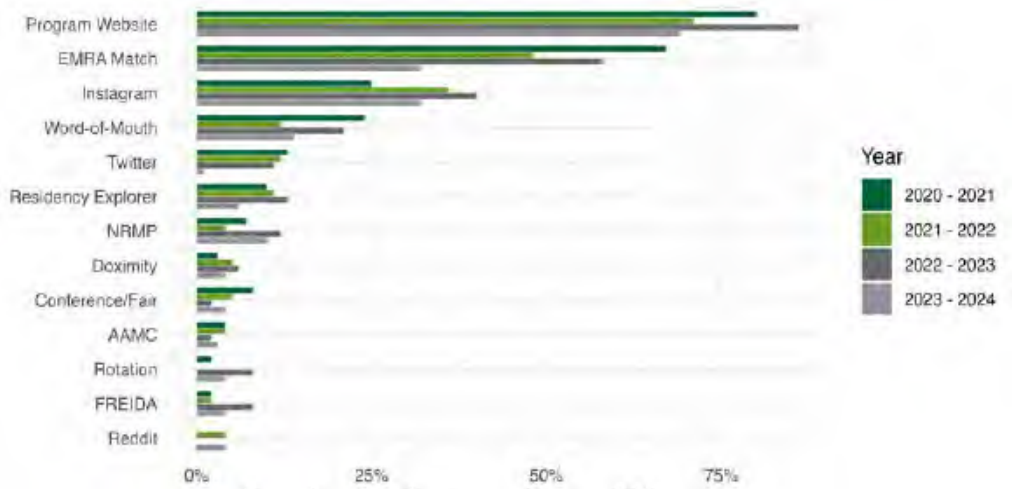

Figure 1. Proportion of applicants that reported using various resources to learn about residency program.
EMRA, Emergency Medicine Residents' Association, *NRMP*, National Resident Matching Program; *FREIDA*, Fellowship and Residency Electronic Interactive Datase; *AAMC*, Association of American Medical Colleges.

websites (91.5% of applicants) as well as social media platforms including Doximity (47.6%), Instagram (38.5%), and X (formerly Twitter, 19.4%).[13] Similarly, for medical students applying to general surgery residency programs in the 2020–2021 application cycle, residency program websites were the most used resource (92.4% of applicants), followed by social media platforms including Doximity (36.5%), X (35.6%), Instagram (33.7%) and Facebook (11.6%).[14] The relatively low use of X may be explained by our program's discontinuation of active use in 2022.

Additional shifts in social media use have been documented during and following the COVID-19 pandemic. For example, the use of X increased from 21% to 41% in matched applicants to neurosurgery programs in the application years 2021–2022 as compared to 2019–2020.[15] Use of social media accounts by residency programs also increased. In an evaluation of EM residency programs, an increase in social media use by 34% was documented following the onset of the COVID-19 pandemic in 2020.[5] The most commonly used social media platforms by EM programs were X (75% of programs), Instagram (61% of programs) and Facebook (38%). Instagram use increased the most following the onset of COVID-19, with nearly half of all accounts created after March 2020, illustrating the dynamic nature of the use of these platforms in communicating with potential residency applicants.

Our descriptive analysis of resources used by applicants to learn about EM residency programs was in line with the trends from prior studies, yet some of our results were unexpected. Instagram use is rising and will likely surpass use of the EMRA Match website in the next interview season. The many other sites and online databases for students through our national organizations were rarely reported to be used.

Our "word-of-mouth" category included advising from mentors and conversations with peers. While it may seem surprising that this category was lower than the three resources above, the design of this study likely did not allow us to fully capture the impact of personal conversations. This free- text response measured frequency, without a way to measure the value of the information. Rotation experiences were also quite low. Some respondents may not have considered these to be "resources" and, therefore, did not consider typing "rotation" or "word of mouth" into our questionnaire.

LIMITATIONS

The strength of our data lies in the sample size of 322 applicants over four years. However, a limitation is that the sampled cohort comes from a single residency program in the Northeast, established in 2019. Applicant responses may have differed if surveys were conducted at other programs across the country. Our method of data collection used free-text responses, which allowed students to type in the sources that first came to mind. Although this approach provided valuable insights, using a drop-down list or a menu of options might have been more efficient. Future research could include a multicenter study across various programs nationwide or a standardized question with a list of options to rank in order of preference, possibly integrated into commonly used scheduling platforms, such as Thalamus or the Electronic Residency Application Service.

CONCLUSION

Our descriptive study of reported resources used by applicants to learn about residency programs showed that the program website remains the top resource and that Instagram and the EMRA Match website are also frequently used. Other websites and online databases, as well as program fairs at conferences, are rarely reported by applicants as providing important information. These findings might help program

leaders to direct their efforts towards those resources that might have the greatest impact on recruitment.

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Emergency Medicine Residency Website Wellness Pages: A Content Analysis

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Introduction: The COVID-19 pandemic impacted the way medical students seek residency positions. In 2020, the Accreditation Council for Graduate Medical Education advocated for virtual interviews. Most emergency medicine (EM) interviews in 2023 remained virtual, and this format will persist for the foreseeable future. Since students are not evaluating programs in person in most cases, residency websites are crucial for prospective residents. Resident wellness is critical for resident training and important to prospective residents; it follows that programs must be transparent about resident wellness on websites. In this study we aimed to quantify the number of EM programs with wellness pages on their websites and identify themes portrayed on those pages.

Methods: We analyzed residency website wellness pages from EM websites based on the 2022 directory of the Electronic Residency Application Service. We independently coded wellness statements through an inductive process. Codes were revised iteratively to consensus and organized into themes.

Results: We identified 278 (100%) EM residency websites. Of these websites, 57 (20.5%) had a wellness page, 45 (16.2%) linked to an institutional page that discussed wellness, 169 (60.8%) discussed wellness themes on their website in areas other than a wellness page, and 69 (24.8%) had no direct mention of wellness anywhere on their website. Using this information, we identified themes including community involvement, growth and development, nutrition and health, psychological well-being, social and relaxation activities, wellness culture and environment, wellness curriculum, wellness structure and resources, and work-life integration.

Conclusion: Most EM program websites do not include a wellness page. Of the programs that do, we identified important themes. The absence of dedicated wellness pages on most EM websites suggests an opportunity for programs to better communicate their wellness initiatives to applicants, helping them identify programs that align with their values. [West J Emerg Med. 2025;26(3)573–579.]

INTRODUCTION

Physician wellness is critical.[1] Burnout, as defined in the 1970s by Herbert Freudenberger, details the repercussions of significant amounts of stress in "helping professions."[2] Emergency medicine (EM) has a higher rate of burnout when compared to other specialties.[3] A national EM resident wellness survey study disseminated in 2017 found that 77.7% of residents were identified as burned out.[4] The COVID-19 pandemic exacerbated levels of burnout in subsequent years.[3]

The COVID-19 pandemic also created a shift in the way medical students apply for residency. Specifically, in June 2020 the Accreditation Council for Graduate Medical Education released a statement that advocated for virtual interviews.[5] The Association of American Medical Colleges advocated for a

continuation of virtual interviews for the 2022-2023 cycle, as it eliminates financial and scheduling challenges for programs and applicants. The Council of Residency Directors in Emergency Medicine further encouraged EM residency programs to follow virtual interview guidelines. It appears that virtual residency interviews will remain the dominant format for years to come. Emergency medicine-bound students list program websites as the most important factor in determining their rank lists in the post-COVID-19 era and rank program websites as important in determining faculty reputation, program diversity and inclusion, and program culture.[6,7] We can expect EM students to continue to rely heavily on program websites for the foreseeable future.

Residency training is known to have negative effects on physical, emotional, and social wellbeing.[8] Eliminating the in-person evaluation of perceived happiness and comradery among residents will require programs to be transparent about resident wellness on websites.[5] A survey conducted in 2022 showed that resident wellness was identified by medical students as the most important content on a residency website.[9] Studies have been performed evaluating wellness content on program websites in several fields, but not in EM. By analyzing how wellness is presented on EM websites, we aimed to provide insight into the current landscape of this aspect of wellness communication.

Population Health Research Capsule

What do we already know about this issue?
Wellness is important to applicants when deciding how to rank residency programs. However, wellness content is not always available on program websites.

What was the research question?
What percentage of EM programs have a wellness page on their website and what themes are discussed?

What was the major finding of the study?
20.5% of programs had a wellness page, while 24.8% did not mention wellness anywhere on their website.

How does this improve population health?
Enhancing website wellness content can improve applicant decision-making and encourage programs to think deliberatively about their wellness initiatives.

METHODS

We obtained a list of all EM residency programs accepting Electronic Residency Application Service (ERAS) applications for the 2022 application cycle. The EM ERAS directory was accessed in March 2023, and we accessed each EM program website between April 1–April 30, 2023. If the ERAS directory did not link to a program website, we performed a Google search to identify the residency program website. Each program website was reviewed by a single reviewer to determine whether there was a wellness page on the website. We also reviewed each website in its entirety to determine whether other pages on the website discussed themes of wellness or wellbeing. If a website linked to an institutional page discussing wellness separate from the residency website, that page was reviewed as well. Wellness pages and linked graduate medical education (GME) pages were recorded in an Excel spreadsheet with the full text from that webpage.

At the time of analysis, AS was a medical student, bringing a unique perspective as a prospective applicant navigating the residency application process. BM was an associate program director during analysis. The combination of these viewpoints allowed for a more comprehensive understanding of the wellness information presented on residency program websites. Using constructivist grounded theory, each author independently examined the full text from 15 wellness pages to generate initial codes. AS identified 138 descriptive codes, and BM identified 70 descriptive codes (184 unique codes combined). After discussion and review of each of the first 15 statements, areas of overlap were identified, and the initial codes were consolidated into a codebook containing 47 codes.

We independently reviewed an additional 10 website texts, and the codebook was revised. One code was added, two were removed, and five were redefined, resulting in 46 final codes. We then re-coded the first 25 wellness statements using the updated codebook. The coding structure was stable, and no additional codes were added to the codebook. We coded the remaining wellness statements and identified themes. We then held a Zoom meeting to discuss and resolve discrepancies. During this meeting, we reviewed the source text simultaneously with the codebook open. Through discussion and mutual agreement, we resolved all discrepancies without having to involve an additional coder or arbitrator. Themes were identified by grouping related codes into broader conceptual categories that represented patterns in website wellness content. We discussed these themes and agreed upon them. This study was determined to be non-regulated research by the University of Oklahoma Internal Review Board in February 2023.

RESULTS

We identified 278 EM residency programs based on the 2022 ERAS Directory list of participating programs and specialties. Websites were identified and accessed for 278 (100%) programs. Fifty-seven programs (20.5%) had a main page or subpage dedicated to wellness or wellbeing, 169

(60.79%) programs discussed wellness somewhere on their website other than on a page dedicated to wellness, 45 (16.19%) programs linked to a GME page highlighting wellness, and 69 (24.82%) programs did not directly mention wellness or wellbeing anywhere on their website. Programs were counted in multiple categories if information was included in multiple areas of their website.

Of the 57 programs that had a page dedicated to wellness on their departmental website, 22 (38.6%) were titled "Wellness," 12 (21.05%) were titled "Resident Wellness," and the remainder were a variation of wellness or wellbeing. A complete list of page titles can be found in Appendix A. One wellness page contained pictures only, and it was not included in the content analysis. The most common subjects discussed on wellness pages included social events, mental health, physical health, institutional support, wellness didactics, and burnout. The percentage of programs that discussed each subject can be found in Table 1. The least common subjects, defined as <5%, that appeared on residency wellness pages were empathy, achievement, personal development, legal concerns, leadership skill development, lack of personal fulfillment, imposter syndrome, and harassment.

Nine broader themes emerged from analysis of EM residency website wellness pages:

Theme 1: Social and Relaxation Activities

The most common theme that appeared was social and relaxation activities. 83.9% of programs highlighted retreats, class activities, and other social events on their wellness page and 68.4% included pictures of their residents participating in social activities.

> These outings include paintball, large group dinners, and outdoor activities such as skiing and team sports. In the past they have organized softball games and ping-pong and bowling tournaments between the other local EM residencies.

Theme 2: Psychological Wellbeing

Many programs found it difficult to discuss wellness without discussing burnout. Programs also included their approach to mitigating burnout and building resilience.

> Healthcare providers are not immune to poor wellness and well-being, and their high prevalence of burnout, depression, anxiety, and sleep disorders are all contributing factors.

> At this monthly get together, at an attending's house we discuss building resilience and professional excellence and externalizing and highlighting serious threats to wellness like substance abuse, interpersonal conflict, and PTSD.

Table 1. Distribution of wellness topics on emergency medicine residency wellness webpages.

Wellness topic	N (%)
Social events	47 (83.93%)
Mental health	32 (57.14%)
Physical health	31 (55.36%)
Institutional structure	30 (53.57%)
Didactics	29 (51.79%)
Burnout	28 (50.00%)
Food	27 (48.21%)
Resident wellness committee	24 (42.86%)
Culture	23 (41.07%)
Resilience and coping	23 (41.07%)
Work-life balance	22 (39.29%)
Stress	19 (33.93%)
Resources	18 (32.14%)
Finance	17 (30.36%)
Peer support	17 (30.36%)
Professional development	17 (30.36%)
Local amenities	16 (28.57%)
Mentorship	16 (28.57%)
Counseling services	13 (23.21%)
Relaxation	13 (23.21%)
Depression/suicide	11 (19.64%)
Medical health services	10 (17.86%)
Destructive habits	9 (16.07%)
Professional satisfaction	9 (16.07%)
Spiritual health	9 (16.07%)
Family and childcare	9 (16.07%)
National involvement	8 (14.29%)
Self-monitoring	8 (14.29%)
Community service	7 (12.50%)
Definition	7 (12.50%)
Schedule	7 (12.50%)
Coaching	6 (10.71%)
Efficiency	6 (10.71%)
ACGME requirements	5 (8.93%)
Advocacy	4 (7.14%)
Contract negotiations	4 (7.14%)
Scholarship	4 (7.14%)
Harassment	2 (3.57%)
Imposter syndrome	2 (3.57%)
Lack of professional fulfillment	2 (3.57%)
Leadership skill development	2 (3.57%)
Legal concerns	2 (3.57%)
Personal development	2 (3.57%)
Achievement	1 (1.79%)
Empathy	1 (1.79%)

ACGME, Accreditation Council for Graduate Medical Education.

Programs acknowledged that residents are partners in improving wellness and the best initiatives are often resident driven.

> We understood the importance of resident input and feedback into their own wellness. Who else would know what residents need, in terms of wellness, other than residents themselves?

> This year we added a 4th elected chief resident position specifically dedicated to wellness!

Wellness is not one size fits all and frequently requires a more individualized approach.

> We understand that wellness is not mandatory events, meditation, and yoga for everyone. While we have a robust curriculum to explore the different avenues of wellness, we encourage our residents to identify their own stress relieving practices and to maintain those activities to avoid burning out.

> While we know that residency is hard, we also know that "wellness" is a moving target and that which makes a person "well" is highly individualized.

Theme 3: Nutrition and Health

About half of programs mentioned food available to residents while at the hospital and on shift, as well as gyms and other physical fitness resources available to residents.

> Residents have their own dedicated lounge and fully stocked fridge with food and drinks. There are food trucks available at nearly all hours of the night out front of the main facility to take care of those evening and late-night cravings. Tired of the cafeteria food? Need something quick? The snack shack in the main ED provides this – of course available to use with your meal stipend.

Theme 4: Wellness Structure and Resources

Many programs had both departmental and institutional structure to wellness and addressed their holistic approach on their website.

> The infrastructure supports and promotes preventative care, healthy living, mental health, second-victim support, work-life balance, and peer-peer counseling and mentoring.

> Our wellness activities focus on service, resiliency, and career development, and will continue to grow with creative ideas to support and empower residents.

> Through intentional reflective practices, didactic sessions, and interactive social opportunities, our goal is to help residents maintain perspective and create healthy habits that promote longevity in Emergency Medicine.

Programs also included information about counseling services or methods of monitoring mental health throughout residency.

> Trainees are required to complete the Well-being Index twice each year while in their training program. During resident/fellow semi-annual review meetings with their Program Director, one of the topics for discussion will be the trainee's self-care and completion of the Well-being Index.

Additionally, 42.9% of wellness pages talked about a wellness committee.

> Specific goals of the wellness committee include: Promote a healthy work life balance. Provide physical, psychological, social and professional wellness education. Maintain a peer support and advocacy network for the residents.

> The Wellness Committee, made up of attendings and residents from all years, provides resources, workshops and events to build and support the physical, psychological and emotional well-being of our emergency department.

> The Department of Emergency Medicine has established a wellness committee to promote the wellness of its residents through a multifaceted approach that includes education, social programming, mentorship, and organization-directed interventions.

Theme 5: Wellness Culture and Environment

The clinical environment can be an impediment to resident wellness. Some programs discussed their wellness culture and how they can make changes in the clinical and learning environments to positively impact their team.

> Implementing projects designed to improve the meaning residents find in their daily work.

> Advocating for changes in the learning environment that will improve resident well-being without compromising patient care or education."

Theme 6: Wellness Curriculum

Nearly all programs have a didactics section on their website, but 51.8% of programs with wellness pages featured ways that they incorporate wellness topics into their didactic sessions.

> Developing a wellness curriculum that includes traditional lectures (depression, substance use), faculty panels (sleep, work-life balance), guest speakers (financial health), and experiential exercises (yoga, mindfulness).

Theme 7: Work-Life Integration

The scheduling demands of residency are one of the drivers of decreased wellness. Many programs mentioned how their schedule and other residency requirements directly affects wellness.

> Sleep loss has negative effects including learning and cognition which is why it is important to avoid sleepless nights and to watch for circadian violations.

> Resident centric scheduling, maximizing vacation preferences.

> Every block, each residency class will have a protected Wednesday evening as a class after Grand Rounds to spend time as a class, have social events sponsored by the residency program, catch up on appointments, errands, or have family time.

> In order to decrease physician burn-out, our shifts are 8-hours in length. We also encourage our providers to stop seeing new patients 1-hour before shifts end in order to decrease charting-time past your shift. Moreover, as you progress in your residency, the total number of your shifts per block gradually decreases, allowing for more time for other activities.

Theme 8: Growth and Development

Professional growth and development is a natural and necessary part of residency. Many programs outlined various curricula and mentoring programs that help their residents succeed professionally and improve their mental wellbeing.

> The focus of coaching is to improve current performance by helping a person learn how to do things better to reach their desired outcome. The goal of coaching is to help trainees reach their peak potential, personally and professionally while in training.

> Faculty mentors are chosen for their professional and life experience and ability to model and mentor healthy life/work balance and continued joy and success in their practice of medicine. Through the faculty mentorship program, residents are guided through their residency and are able to learn and adopt skills from their mentor's years of experience.

Theme 9: Community Involvement

Although community involvement appeared less frequently than many other themes, some programs highlighted their involvement in wellness and advocacy on a national level.

> Our section strives to provide local, regional and national leadership toward improving the health and wellness of all physicians and healthcare providers. Leaders in our department have been involved in advocating for and promoting local, regional, and national change in the healthcare system with the goal to improve wellness for physicians and healthcare providers.

Forty-five programs linked to a general GME wellness page that applied to all residencies, not just EM. These pages were analyzed as well using the same codebook developed for EM pages. The most common subjects on GME wellness pages included wellness resources, mental health, physical health, and institutional support. All subjects discussed on GME pages can be found in Appendix B.

Most programs (60.79%) discussed their program's commitment and approach to wellness on areas of their website other than a dedicated wellness page. The most common website pages on which themes of wellness were mentioned included PD/Chair Welcome, Curriculum, Why Us, Mission/Values, FAQs, and Overview. The complete list of page titles that include themes of wellness are outlined in Appendix C.

DISCUSSION

Residency applicants strongly consider wellness when determining which programs to apply to and rank.[9] Residency websites are one of the few ways that applicants can learn about a program's approach to wellness. Despite this, only 68.35% of EM residency websites discussed wellness directly on their websites, and only 20.50% had website pages dedicated to wellness. Over half of programs that had wellness pages on their websites discussed social events, mental health, physical health, having institutional structure for wellness, wellness didactics, and burnout.

Forty-five programs linked to institutional pages. These pages were evaluated as well, but the topics that occurred most were different from the sub-themes on EM-specific pages. Conveying wellness information is clearest with a page dedicated to wellness, but wellness information appears throughout residency websites. Students may not access all parts of the website; so featuring wellness information on a prominent section such as a "PD Welcome" section or "Program Highlights" would be most visible.

To our knowledge, this is the first study in EM to explore residency websites for wellness-related statements. In 2021 Pollock et al performed a descriptive analysis of EM residency

websites to characterize the presence of 38 items organized into the following categories: general program information; application process; research; facility information; resident information; lifestyle; and social media.[10] Wellness was not directly assessed in their analysis. A radiology group previously performed a deductive analysis of radiology residency websites to determine the presence or absence of 26 predefined criteria related to resident wellness.[5] They found that financial, clinical, and technical aspects of programs were commonly present on websites, but less than 10% of radiology programs mentioned resident mentoring, wellness committees, or their non-clinical curricula.

Similarly, in internal medicine a group reviewed 579 internal medicine websites for variables that a focus group found to be important to wellness and found that 81% of internal medicine websites mentioned wellness, and 41% had a page dedicated to wellness.[11] Pavuluri et al accessed urology residency websites to determine whether the words "wellness" or "wellbeing" were used anywhere on the website and found that only 20% of programs mentioned one of these terms.[12] Using a two-proportion z-test (P <0.001), we found that in EM, a significantly higher percentage of programs mentioned wellness directly.

In contrast to the reviews published in the radiology, internal medicine, and urology literature, we performed an inductive conceptual analysis. We sought to characterize all concepts discussed on residency wellness pages rather than a predetermined list of criteria. While a deductive approach employed by other groups may be less prone to bias, it also misses important content, and the depth of analysis is limited. Our approach allowed us to assess the topics that residency programs deemed important to convey to applicants or the public. Social events were the most common sub-theme on EM residency websites, with 83.9% of programs discussing events that they hold for residents. In programs that linked to a GME page highlighting wellness the most common subtheme was institutional resources.

While there are no published studies that establish a correlation between a residency website's representation of wellness and actual resident wellbeing, describing website representation of wellness among EM programs is still valuable for residency program leadership, marketing teams, web design teams, and social media teams. We hope that this article will lead programs to enhance the quality of wellness information on their website and, more so, to continue to improve wellness initiatives for their program. After reviewing 278 EM websites, we believe that the following information should be included on EM residency program pages:

1. A subpage dedicated to wellness
2. Feature wellness information in a prominent location such as the program director's message or the program highlights
3. The program's approach to social activities, psychological wellbeing, health, wellness resources, culture, and curriculum focused on wellness
4. Specific examples of programming, curricula, committees, resources, or social events that increase wellness and mitigate burnout through inclusion of descriptions, photos, videos, or linked pages

A comprehensive and mission-aligned description of wellness on the program website could increase medical student interest, engagement, and ultimately recruitment to programs. Additionally, reviewing the approach to each of the themes discussed above may lead programs to improve aspects of their program's overall wellness structure.

LIMITATIONS

Our study provides insight into how EM residency programs convey their wellness structure and culture to applicants through their websites, but it is important to acknowledge some limitations. First, we accessed websites in Spring 2023. Because program websites are constantly evolving, the current website content and page structure may be different from when we reviewed. Additionally, websites are only one way that programs communicate information to applicants. In addition to their website, programs may use social media, virtual meet-and-greet sessions, second-look events, interview days, and other means to highlight aspects of their program's wellness efforts. None of those communication platforms were considered in the current study.

Second, we had a small team, and coding was performed by two individuals. While we followed rigorous methodology and iteratively developed and refined a codebook, this type of analysis lends itself to bias. Third, some programs have multiple websites. In this instance, we did consider all wellness statements if they appeared on any website that was found. While our best efforts were made to include data points from any program website, it is possible we may have missed programs who have multiple websites under varying names or nicknames for the program. Finally, our content analysis was based on the presence of concepts and did not assess the detail or quality of information provided.

CONCLUSION

Residency websites are an important resource for medical students when they are reviewing programs for residency. Information about wellness is important to most students. There is significant variation in how programs address wellness topics on their website; 75.18% of programs discuss wellness either on a dedicated wellness page, in other locations on their website, or on a linked institutional wellness page. Of the 20.5% of programs that have a dedicated page to wellness, they explore themes related to community involvement, growth and development, nutrition and health, psychological wellbeing, social and relaxation activities, wellness culture and environment, wellness curriculum, wellness structure and resources, and work-life integration. We hope this study encourages

improvement in the way EM residency programs present wellness information on their websites, as the internet will continue to be a vital source of information for applicants. Future research could explore the alignment or misalignment between wellness programs offered and the perceived needs of EM residents.

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Effects of Emergency Department Training on Buprenorphine Prescribing and Opioid Use Disorder-Associated ED Revisits: Retrospective Cohort Study

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Introduction: Prescribing patients buprenorphine from the emergency department (ED) is recommended by multiple organizations. However, it is unclear how best to encourage physicians to prescribe buprenorphine from the ED. Our objectives in this study were to examine the effects of a departmental-wide training initiative for emergency physicians to prescribe buprenorphine, increase buprenorphine prescribing, and decrease ED re-utilization for opioid use disorder (OUD) complications.

Methods: We performed this retrospective cohort study at an academic medical center. Beginning May 1, 2018, the ED started a buprenorphine-education initiative and tracked the proportion of clinicians who obtained buprenorphine-prescribing certification over the following 16 months. We identified adult patients referred to an addiction clinic from the ED during this period. Our primary outcome was the proportion of patients who received a buprenorphine prescription from the ED. Secondary outcomes included ED re-utilization for OUD complications and buprenorphine refills, as well as follow-up in the bridge clinic within 30 days.

Results: The proportion of physicians eligible to prescribe buprenorphine increased from 37% to 88% over the study period, and 430 patients were referred to an addiction clinic. The proportion of patients referred to a bridge program who received a buprenorphine prescription increased from 50% during the first month compared to 92% during month 16 (odds ratio 1.14, 95% confidence interval 1.08-1.21 per month). There were no statistically significant changes in any secondary outcomes.

Conclusion: Our intervention increased buprenorphine prescribing by emergency physicians. It did not decrease ED reutilization for complications related to opioid use disorder. [West J Emerg Med. 2025;26(3)580–587.]

INTRODUCTION

Opioid use disorder (OUD) and associated complications continue to be a major reason for emergency department (ED) visits across the United States. Mortality rates after ED visits for non-fatal opioid overdose are high, with an estimated 1% of patients dying in one month and 5% of patients dying within a year after discharge from the ED.[1] Use of the ED by patients with OUD has been consistently increasing, with opioid-related ED visits doubling over the past 10 years.[2,3] These trends are mainly due to patients with OUD relying

heavily on the ED for most of their healthcare needs. This group of patients tends to be marginalized, with increased rates of homelessness and low socioeconomic status. These are important contributors to decreased access to primary care services and delayed treatment.[4] Therefore, addressing OUD during ED encounters has been recognized as a unique and critical opportunity to initiate medication for opioid use disorder (MOUD) and link patients to ongoing care.

Historically, emergency physicians (EP) have not provided prescriptions to patients interested in MOUD, instead serving as a linkage to outpatient addiction services, such as a primary care physician who is able to prescribe MOUD or refer to an addiction specialist.[5] However, a seminal study published in 2015 demonstrated that ED buprenorphine prescribing with linkage to ongoing care was associated with 78% of patients retained in outpatient addiction treatment, compared to 37% of individuals receiving referral alone and 45% receiving a brief intervention in the ED at 30 days from the ED encounter. Buprenorphine initiation in the ED also significantly decreased the use of inpatient addiction treatment services.[6] Subsequent research has shown similar results in regard to long-term MOUD success.[7] Many professional organizations, including the American College of Medical Toxicology and the American College of Emergency Physicians now strongly endorse this practice in an effort to expand access to addiction treatment services.[5,8]

Despite the evidence supporting prescribing buprenorphine within the ED, the practice has not been adopted universally across the country.[9] Emergency physicians are often uncomfortable prescribing buprenorphine due to lack of experience, and clinicians interested in prescribing buprenorphine must go through eight hours of additional training and register with the US Drug Enforcement Administration (DEA). These barriers, along with the lack of outpatient follow-up, are common reasons for the hesitancy to incorporate buprenorphine into standard practice.[9-12] To combat the lack of outpatient follow-up, many EDs and outpatient addiction medicine clinics are working together to form bridge programs, in which patients seen in the ED are provided with a referral and scheduled appointment to the addiction medicine clinic, usually within days from ED presentation.[13-15]

Buprenorphine prescriptions initiated in the ED have only recently gained attention. Few studies have been published regarding initiatives to increase physician buprenorphine prescribing. Our objectives in this study were to examine the effects of a departmental-wide initiative to receive certification to prescribe buprenorphine and ED re-utilization for OUD complications.

Population Health Research Capsule

What do we already know about this issue?
Complications associated with opioid use disorder are a major reason for ED visits. Buprenorphine administration, prescribing, and linkage to care in the ED is safe and effective.

What was the research question?
Does departmental buprenorphine training increase prescribing and impact reutilization for opioid use disorder-related complications?

What was the major finding of the study?
Buprenorphine prescribing eligibility increased (37-88%) as did bridge referrals (50-92% [OR 1.14, 95% CI 1.08-1.21]).

How does this improve population health?
Buprenorphine access is limited. Departmental training increases physician prescribing and buprenorphine access for individuals with opioid use disorder.

METHODS

Study Design and Setting

We performed a retrospective cohort study at an academic medical center, Cooper University Health Care, in Camden, NJ. Our institution developed a bridge program for patients with OUD in 2018. The bridge program is a referral system in which patients with OUD are referred by an EP to an outpatient addiction medicine clinic. Patients are referred to one of five addiction medicine clinics within Camden County, two of which are part of the study institution. All patients referred to an addiction clinic from the ED have an appointment scheduled prior to ED discharge. Available clinic appointments are posted in the ED. Patients are assigned a specific appointment by the treating physician without the need to contact a clinic directly. Clerical staff send the sign-up sheets to the respective clinic at the end of the day. Patients are also informed that if they miss their appointment, they can walk in during clinic hours for a new appointment. While the bridge program is available for patients with any substance use disorder, in this study we aimed to examine the impact of buprenorphine training on physicians and patients with OUD.

The institutional review board at our institution approved this study with waiver of informed consent. This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement (Supplemental Material).

Participants

The study included all adult patients referred to a bridge clinic by an EP from May 1, 2018–September 30, 2019.

Inclusion criteria were as follows: 1) adult patients (≥18 years of age); 2) evaluated as a patient in the ED; and 3) EP referral to an addiction clinic for OUD during index ED visit. Patients were included regardless of etiology for index ED visit. We used ED bridge clinic referral records to identify potential subjects. If patients were referred to a bridge clinic multiple times within the study period, only the first referral was included in data collection. Follow-up data was only available for those individuals referred to a bridge clinic affiliated with the ED's institution. Because three of the referral clinics were not directly affiliated with the ED institution, individuals referred to these clinics were not included in the analysis as these clinics use a different electronic health record (EHR) and there was no mechanism in place to follow these individuals longitudinally.

Intervention

As part of a quality improvement initiative, our ED Division of Toxicology and Addiction Medicine provided a no-cost educational program to encourage EPs at our institution to meet DEA requirements and become comfortable appropriately prescribing buprenorphine from the ED. All physicians were required to complete this training to prescribe buprenorphine. Our initiative consisted of a no-cost hybrid educational seminar offered multiple times, aimed at obtaining the required training for buprenorphine prescribing. In-person sessions were four hours long and consisted of didactic lectures and small-group discussions. An additional four hours of educational sessions were asynchronous and online. The in-person sessions were led by the addiction medicine team, consisting of EPs and medical toxicologists, as well as a fellowship-trained addiction medicine specialist. Sessions were offered during ED faculty meetings and other various times to work around EP schedules.

The initiative was announced and encouraged by the ED chair during monthly faculty meetings and through email reminders. Additionally, an addiction medicine curriculum was created by emergency medicine (EM) residents in consultation with addiction medicine faculty, and all EM residents complete buprenorphine training prior to graduation. Prior to this initiative, our institution's addiction medicine consult service was available for prescribing MOUD upon ED discharge.

Data Collection

We tracked the proportion of EPs at our institution who were X-waivered over time. Patient data was collected from our EHR Epic (Epic Systems Corporation, Verona, WI). We used Epic Care Everywhere, a continuity-of -care document interchange between hospitals and organizations across the country that use the Epic EHR, which allows sharing of clinical information between EHRs to assess for ED reutilization. We have previously used this methodology to identify ED admissions to any hospital in the country that uses Epic Care Everywhere.[16] The index visit was defined as the ED visit in which the patient was referred to the bridge clinic.

Two investigators independently reviewed the EHR for each subject and abstracted the data. Both abstractors had previous experience using Epic and underwent a formal training session, including performing joint data extraction on a set of practice medical records to ensure uniform handling of data. A standardized data extraction form and predefined definition of variables were used for all data collection. The abstractors held periodic meetings to review coding rules and to monitor performance.[17] We calculated inter-observer agreement using the kappa statistic between the two abstractors. For any discrepancies, the chart was reviewed by both abstractors and consensus was reached. If a consensus was not clearly reached, we planned to have a third reviewer review the case; however, the process for handling disagreement was not required.

Abstracted data included demographics, comorbidities, additional substance use history, the etiology of the index visit, and administration of MOUD in the ED. We also determined the number of ED visits for each patient in the six months prior to the index ED visit, as well as the time from index ED visit until scheduled appointment.

Outcome Measures

Our primary outcome was the proportion of patients with OUD referred to a bridge clinic who were prescribed buprenorphine at the index visit. We also recorded the daily dose (in milligrams [mg]) of buprenorphine prescribed for each patient. Secondary outcomes included the following: 1) ED reutilization (ie, repeat ED visit after the index visit) for opioid complication (ie, withdrawal or overdose) in the six months following the index visit; 2) ED reutilization for buprenorphine refill during the six months after index ED visit; and 3) successful follow-up at the bridge clinic within 30 days of the index visit. To determine ED reutilization we used Epic Care Everywhere as described above. We defined successful follow-up at a bridge clinic within 30 days, as opposed to scheduled appointments, given our clinic allows walk-ins and that many patients with OUD have barriers to making specific appointment times.

As part of standard operating procedure, our bridge clinic maintained a spreadsheet that listed referred patients, their appointment date, and treatment encounter dates, which was provided to the study team. Emergency department patients are referred to one of five local addiction clinics. Data was available for three of the local clinics. We excluded from this analysis subjects referred to the other two clinics. We entered all data into a Research Electronic Data Capture (REDCap, Vanderbilt University, TN) database,[18] hosted at Cooper University Health Care and exported it into Stata/SE 16.1 for Mac (StataCorp, LP, College Station, TX) for analysis.

Data Analysis

We reported continuous variables as mean and standard deviation or median and interquartile range (IQR) depending

on data distribution. We reported categorical variables as frequency and percentages. We used a *t*-test or Wilcoxon rank-sum test to compare continuous variables, and the Fisher exact test to compare categorical variables between patients who did and did not receive a buprenorphine prescription from the ED.

We graphed the frequency of patients referred to an addiction clinic over each study month (every 30 days). We also graphed the proportion of physicians with X-waivers and the proportion of patients who received a buprenorphine prescription from the ED over each study month. For our primary outcome, we used logistic regression to calculate the odds ratio (OR) for receiving a buprenorphine prescription by study month. We also report the OR across the entire 16-month period (ie, OR calibrated for the 16-month change). We used linear regression to test whether prescribed buprenorphine dose (mg) and/or prescription length (days) increased over the study period.

For the secondary outcomes we used a Cox proportional hazards model to calculate adjusted hazard ratios (aHR) with time to ED reutilization for OUD complications as the dependent variable. We entered buprenorphine prescription at index ED visit (yes/no) as the independent variable of interest and adjusted the model for 1) ED visits in the six months prior to index ED visit, and 2) history of co-occurring substance use. We used logistic regression to calculate the OR for successful clinic follow-up as the dependent variable. We entered study month as the independent variable of interest and adjusted for lag time until scheduled clinic appointment (in days). We repeated the Cox proportional hazards model analysis for time to ED reutilization for buprenorphine refill.

RESULTS

Forty-one EPs were employed at the study institution during the study period. The proportion of EPs eligible to prescribe buprenorphine increased over the study period from 37% during the first month to 88% at the end of the study (Figure 1).

A total of 430 patients were referred to an addiction clinic and were included in the study. The number of patients referred to an addiction clinic increased over time (Figure 2). Of the 430 patients, 133 were female (31%). The mean (SD) age was 38 (10) years. Most patients were White (241/430, 56%), and 115 were Black (27%). Sixty-seven patients were Hispanic (16%). Co-occurring substance use was present in 186 patients (43%) (Table 1). There was no significant difference in demographics between patients who received a buprenorphine prescription and patients who did not receive a buprenorphine prescription. Most patients (66%) had an ED visit in the six months prior to the index ED visit. The characteristics of the index visits are detailed in Table 2. Overdose was the most common cause for the index visit (37%). Less than one-third of patients were administered buprenorphine in the ED (30%), and there was no difference

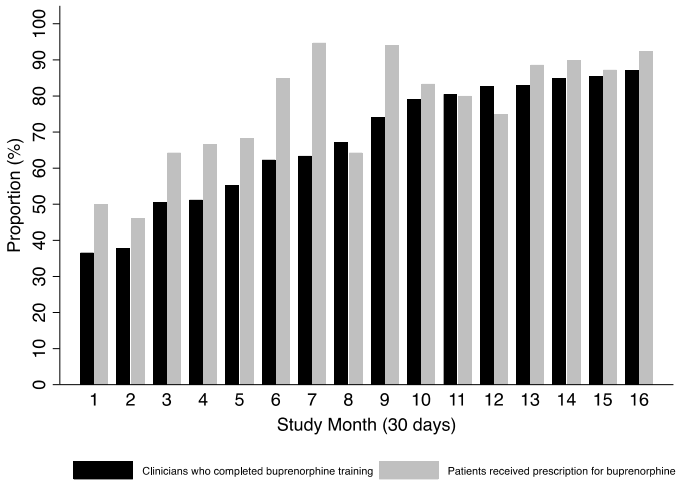

Figure 1. Proportion of physicians who completed training for prescribing buprenorphine and proportion of patients who received a prescription for buprenorphine per month over time.

in the proportion of patients who were administered buprenorphine in the ED among those who received a prescription for buprenorphine compared to those who did not receive a prescription. For our primary outcome, the proportion of patients who received a buprenorphine prescription increased over the course of the study (Figure 1), from 50% in the first month to 92% in month 16 (OR 1.14, 95% confidence interval [CI] 1.08-1.21 per month). Over the entire study period the odds of receiving a buprenorphine prescription increased over 600% (OR 7.49 [95% CI 3.21 -17.32]). Of the patients prescribed buprenorphine, the median (IQR) daily dose was 16 (8-16) mg and increased over time (0.30 [95% CI 0.20 to 0.40] mg per month). The median

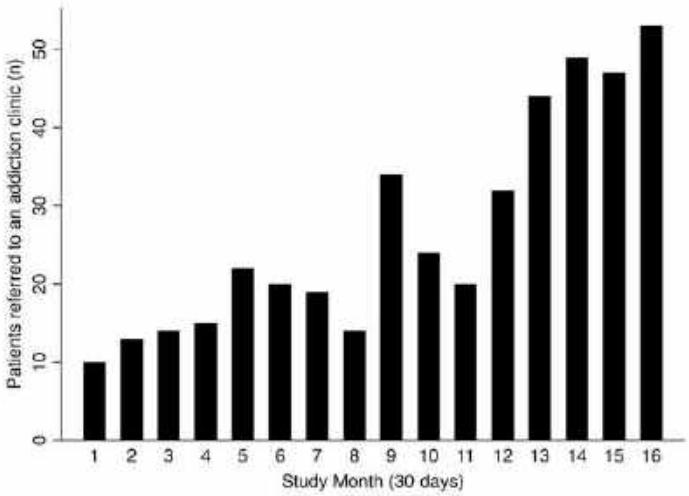

Figure 2. Frequency of patients referred to the bridge clinic per month over time.

Table 1. Baseline patient characteristics.

Variables	All subjects N = 430	Buprenorphine prescription n = 354	No buprenorphine prescription n = 76	P - value
Age (years [SD])	38 (10)	39 (10)	38 (10)	0.621
Female (n [%])	133 (31)	108 (31)	25 (33)	0.683
Race (n [%])				
White	241 (56)	194 (55)	47 (62)	
Black	115 (27)	98 (28)	17 (22)	0.533
Other	74 (17)	62 (18)	12 (16)	
Hispanic ethnicity (n [%])	67 (16)	57 (16)	10 (13)	0.711
Pre-existing comorbidities (n [%])				
Diabetes	17 (4)	11 (3)	6 (8)	0.095
Hypertension	56 (13)	46 (13)	10 (13)	1
Pulmonary disease	72 (17)	58 (16)	14 (18)	0.735
Depression	67 (16)	53 (15)	14 (18)	0.486
Anxiety	72 (17)	59 (17)	13 (17)	1
Bipolar	40 (9)	31 (9)	9 (12)	0.388
Schizophrenia	8 (2)	8 (2)	0	0.361
PTSD	16 (4)	14 (4)	2 (3)	0.749
Other substances [n (%)]				
Alcohol	22 (5)	19 (5)	3 (4)	0.779
Cocaine	124 (29)	97 (27)	27 (36)	0.164
Marijuana	81 (19)	67 (19)	14 (18)	1
Phencyclidine	12 (3)	10 (3)	2 (3)	1
Any polysubstance use	186 (43)	151 (43)	35 (46)	0.611
Prior ED visit in the six months prior to index ED visit (n [%])	285 (66)	232 (66)	53 (70)	0.507
Number of ED visits in the six months prior to index ED visit* [median (IQR)]	3 (1 - 6)	3 (1 - 6)	2 (1 - 5)	0.853

*Among those with an emergency department (ED) visit in the six months prior to index ED visit (N = 285).
IQR, interquartile range; *PTSD*, post-trauma stress disorder.

(IQR) prescription length was 6 (4-7) days and did not change over time (0.03 [95% CI -0.03 to 0.10] days per month).

Emergency department reutilization for OUD complications was recorded in 183 patients (43%). The median (IQR) time to ED reutilization for OUD complications was 41 (11-84) days. There was no change in ED reutilization for OUD complications or medication refill by study month (Supplemental Figure 1). In our multivariable model, we did not find an association between ED reutilization for OUD complications and study month when adjusting for potential confounders (aHR 0.99, 95% CI 0.96-1.02) (Supplemental Table 1). Neither did we find a difference in ED reutilization for medication refills (aHR 0.99, 95% CI 0.93-1.04) (Supplemental Table 2). Patient history of prior ED visits and co-occurring substance use was associated with ED reutilization. The kappa statistic for inter-rater agreement for ED reutilization for OUD was 0.77 (0.71-0.83).

Data for follow-up at the bridge clinic was only available for 336 patients (78%), as 94 patients were referred to bridge clinic sites that did not have appointment information available. Of those 336 patients, 151 had successful follow-up (45%). Most patients had their follow-up appointment scheduled within seven days (Table 2), and all patients had an appointment scheduled within 22 days. We did not find an increase in the proportion of patients who had successful clinic follow-up over the study period (aOR 0.95, 95% CI 0.91-1.00). Neither study month nor the number of days to the clinic appointment from the index visit were associated with successful follow-up (Supplemental Table 3).

DISCUSSION

Our results suggest that buprenorphine training is integral to ED patients receiving buprenorphine, with an increasing proportion of physicians certified to prescribe buprenorphine being associated with increased rates of buprenorphine prescriptions. We found both the number of patients referred to an addiction clinic and the proportion of those patients who received a buprenorphine prescription increased over the study

Table 2. Index emergency department visit characteristics.

Variables	All subjects N = 430	Buprenorphine prescription n = 354	No buprenorphine prescription n = 76	P - value
Reason for index visit (n [%])				
Psychiatric	20 (5)	13 (4)	7 (9)	0.064
Medication refill	40 (9)	36 (10)	4 (5)	0.274
Overdose	157 (37)	132 (37)	25 (33)	0.513
Withdrawal	102 (24)	86 (24)	16 (21)	0.656
Infection	33 (8)	24 (7)	9 (12)	0.153
Other	121 (28)	97 (27)	24 (32)	0.483
Social work consult (n [%])	70 (16)	52 (15)	18 (24)	0.060
Buprenorphine administered in ED (n [%])	130 (30)	113 (32)	17 (22)	0.129
Buprenorphine total dose in ED [median [IQR])	8 (8 - 8)	8 (8 - 8)	8 (4 - 8)	0.191
Buprenorphine prescription daily dose [median [IQR])		16 (8 - 16)	N/A	N/A
Buprenorphine prescription length [days, median [IQR])		6 (4 - 7)	N/A	N/A
Naloxone prescription [IQR])	67 (16)	62 (18)	5 (7)	0.015
Days until scheduled addiction clinic appointment [median [IQR])	6 (4 - 7)	6 (4 - 7)	5 (4 - 6)	0.039

period. This is congruent with other studies assessing the barriers to ED buprenorphine utilization. Physicians are required to attend eight hours of education to prescribe buprenorphine. Our ED buprenorphine training intervention made this training more easily accessible for clinicians and increased the proportion of patients receiving a buprenorphine prescription from the ED.[19,20]

Our results demonstrated that ED buprenorphine prescribing was not associated with decreased ED reutilization for overdose or withdrawal, suggesting that substance use disorders are extremely complex to treat and likely involve many confounding variables, including social determinants of health. However, this study was not designed to determine such confounders. We also found that ED reutilization for buprenorphine refill did not increase over the study period, decreasing concerns that patients will use the ED for ongoing buprenorphine prescribing.

While we found that the number of patients referred to an addiction clinic increased over the study period, the proportion of patients with successful follow-up to the bridge clinic remained unchanged. It is likely that ED buprenorphine prescribing is only one part of improving OUD outcomes. Other studies have demonstrated that prescribing buprenorphine in general is associated with decreased OUD complications, such as overdose and hospitalizations.[21-23] Our study failed to replicate these findings. Our differences in outcomes may be a result of social risk factors that may be different in our patient population, including transportation and housing issues, but our study was not designed to account for these risk factors. It is important to remember, however, that the ED remains the point of entry to the healthcare system for many patients with OUD. Therefore, studies examining ED utilization and buprenorphine prescribing may not be replicated nor be applicable to other settings in the healthcare system.

This is one of the few retrospective cohort studies that addresses how ED buprenorphine prescriptions affect subsequent ED usage. A similar study, conducted in 2021 by Sullivan and colleagues, showed that patients significantly reduced their ED usage after attending a bridge clinic.[24] However, many of these patients were not referred to the clinic by EPs, and those who were referred from the ED did not have details of their intervention visit recorded. Another similar study by Le et al in 2021 also showed that ED-initiated buprenorphine was associated with lower ED utilization and hospitalization rates but did not involve a bridge program referral in the treatment course.[25]

LIMITATIONS

Our study had several limitations. First, this study was retrospective and performed at a single site. The retrospective design did not allow identification of all patients with OUD. Further, we specifically looked at the subset of patients referred to an ED bridge program because this subset of patients were those identified by clinicians as patients seeking help for OUD. Further, all patients prescribed buprenorphine should be provided follow-up resources. Even among those seeking help and referred to an addiction clinic we found only half were prescribed buprenorphine prior to the intervention, and the number of patients referred to the clinic and the proportion of these patients who were prescribed buprenorphine increased after the intervention.

Second, we found that the number of patients referred to an addiction clinic increased over time; however, given we did not have data on the total number of patients with an OUD who presented to the ED, it is unclear whether this increase in clinic referral was due to physicians referring a higher proportion of patients with OUD to a clinic or to the absolute number of patient with OUD presenting to the ED increased. Third, we were only able to obtain information for bridge clinic follow-up for three of the five clinic sites as there was no data-sharing possible with the other two sites. Therefore, our results showing no change in the proportion of successful follow-up over the study period is limited. It is possible that patients referred to a clinic had successful follow-up at a different clinic outside our included clinics.

Fourth, increased awareness of buprenorphine prescribing outside the intervention training may have led to the increase in buprenorphine utilization in the ED. Further, new faculty joined our program who had already been trained in and had experience with prescribing buprenorphine, which may also have led to a rise in buprenorphine prescribing as opposed to the internal training. Although our results are limited to patients referred to an addiction clinic, we believe they are important and suggest that training emergency clinicians on buprenorphine use increases buprenorphine utilization. These results provide scientific rationale for future prospective studies evaluating the effects of physician training on a more generalizable population of OUD.

CONCLUSION

Our intervention increased the number of physicians with training on buprenorphine use, which was associated with increased buprenorphine prescribing. We did not find an increase in return visits for medication refills or a decrease in ED reutilization for opioid complications. Further prospective research is needed to determine drivers of follow-up and treatment adherence, as well as the association between ED buprenorphine dosing compared to prescription alone and the association with treatment retention.

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"Oh, Another Overdose, for the Love of Pete": First Responder Perspectives on Overdose Response Technology

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Background: Overdose response applications and hotlines are novel overdose response technologies (ORT)/virtual harm reduction strategies that have recently emerged as a strategy to reduce the harms associated with the ongoing opioid epidemic. First responders are often the first point of contact for people who have overdosed and play a significant role in responses enacted by these services. In this study our aim was to explore the attitudes and perceptions of first responders on these novel technologies.

Methods: We recruited 17 participants using purposive sampling through the province of Alberta between February–April 2023 including 11 paramedics, two firefighters, and five emergency communications operators. To be included in the study, participants were required to be older than 18 years of age, have the ability to communicate effectively in English, provide verbal informed consent, and work in an emergency responder role. Semi-structured interviews were conducted by two evaluators. When reviewing interview transcripts we used thematic analysis to identify key themes and subthemes.

Results: Participants discussed their current operating procedures, their current perspectives on overdose response hotlines and apps, how they would best integrate them into their current workloads, and how to raise awareness of these services within first-responder communities. Participants were apprehensive about the integration of these services into their current workloads, including their potential benefits, and raised concerns about their efficacy within communities of people who use drugs. Key strategies were raised for the successful integration of these services into emergency responses including providing information to clients and the feasibility of overdose responses by the general public.

Conclusion: This study's results add to the existing literature on the toll of the overdose epidemic seen within first-response communities. Furthermore, we explored the communities' diverse perspectives on these novel technologies, including support and concerns, and propose additional strategies for their integration into emergency responses. [West J Emerg Med. 2025;26(3)588–599.]

BACKGROUND

Canada continues to face disproportionate rates of mortality resulting from an increasingly toxic drug supply and substance use harms associated with isolation measures put in place during the pandemic, with this region seeing nearly double the number of illicit drug deaths during that time period.[1] More recently, the province of Alberta has seen a dramatic rise in opioid-related emergency service calls per

week, which have doubled between January and April 2023,[2] highlighting the need for effective and novel strategies to address this crisis. On the frontlines of this epidemic are first responders, including emergency medical service (EMS) workers, firefighters, and 9-1-1 dispatch operators, who face significantly increased workloads and greater numbers of interactions with people who use drugs (PWUD).

Various harm reduction measures have helped to curb the rates of EMS interactions within this population,[3] yet these frontline workers continue to face increased interactions with PWUD.[2] While not generalizable to the entire nation, first responders in Canada have been cited to have favourable attitudes to the integration of harm reduction in their communities.[4] Often, however, these harm reduction measures are centralized within large urban centers, with rural communities experiencing higher rates of fatal overdose.[5] One novel measure that has emerged to both counteract the negative impacts of isolation and to provide more equitable access to rural communities has been the advent and scaling of novel, virtual harm reduction services such as overdose response applications and hotlines, sometimes referred to in the literature as mobile overdose response services.[6–8]

In particular, services that can be accessed by anyone with a mobile/cell phone, including overdose response hotlines (Canada's National Overdose Response Service, America's Never Use Alone, or Massachusetts Overdose Prevention Line)[9,10] and overdose response applications (Digital Overdose Response Service [DORS] app, Lifeguard, and UnityPhilly),[11,12] which allow for the spread of harm reduction beyond their brick-and-mortar counterparts. The former, overdose response hotlines, traditionally connect people using substances to a live operator who will co-create an emergency response plan with an individual using substances and enact said plan should an individual become unresponsive. Overdose response applications, on the other hand, use a smartphone, timer-based system in which people using substances alongside the app are prompted to refresh a timer at regular intervals, followed by connecting them with emergency communications officers should they be unresponsive, and dispatching EMS to their location.[13]

As these technologies emerge, it is imperative to understand the perspectives of stakeholders who are most impacted by these types of services. Indeed, while the current literature suggests that these services are acceptable for many PWUD,[14–16] in particular gender minorities,[17] there is a dearth of literature on the perspectives of various first responders.[18] However, interactions between PWUD and EMS present points of critical intervention and valuable interactions with the healthcare system as many individuals choose not to seek higher levels of care, potentially arising from stigma or precipitated withdrawal resulting from high doses of naloxone administration.[19,20] A recent review by Bolster et al highlights the urgent need for addressing the "overlooked and under-researched" role of EMS and other first responders in the care of PWUD. Indeed as highlighted within their review, first responders are in an excellent position to provide additional support and resources to reduce the harms associated with substance use.[21] In our study we aimed to determine the perceptions of first responders on novel overdose response applications and hotlines including their current knowledge of and future potential to integrate these services into their scope of practice.

Population Health Research Capsule

What do we already know about this issue?
Overdose response technologies (ORT) aim to address the rising mortality from the opioid crisis; however, no research examines first-responder perspectives of ORT.

What was the research question?
What are first responders' perceptions of ORT and their integration into current scope of practice?

What was the major finding of the study?
While acknowledging ORT benefits such as outreach to geographically isolated individuals, they expressed concerns about personal and client safety during responses.

How does this improve population health?
First responders offer a valuable opportunity to disseminate information about ORT to reduce the mortality rate from the opioid epidemic.

METHODS

To understand the perspectives of first responders on overdose response hotlines and apps, we conducted 17 semi-structured interviews of firefighters, paramedics, and emergency service dispatchers within the province of Alberta. Interviews were conducted between February–April 2023. Interview participants were identified through a combination of convenience and snowball sampling through existing networks with Alberta Health Services, a province-wide health authority located in Canada. Participants were initially contacted via email and invited to participate in this study. The province of Alberta is the fourth largest province in Canada with a population of 4.8 million as of the most recent estimates (2024)[22]; this province also sees the second highest rates of fatal overdoses within the country.[1] The population of this province is primarily concentrated within urban areas (93.4%).[23] There have been 200 uses of the Provincial

Overdose Response Application DORS since its launch in 2021 until when these interviews were conducted (April 2023).[24] Similarly, the National Overdose Response Service was used 1,108 times across the three prairie provinces (including Alberta) from December 2020–April 2023.[24]

Inclusion criteria required participants to be residents of Alberta at the time of consent, ≥18 years of age, able to communicate effectively in English, and to provide informed verbal consent. In addition, participants had to be employed in an emergency response role, which may be impacted by the use of virtual harm reduction tools (such as paramedics, emergency communications officers or firefighters). Due to the relative recency of overdose response applications and hotlines, participants were not required to have previously responded to a call initiated by these services. To minimize potential interview bias, the interviews were conducted by two masters-level trained female evaluators (SJ and SC) who are part of a third-party research organization specializing in qualitative research. There was no previously established relationship between evaluators and interview participants; only the interviewer and interviewee were present on the call. Prior to conducting interviews, participants were provided with a brief information package about the various overdose response hotlines and applications available. No honorarium was granted for participant interviews, and no participants dropped out during or after the interviews were completed.

We consulted with both overdose response hotline and application administrators and PWUD before creating the recruitment package, which included a verbal consent form, contact information of the study personnel, a telephone recruitment script, and a letter detailing the research study. An implementation science framework was used to guide the question design.[25] Telephone interviews ranged from 20-60 minutes in length. The third-party transcription service TapeACall was used to record and transcribe the data. No field notes were taken for this analysis, transcripts were not returned to any participants to confirm validity, and no repeat interviews were conducted. We used the consolidated criteria for reporting qualitative research (COREQ) to guide the reporting of the results. The study received ethical approval from the University of Calgary Conjoint Health Research Ethics Board (REB22-0326).

Qualitative information was encoded via thematic analysis to identify themes that could help organize the perceptions and opinions shared by study participants. Interviews were conducted until data saturation was reached, which was defined as the lack of new themes emerging.[26] The transcripts were independently coded by both interviewers using Dedoose (SocioCultural Research Consultants, LLC, Redondo Beach, CA). After coding the first three transcripts, evaluators met to discuss and refine a codebook that was updated in real time based on joint evaluator agreement. Disagreements between evaluators were resolved through consultation with the project manager (KM) and the principal investigator (MG).

RESULTS

Through our study, we collected the perspectives of 12 emergency medical first responders and five EMS dispatchers. Due to the geographic variation within our subject pool, respondents also varied significantly in the number of overdose responses they attended. Furthermore, participants varied in their previous awareness of ORT, with 12 having a basic understanding of these services and five without prior knowledge. Years of service and ethnicity data were only collected for 14/17 (82.3%) of individuals; however, of these individuals, 11/14 (78.5%) were White and had an average of 11.2 years of service (SD 7.4). Additional demographic details can be found in Table 1.

Four major themes were identified from the interviews: *the current toll of overdose calls on emergency responders; current awareness of overdose response hotlines and opinion that apps should be improved; acceptability of these services;* and *integration of these services into communities and current workloads.* Outside the frequency of overdose calls, there were no significant differences between participants' perspectives based on rurality and gender. Key themes, subthemes, and points are summarized in Table 2.

Current Toll of Overdose Calls on Emergency Responders

Despite the varied number of overdose responses enacted by EMS across the province, participants' views on the impacts of the overdose crisis were relatively similar. In general, participants noted an increasing call volume and stress on already scarce resources.

> *Overdose responses are presenting a pretty significant challenge, in my opinion, for our healthcare system. We take a lot of overdose calls….A lot of EMS resources are spent responding to these calls.* – EMS15

Undoubtedly, many first responders faced significant emotional tolls and a cycle of frustration and exhaustion due to repeated attended calls. Many individuals describe that the impact of this crisis has left them *"jaded"* (EMS 13) and demoralized.

> *It can be quite demoralizing as a first responder. I've worked with people who have given NARCAN and reversed the effects of narcotics twice to the same person on the same shift.* – EMS 04.

Acceptability of Overdose Response Hotlines and Applications

After hearing a brief description of the services presented as part of the interview guide (Appendix 1) interviewers explored the perspectives of first responders and dispatchers on the use of overdose response hotlines and applications as a part of a comprehensive harm reduction and treatment strategy. While participant perspectives were mixed on the acceptability of these services in their community, some

Table 1. Participant demographic data.

Pseudonym	Role	Previous awareness of overdose response hotlines and applications	Gender	Location	Years in service	Ethnicity
EMS 01	Firefighter/paramedic	Yes	Male	Urban	10	White
EMS 02	Community paramedic	Yes	Male	Urban	Not collected	Not collected
EMS 03	Community paramedic	Yes	Male	Urban	Not collected	Not collected
EMS 04	Firefighter/paramedic	No	Male	Urban	19	White
EMS 05	Fire Captain	No	Male	Urban	19	White
EMS 06	Primary care paramedic	No	Male	Urban	8	Asian
EMS 07	Advanced care paramedic	Yes	Female	Urban	Not collected	Not collected
EMS 08	Mobile integrated health and EMS paramedic	Yes	Male	Urban	17	White
EMS 09	Primary care paramedic	Yes	Non-binary	Rural	12	White
EMS10	Primary care paramedic	No	Female	Rural	4	White
EMS11	Primary care paramedic	Yes	Male	Rural	11	White
EMS12	Advanced care paramedic	Yes	Female	Rural	25	White
EMS13	Call evaluator	No	Female	Urban	1	White
EMS14	Emergency communications officer	Yes	Male	Urban	20	White
EMS15	Emergency communications officer	Yes	Male	Urban	1	White
EMS16	Emergency communications officer	No	Female	Urban	10	Indigenous
EMS17	Emergency communications officer	Yes	Female	Urban	3	White

EMS, emergency medical service.

participants described the apprehension among staff members due to the relative novelty of these services, response times, and safety concerns.

> *I think it's going to be a hard sell to first responders… Talking to other people, our concern was how many false alarms are we going to start going to now?... I think if you explain to them how it works … that would probably help …* – EMS 08

Furthermore, we aimed to determine the perspective of individuals on the two types of services (applications or hotlines) that are currently available. In reference to application-based services, one participant stated:

> *They're a critical piece that needs to be implemented and supported, and people need to be aware of it and, you know, educated.* – EMS 01

Participants additionally recognized the potential to provide support for individuals *"isolated in society"* (EMS 09). Individuals who are using alone, in their own homes, or in First Nations, rural and remote communities could see additional benefits, according to participants. While there were some concerns regarding false alarm calls, both EMS workers and call-takers noted that it would not be outside the norm of those seen with current life-alert systems. Additional apprehension was raised with respect to responder safety when accessing a location, technological issues, and the acceptability of these services among PWUD.

Regarding peer-to-peer services described above, participants held favorable attitudes toward these types of services. Indeed, participants highlighted that relationships developed between callers and operators would greatly benefit this type of service.

> *Even just something as simple as that lets them know that there is somebody that actually cares… I think that gives people hope.* – EMS 08

> *If it didn't exist, then you would be at the situation we're at now. Where high volume of calls … And there has to be a better way of managing* (the high volume of calls related to the opioid crisis). – EMS 14

Participants additionally highlighted the opportunity of these services to connect individuals to harm reduction and treatment resources at the appropriate times.

Table 2. Summary of themes and sub-themes.

Theme	Subtheme	Key points
Current toll of overdose calls on emergency responders	Current overdose response frequency	Increase in frequency of overdoses Discussion of daily, monthly and annual approximate frequency metrics Geographical impact on overdose frequency
	Current management/ response to overdose calls	Treatment disparities for patients/overdose calls Strained resources for responding to overdose calls Lack of protocols and procedures for managing/responding to overdoses Improving emergency response and questioning protocols Challenges of providing emergency medical instructions to impaired callers
	Impacts of responding on EMS/first responders	Emotional toll of dealing with the overdose crisis Cycle of frustration and exhaustion in responding to repeat overdose calls Increased danger and personal safety concerns in overdose calls Opportunities and impact for helping others in overdose calls
Acceptability of overdose response hotlines and applications	Automated overdose response apps and how they fit the needs of EMS/ first responders	An important tool in harm reduction Early activation of emergency services is a strength of automated response apps Improved location accuracy for emergency response. Automated services are most appropriate for specific populations of people who use substances. Concerns about false alarm calls with automated apps compared to other medical alarm services
	Limitations of automated overdose response applications	Balancing harm reduction and enabling Possibility of false alarm calls Time-sensitivity and efficiency concerns Safety concerns for first responders Apprehension toward automated services as an emergency response tool Need to partner with further supports with automated overdose response applications Accessibility limitations for PWUD
	EMS/first responder perception of overdose response hotlines	Provide empathy and peer support in overdose response Provide personalized support and referral service for substance use Peer-to-peer services are targeted to specific populations Peer-to-peer services do not deter people from using substances
	Hotline overdose response services meet the needs of EMS/first responders	Enhanced information and context from peer-to-peer services Hotline services are more reliable/have fewer false alarms than automated services. Safety and liability concerns with peer-to-peer services Considerations of resource availability and time commitment Reliance on technology could pose safety issues.
	Impact of overdose response hotlines and applications on EMS/ first responders	Overdose response hotlines and applications might lower the stress of overdose calls and result in better outcomes. Overdose response hotlines and applications could reduce the resource impact on the healthcare system by minimizing the number of false alarm calls. Impact and concerns about capacity and call volumes
	Perceived impact if overdose response hotlines and applications did not exist	If virtual harm reduction services didn't exist, there would be more overdose calls and more strain on resources. There would be no impact as EMS/first responders have not seen these services used. If these services didn't exist, there would be fewer avenues for compassionate care for PWUD.
Integration of overdose response hotlines and applications into communities and current workloads is feasible	Integrating automated applications into dispatch	Overdose response hotlines and applications could be integrated into dispatch protocols similarly to other alarm calls. Direct integration of overdose response hotlines and applications into emergency dispatch services can be helpful. Real-time feedback and follow-up services for EMS/first response could be conducted.

EMS, emergency medical services; *ORT,* overdose response technologies; *PWUD,* people who use drugs.

Table 2. Continued.

Theme	Subtheme	Key points
Integration of overdose response hotlines and applications into communities and current workloads is feasible	Perspectives of lay responders to overdose response hotline and application dispatches	Trust and comfort in personal connections is key. Responding laypersons should be aware that they have been requested to respond and have the necessary training and resources to effectively respond to an overdose. Using friends and family as support persons is the most appropriate way to respond. Laypersons responding to overdoses could delay the appropriate response. Concerns about layperson response and associated trauma on them Concerns about the safety and effectiveness of layperson naloxone administration.
	Recommending overdose response hotlines and applications to patients	EMS/first responders would recommend these services to patients as a harm-reduction measure. EMS/first responders would recommend these services to certain patient populations only. There are barriers for promoting overdose response hotlines and applications in EMS dispatch.
	Appropriateness of discussing overdose response hotlines and applications with patients	Individuals are not likely to be receptive to information during post-resuscitation. Fatigue and burnout impacting EMS/first responder engagement in providing further services. Discussing ORT in post-resuscitation situations may sound patronizing. Discussing ORT in a post-resuscitation situation may not be appropriate for all patients. Challenges of meaningful interaction during opioid overdose response, including time constraints, complex cases and patient care prioritization
Current awareness of overdose response hotlines and applications should be improved	First responder awareness of overdose response hotlines and applications	Participants had heard of these services prior to the interview (n=12). Participants had not heard of these services prior to the interview (n=5). Overdose response hotlines and applications are technological forms of harm reduction. Overdose response hotlines and applications do provide privacy and anonymity in substance use support.
	First responders heard about overdose response hotlines and applications through a variety of means	Personal connection with an overdose response hotline and application advocate Presentation from an overdose response hotline and application advocate Advertisements for the services through posters or pamphlets Emails from management to notify staff of the services Reading about the services in articles Encountered overdose response hotline and application in their role as EMS/first response Through advertisements in naloxone kits Through TV advertisements
	Increasing awareness of overdose response hotlines and applications amongst first responders	Current awareness of overdose response hotlines and applications amongst first responders is lacking. Awareness of overdose response applications and hotlines is not necessarily needed for first responders. Education and training is needed for effective promotion and understanding by EMS/first responders. A detailed understanding of overdose response hotlines and applications is needed to increase buy-in from EMS/first response. Challenges in communicating and educating EMS/first responders about overdose response hotlines and applications are present. Effective communication channels for raising awareness of these services is needed among first responders.

EMS, emergency medical services; *ORT,* overdose response technologies; *PWUD,* people who use drugs.

> *Being able to have that personal connection and have that conversation and enter into a safety contract that is explicitly chosen by the person with substance abuse concerns. And that potentially could facilitate more appropriate long-term interventions and supports.* – EMS 09

Lastly, some first responders viewed these services as enabling and that they would not deter individuals from using substances.

Integrating Overdose Response Hotlines and Applications into Communities and Current Workloads Is Feasible

Noting many of the strengths of these services previously outlined by interview participants, questions were raised about how these services may be integrated into current EMS and call-taker workloads. There was

significant discourse around the appropriateness of providing information to people who have experienced an overdose, primarily due to altered mental states faced by individuals after overdose reversals.

In my experience when patients wake up they're not often in the best state of mind so talking to them at that particular point. – EMS-06

I do and I have [recommended these services to patients]… I do think that these types of apps and services, or hotlines, do fill an important gap in our current provisions of care, for this type of thing. – EMS 03

In contrast, many 911 dispatchers noted that while they would be supportive of providing this education there would be challenges to disseminating knowledge of these services due to the limitations of their protocols and scripts.

For ECOs (Emergency Communications Operators) at the moment, there's nothing in the protocols that would allow us to actually do that…it would need, like something added in now. That's not to say it couldn't be done, that shouldn't be done. – EMS 14

Lastly, the concept of contacting members of the public to potentially provide more timely naloxone administration was discussed. Participants held mixed views about the integration of the public to respond to reported overdoses. While some recognized the value in potentially more rapid intervention and reaching out to a support system to intervene, others were concerned about lay responder safety, liability, training for appropriate responses, potential delays in emergency medical dispatch, and mental health and trauma arising from responses. Participants also raised concerns about potential delays in emergency response should community members be contacted first.

"I don't know if I'd be completely comfortable with them administering NARCAN to a complete stranger. Some people wake up swinging, some people don't wake up at all. – EMS 04

Current Awareness of Overdose Response Hotlines and Applications Should be Improved

In general, participants who had heard of the services noted that their knowledge was limited. Participants recalled hearing information about these services through various communication channels, including articles, television programming, province-wide newsletters, emails, posters, and presentations, but many acknowledged that they had only heard of the services in name only. Not surprisingly, the government-funded and Alberta-specific DORS app made up most of individuals' knowledge on this subject.

I think it's an app on the phone and it calls somebody – you set it up before you use and then when the app checks it. Basically, it's a, I think an alarm. And that's pretty much all I know. – EMS11

Some participants suggested that continuing education modules, education days, and continual communication about these services as they develop would build a more concrete understanding of the methodology and rationale of overdose-response hotlines and applications. In contrast, others did not see a need to be educated on these services.

DISCUSSION

This study is the first to explore the perceptions of first responders regarding various facets of implementing overdose-response hotlines and apps. As previously highlighted, participants were recruited from a province that developed and promoted a provincial virtual harm reduction tool, the DORS app, in April 2021, which is directly linked to their emergency medical system.[27] Tailored messaging on naloxone kits has helped to disseminate these services to individuals and spread their awareness.[28] Other national services, including the National Overdose Response Service and Brave app, are also available within the province.[9,29]

Current Toll of Overdose Calls

The recent COVID-19 pandemic and ongoing opioid overdose epidemic have placed significant strain on EMS within the province and Canada as a whole. Within the previous four months, the province of Alberta has seen double the number of EMS responses to opioid-related events per week.[2] As echoed within the results of our study, previous findings describe the taxing nature of overdose responses, particularly for those who overdose multiple times within a day.[30,31] As demonstrated within our results, EMS workers find this work demoralizing and attribute the overdose crisis to occupational burnout.[32] Indeed, a cross-sectional survey of EMS workers in the state of Pennsylvania in the US found a correlation between the number of overdoses workers responded to and rates of depression among service personnel.[33] Part of this stress has been attributed to role conflicts from first responders noting that they felt they "only provided a temporary, sometimes ineffective, solution for PWUD,"[30,31] focusing on resuscitation only.

We suggest that broadening the scope of services provided by first responders to help with harm reduction education and facilitation of treatment may be a potential solution to help alleviate this burden.[30] Throughout our results, some participants identified the opportunities of introducing these services to PWUD as long-term solutions that connect individuals to support and fill an important gap in healthcare. In conjunction with many well-researched strategies for reducing stress and mental health concerns within this population,[34] expanding the purview of EMS personnel

and capitalizing on their connection with PWUD should be considered as a potential support to address the mental health impacts of the overdose crisis on service workers.

Current Awareness of Overdose Response Hotlines and Applications Should be Improved

Throughout our interviews, many participants were aware of overdose-response hotlines and applications available to PWUD; however, most were not familiar enough with them to the extent of recommending them to others. Indeed, increasing awareness of these services as well as public health messaging for PWUD has been discussed in recent literature.[6,28,35–37] One participant familiar with the technology recommended it to PWUD with whom they have interacted, demonstrating that building a greater awareness of these services among EMS personnel may help spread awareness of both overdose response hotlines and applications and additional harm reduction strategies within PWUD.

Interview participants also suggested that diverse methods be employed to educate their colleagues and staff members on these resources. A multipronged approach to education would likely help best disseminate this knowledge among first responders. This work can be undertaken in conjunction with stigma reduction and trauma-informed care initiatives to increase treatment uptake and harm reduction service access.[38,39]

Acceptability of Overdose Response Hotlines and Applications

Our study found mixed perspectives on the acceptability of these services among first responders and diverse opinions on the types of virtual harm-reduction services. While some inherent strengths were discussed, some participants felt these services and other harm-reduction measures were enabling. These persistent attitudes have been previously described across communities of frontline workers,[40–43] and they persist despite evidence of their efficacy in reducing harms from illicit substance use.[44] As previously mentioned, first responders are often the first and sometimes the only interaction with the healthcare system for PWUD, particularly those who refuse care. Sharing knowledge of evidence-based harm reduction approaches, as well as the evidence for the various virtual harm reduction interventions, could help build an understanding of the importance of these services in dealing with opioid overdoses. In this way, stigma reduction education for first responders has demonstrated positive outcomes for PWUD, including treatment outcomes and individual self-esteem.[45]

Similar to previous studies on paramedic-attended overdose events, in this study we found that individuals held concerns about their safety when responding to these situations.[31,46] Drug paraphernalia, post-naloxone aggression, and fears of violence have been discussed throughout various EMS perspectives on overdose response.[31,47] Overdose response hotlines and apps should, therefore, encourage service users to appropriately plan for an overdose event similar to those implemented within the National Overdose Response Service to reduce this risk.[48] Education to service users about removing paraphernalia, unlocking the front door, securing pets at home, and having a "hospital to go bag" filled with extra clothes and toiletries in case they have to go to the hospital are all interventions that could improve both the client and EMS professional experience on these lines.

Additionally, concerns about response times were addressed by participants. In the case of overdose and hypoxemic brain injury, rapid response times would be crucial to prevent severe outcomes. While these services may enable more rapid interventions when using drugs alone, future efforts should be considered to educate PWUD on response times within their areas and the resulting greater risks of overdose. In particular, rural areas may see response times nearly double those in more urban jurisdictions.[49] Emergency response plans made in consultation with peer service operators should consider different response times within geographic regions to ensure appropriate interventions are available in the event of an overdose. Only two peer reviewed studies have shown early effectiveness in reducing illicit drug mortality.[7,29,50] Continued evaluation of these services and data transparency on behalf of provincially run timer-based application services like the DORS and LifeGuard apps may help to counter current apprehension within the first responder community.

False alarm calls were also addressed within participant responses. Combined with extraordinarily high rates of first responder calls for opioid-related events,[2] the potential to burden an already overburdened community is high. Current research of one service, however, has shown limited numbers of false alarm calls and a positive cost-benefit ratio.[29,50,51] These figures fall far below those reported in other automatic dispatch services, such as fall alarms.[52] To our knowledge, there is no peer-reviewed literature describing the rates of false alarms in timer-based applications. Continuous monitoring is needed to ensure that these services are resources to respond to emergency calls adequately and do not contribute to significant additional stress on EMS professionals.

Lastly, participants discussed the potential strengths that peer support may offer on hotline-based services. Previous studies about connecting to in-person peer support have demonstrated improvements in patient engagement and knowledge translation.[53–56] Previous studies of application-based services have also demonstrated their capability to disseminate public health information.[36] Future research may help determine whether overdose response hotlines and apps demonstrate similar results and outcomes among PWUD populations.[56,57]

Current Awareness of Overdose Response Hotlines and Applications Should be Improved

As highlighted within a recent scoping review, Bolster and colleagues suggest that paramedic-attended overdose events are a unique and valuable opportunity to provide meaningful engagement with PWUD beyond an overdose response.[21] The results from our study suggest that paramedics demonstrated a willingness to engage with individuals beyond emergency response, providing clients, family members, and friends with resources that may help to reduce the harm associated with substance use. First responders have previously expressed their desire to provide quality care and education to PWUDs in need of resources and support.[30] Against the backdrop of high rates of overdose within a year since using EMS,[58] particularly when individuals are not transported to additional care resources,[59] these interactions are a critical window for providing resources and support for PWUD.

Interview participants noted that it was common that they would provide naloxone kits to individuals after an overdose event and, indeed, these have been previously considered as a public health messaging tool.[28] Previous studies note that individuals and family members who were offered and accepted naloxone kits were 2.47 and 5.6 times more likely to seek out substance use support than those who did not receive a kit, respectively.[60] The provision of naloxone kits in combination with education on ORT and the supports provided therein may help make additional strides in reducing the harms associated with illicit drug use. However, challenges may arise from interacting with individuals recovering from overdose or in naloxone-precipitated withdrawal due to the altered mental states associated with these conditions.[61]

Lastly, interviewee perspectives were mixed regarding trained members of the public responding to overdoses within their communities. Concerns about community member safety, liability, training, critical incident stress and delays in emergency medical services were all raised. As previously mentioned, education for ORT users regarding responder safety would likely go a long way toward this goal; however, issues regarding potential aggression resulting from precipitated naloxone withdrawal would remain to be addressed. Training community responders regarding life-saving interventions, including naloxone administration, airway protection in conjunction with liability protections offered by the Good Samaritan Act, and safety concerns in the event of precipitated withdrawal, should also be provided. Critical incident-stress impacts should also be considered for individuals responding to overdoses through these services to minimize stressors and potential long-term mental health impacts from these events. In regard to delays in EMS, one ORT, Unity Philly, had previously used and studied this strategy for overdose response and noted that in 74 cases (59.5% lay-person intervention preceded interventions by emergency medical services by greater than five minutes.[62]

LIMITATIONS

When interpreting the findings contained within our study, a few limitations must be considered. Firstly, interviews were conducted in the province of Alberta and, thus, may not apply to the experiences of all EMS personnel across Canada or internationally. As the DORS has been a province-led initiative, awareness of overdose response hotlines and apps is likely higher than that seen in other jurisdictions. Additionally, the convenience and snowball sampling nature of our participant pool may have reduced the diversity of responses contained within the study. Efforts were made to recruit individuals from diverse geographic, occupational, and experience backgrounds to incorporate diverse perspectives of these individuals in their care for PWUD. The results of this study do not prove the effectiveness of this strategy in reducing the harms associated with illicit drug poisoning, and additional research should be conducted to determine measurable outcomes from integrating education and the provision of resources for emergency responses, particularly in the context of individuals refusing treatment. Lastly, due to issues with data collection, we were unable to collect the demographic data from every participant, and thus our results do not fully represent the ethnicities and years of service of our participant sample.

CONCLUSION

Our findings reinforce the existence of continued pressures faced by first responders within the context of the opioid epidemic and highlight current reservations and suggestions regarding the implementation of overdose response hotlines and apps across the province of Alberta. Overall, first responders within the province of Alberta had a general awareness of the virtual harm reduction services available for PWUD; however, they had a limited understanding of their application and efficacy. Furthermore, while participants highlighted the various opportunities provided by these services, including more rapid response to overdoses, referrals to services, and connection to peer support, they expressed concerns about both personal and client safety during responses and false alarm calls. The results from our study demonstrate that discussing these services with clients is an acceptable strategy within the first responder community; however, additional steps should be taken to continue to evaluate these services and disseminate information amongst this population.

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Randomized Controlled Trial of Atorvastatin in Acute Influenza in the Emergency Department

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Objectives: We sought to determine whether atorvastatin administration attenuates the inflammatory response and improves clinical outcomes in acute influenza.

Methods: We conducted a randomized double-blind trial administering atorvastatin 40 milligrams or placebo to adults with confirmed influenza for five days between December 2013–May 2018. Patients were primarily enrolled in the emergency department (ED) at an urban, tertiary-care center. Serum was obtained at enrollment and 72 hours for the primary outcome, change in interleukin (IL-6). Patients reported severity of influenza symptoms over 10 days. We used linear mixed-effects models for the primary comparisons.

Results: Of the 116 enrolled patients, 59 received atorvastatin and 57 received placebo. Groups were well-matched including baseline influenza symptom scores and receipt of an antiviral medication. There was no difference between groups in the change in interleukin-6 (IL-6) levels (P=0.468). However, there were significant differences in the overall influenza symptom scores, favoring faster resolution in the atorvastatin group (P=0.05). For patients presenting within 48 hours of symptom onset, resolution was faster for the overall score (P <0.001) and for the fever (P=0.001), sore throat (P=0.005) and headache (P=0.006) components. No safety concerns were identified.

Conclusion: Atorvastatin administration in acute influenza appears safe. We did not find attenuation of IL-6 with atorvastatin. Patients receiving atorvastatin reported improvement in their clinical symptoms at a faster rate than those in the placebo group, particularly in patients presenting within 48 hours of symptom onset. This trial is registered at ClinicalTrials.gov, Identifier: NCT02056340.
[West J Emerg Med. 2025;26(3)600–608.]

INTRODUCTION

The World Health Organization estimates 3-5 million cases of severe influenza illness worldwide and attributes 250,000-650,000 respiratory deaths to seasonal influenza outbreaks annually. These figures have remained relatively stagnant over time, and incidences of other comorbid conditions spike when influenza is circulating.[1,2] Vaccination represents the best means of preventing outbreaks, but there is no universal influenza vaccine. For infected patients, the remaining treatment options include existing antiviral agents; however, there are several practical challenges with using these agents as a singular line of defense including cost, efficacy late in disease, limited supplies, and emerging resistance.[3–6] Moreover, these current strategies do not directly address the severe inflammatory response

elicited by the virus that causes the infection-associated morbidity and mortality.[7,8] Pro-inflammatory mediators such as interleukin 6 (IL-6) are associated with severe disease and death and, therefore, may represent key therapeutic targets in the treatment of acute influenza infection.[9–12]

The class of medications referred to as "statins" has a first-line application in reducing cholesterol levels, but they also have pleiotropic anti-inflammatory and immunomodulatory effects. Multiple studies have suggested an association between the use of statin drugs and a reduction in morbidity and mortality in other types of infection.[13–16] While there is less direct evidence for statin therapy in acute influenza infection, the preponderance of population-level, observational studies suggest statins are beneficial.[17–24] We hypothesized that the administration of a statin medication would attenuate the inflammatory response in patients with acute influenza, resulting in 1) decreased levels of circulating pro-inflammatory cytokines and 2) reduction in the severity of illness and time to clinical resolution of influenza symptoms. To test these hypotheses, we performed a randomized clinical trial administering atorvastatin vs placebo to patients with acute influenza infection.

Population Health Research Capsule

What do we already know about this issue?
Statins have anti-inflammatory properties; observational studies have suggested a clinical benefit for patients taking a statin at the time they contract influenza.

What was the research question?
This trial was designed to assess the effect of atorvastatin therapy on inflammatory markers and clinical outcomes in influenza.

What was the major finding of the study?
We found no change in the primary outcome measure , interleukin 6. We found a clinical benefit favoring faster resolution of symptoms in the atorvastatin group, particularly early in infection (P <0.001).

How does this improve population health?
Given their low cost and safety profile, statins may represent a strong adjuvant treatment option in both acute influenza and other viral infections. Further study is needed.

METHODS

Study Design

This was a single-center, randomized, double-blind, placebo-controlled trial comparing atorvastatin to placebo in patients with confirmed influenza (ClinicalTrials.gov Identifier: NCT02056340). The study was conducted at Beth Israel Deaconess Medical Center in Boston, Massachusetts, and was approved by our institutional review board. Study participants were randomized to receive either atorvastatin 40 milligrams (mg) or matching placebo capsule orally daily for five days or to a maximum of seven days in those who remained hospitalized.

Participants

All patients presenting with an influenza-like illness were screened between December 2013–May 2018. Eligible patients were adults ≥18 years with acute influenza confirmed by either a bedside rapid antigen test or a documented hospital laboratory test (direct fluorescence antibody or polymerase chain reaction). Primary screening occurred in the emergency department (ED), but hospitalized patients with a positive influenza test were also screened.

Patients were excluded if they had concomitant or recent (within 30 days) statin medication use; were pregnant; actively breastfeeding; had cirrhosis or acute liver dysfunction with alanine and aspartate aminotransferase (ALT/AST) > 240 international units per liter; had creatinine phosphokinase (CPK) 3x above normal, had an allergy to statin medications; were unable to tolerate oral or nasogastric medications; had a "do not resuscitate" or "comfort measures only" designation; were a member of a protected population; or were otherwise unable to provide written informed consent. Patients were further excluded if they were taking any medications contraindicated with atorvastatin including cyclosporine, HIV protease inhibitors, gemfibrozil, niacin, azole antifungals, clarithromycin, and colchicine. All participants signed a written informed consent.

Randomization and Masking

A 1:1 randomization scheme was created by an independent biostatistician. Atorvastatin 40 mg and matching placebo capsules were created by our institutional research pharmacy. Study drug and the randomization scheme were maintained in the research pharmacy pending enrollment notification, at which time study drug was dispensed to the research team in blinded fashion for delivery to patients.

Procedures

Safety labs (AST, ALT, CPK) were checked prior to randomization as part of the screening process, and blood samples were drawn prior to study drug administration for biomarker profiling. Patients admitted to the hospital had study drug stored in a locked location and dispensed at the same time each day and had safety lab testing performed at 24 and 72 hours, as well as blood samples every 24 hours for biomarker profiles throughout their hospital stay. Patients

discharged from the hospital had the remaining doses of study drug dispensed in a prescription bottle and were asked to return to our clinical research center at 72 hours for blood sampling for both safety labs and biomarker profiles. Any patient with an elevation in safety lab testing above the specified parameters was discontinued from the trial.

Patients were also asked to rate their influenza symptoms (fever, cough, sore throat, headache, myalgias) ranked from 0 to 3 (none, mild, moderate, severe) for a daily score ranging from 0-15 for 10 days.[25] This daily symptom score served as the basis for assessment of clinical outcomes between groups. If patients remained in the hospital, their daily diary scores were collected in person on paper by a trained research assistant. Patients discharged from the hospital were prompted electronically via email (or by telephone for those who did not use email) to both take their study medication and complete their daily symptom diary.

Outcomes

The primary endpoint was to determine whether statin therapy reduces the inflammatory response to acute influenza infection. To achieve this aim, inflammatory biomarkers were measured at time of enrollment, prior to study drug administration, and at 72 hours. The primary endpoint in the trial was the change in IL-6 level from time zero to 72 hours between groups.

The secondary endpoint was to determine whether the administration of statin drugs attenuated disease severity and improved time to clinical resolution of symptoms in patients with confirmed influenza over the first 10 days after enrollment. Our main endpoint in this aim was the trend over time for resolution of the clinical illness based on a daily composite score of major influenza symptoms. Additional secondary clinical outcomes included hospital and intensive care unit (ICU) lengths of stay measured in days, rates of progression to vasopressor-dependent shock in each group, and in-hospital mortality.

Biomarker Analysis

Influenza patient plasma samples were analyzed for multiple vascular endothelial and inflammatory markers (IL-6, tumor necrosis factor-alpha [TNF-α], vascular endothelial growth factor [VEGF], IL-2, IL-10 and vascular adhesion molecule-1 [VCAM-1]) using customized Meso Scale Discovery Human Multiplex Panel (Meso Scale Diagnostics, LLC, Rockville, MD). All samples were measured in duplicate with the interassay coefficients of variability ranging from 2.2-5.8%. We reported the VCAM-1 in log-transformed micrograms per milliliter (mL) and the rest of the markers in log-transformed picograms/mL.

Statistical Analysis

Sample size calculation for the trial was based on a pilot clinical trial in which we randomized 18 patients with septic shock to 40 mg simvastatin—eight patients receiving atorvastin vs 10 receiving placebo daily. At the 72-hour time point, we found a change in IL-6 levels of (-964.3 ± 1501.2) in the statin group and (-471.9 ± 620.0) in the placebo group. Based on these numbers, we calculated 87 patients in each group to detect a change in biomarker levels between the statin and placebo groups at alpha 0.05 and 80% power. The trial was stopped at the end of the study funding period prior to achieving target enrollments.

We planned a *modified intention to treat* analysis for this trial defined by subjects who were consented, enrolled, randomized, and received at least one dose of the study drug. Prior to unblinding, as we had a number of patients who were lost to follow-up with only enrollment data available, we elected to perform a *per protocol* analysis for all patients who had 72-hour biomarker data available and had received all doses of study drug up to that point. We performed an additional post-hoc analysis of patients who presented within 48 hours of symptom onset to determine whether any effect of atorvastatin might be observed earlier in the clinical course, similar to antiviral therapy. Also prior to unblinding, we censored the biomarker results of one patient as only enrollment values and a second lab draw at 150 hours were available. The blood sampling occurred over two days after the last scheduled dose of study medication, and any imputed values may not reflect the effect of the drug.

Descriptive: We summarized the data using means with standard deviation or medians with interquartile ranges (IQR) for continuous variables and proportions (or frequencies) for categorical variables. Wilcoxon rank-sum tests were used to evaluate for the difference between groups for continuous variables and the chi-square or Fisher exact test for categorical variables, as appropriate.

Primary Endpoint:

We compared biomarker levels between the two groups at each time point using a Wilcoxon rank-sum test. The distribution of these markers was assessed and transformed as necessary (eg, log transformation). Mean difference with a 95% confidence interval was calculated for the primary outcome, IL-6, at the 72-hour time point.

Hypothesis testing: We tested for group differences in biomarkers over time using a linear mixed-effects model to account for the correlation from within-subject measurements, testing several covariance structures. We chose the covariance structure based on the model with the lowest log likelihood value. We included an interaction between time and group, which was the primary outcome. A *P*-value <0.05 was considered significant.

Secondary Endpoints:

We used Wilcoxon rank-sum tests to describe the differences in clinical symptoms over time between treatment groups. Both overall symptom resolution and resolution of

individual components were described. Similar to the primary endpoint, we tested for group differences in reported symptoms over time using a linear mixed-effects model to account for the correlation from within subject measurements, including an interaction factor between time and group. For time to 50% symptom resolution, we performed survival analysis and used log-rank tests. For the secondary outcomes of hospital and ICU length of stay, we compared the groups using the Wilcoxon rank-sum test. We performed statistical analyses using Stata software, v14.2 (StataCorp, LLC, College Station, TX).

Role of the Funding Source:

The funder of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

RESULTS

We screened 4,876 patients presenting with influenza-like illness for the trial. Reasons for exclusion are presented in Figure 1. The most common exclusion was current statin use. We enrolled 120 patients between December 27, 2013–April 24, 2018. Two patients in each group discontinued participation prior to receiving the study drug. Fifty-nine patients were randomized to the atorvastatin group and 57 to the placebo group and received at least one dose of study drug. Treatment groups were similar in terms of baseline characteristics (Table 1). Initial clinical parameters between the groups were also comparable with regard to influenza immunization status, initial influenza severity of illness score, duration of symptoms, and medications administered during the ED stay (all $P > 0.05$). Rates of admission to the ICU, hospital ward, and ED observation unit were also similar between groups ($P = 0.083$), with the majority of patients (62.5%) being discharged from the ED.Ten patients were lost to follow up after the initial encounter. An additional eight patients withdrew from the study, two in the atorvastatin group and six in the placebo group, leaving 98 patients who achieved the primary endpoint in the trial, 52 in the atorvastatin group and 46 in the placebo group (Figure 1). This population is represented in the *per protocol* analysis group. There were no differences observed between the groups in safety lab testing at baseline, 24- or 72-hour time points. One patient in the atorvastatin group and two patients in the placebo group were found to have a creatinine kinase elevation above the specified safety lab parameters at the 24-hour time point and were discontinued from the trial.

The primary endpoint in the trial was the change in IL-6 from enrollment to 72 hours. Mixed-model analysis of biomarker data did not detect any significant differences between the atorvastatin and placebo groups with regard to IL-6 levels (P=0.468) or any of the other biomarkers tested (Figure 2). This was also true when the analysis was restricted to the *per protocol* group (all $P > 0.05$). The mean difference

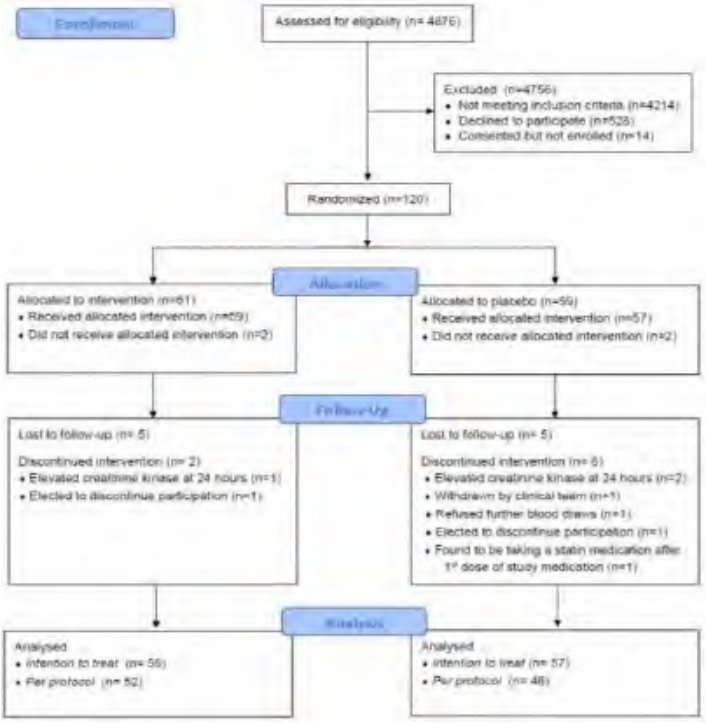

Figure 1. Screening and enrollment for clinical trial on the effect of atorvastatin vs placebo in patients with acute influenza infection.

for log-transformed IL-6 at the 72-hour time point was not significantly different between groups (-0.24, 95% CI -0.88-0.40).

We observed a significant difference in symptoms severity, favoring faster resolution of symptoms in the atorvastatin group (P=0.049). This result was largely driven by the fever (P=0.013) and headache (P=0.010) components of the score. The result persisted in the *per protocol* analysis; P=.047 overall, P=.017 for fever and P=.003 for headache (Figure 3).

The effect on the overall symptom score reporting post study drug initiation was most pronounced on day 3, 4 and 5 of treatment (all $P< 0.05$). On day 3 of treatment, there were 21 (41%) patients in the atorvastatin group who reported return to normal activities compared to 12 (24%) in the placebo group, but this difference did not reach statistical significance (P=0.076). For the overall cohort, we did not detect any difference between groups with regard to reported time to 50% reduction in symptom scores. There were also no differences observed between groups with regard to ICU and hospital length of stay and no patients in the trial died or developed vasopressor-dependent shock (all $P> 0.05$).

When we restricted our analysis to patients who presented within two days of symptom onset (63 for *intention to treat*, 54 for *per protocol*), we observed minimal change in the biomarker analysis but found a significant difference between the groups for the symptom severity outcome (Figure 4). This was true for the overall score ($P < 0.001$) as well as the fever,

Table 1. Patient characteristics for influenza patients receiving atorvastatin vs placebo.

Variable n (%) unless otherwise designated	All Patients (N=116)	Atorvastatin (n=59)	Placebo (n=57)
Age (median, IQR)	37 (25, 54)	34 (23, 51)	43 (29, 58)
Sex			
Male	44 (38)	26 (44)	18 (32)
Female	72 (62)	33 (56)	39 (68)
Race			
White	74 (64)	34 (59)	40 (70)
Black	35 (30)	20 (34)	15 (26)
Other race	6 (5)	4 (7)	2 (4)
Social History			
Alcohol abuse	2 (2)	2 (3)	0 (0)
Tobacco use	7 (6)	6 (10)	1 (2)
Past Medical History			
None reported	45 (39)	24 (41)	21 (37)
Asthma	22 (19)	9 (15)	13 (23)
COPD	10 (9)	6 (10)	4 (7)
Diabetes	6 (5)	2 (3)	4 (7)
Cancer	6 (5)	3 (5)	3 (5)
Obesity	6 (5)	2 (3)	4 (7)
Hypertension	25 (22)	14 (24)	11 (19)
Hyperlipidemia	8 (7)	4 (7)	4 (7)
Liver disease	2 (2)	2 (3)	0 (0)
Renal disease	3 (3)	0 (0)	3 (5)
Stroke	2 (2)	1 (2)	1 (2)
Immunocompromised	7 (6)	2 (3)	5 (9)
Body Mass Index (median, IQR)	28.1 (23.8, 33.5)	26.2 (23.4, 33.9)	28.4 (26.4, 33.4)
Current influenza immunization			
Yes	44 (38)	21 (36)	23 (40)
No	71 (61)	38 (64)	33 (58)
Unknown	1 (1)	0 (0)	1 (2)
Influenza characteristics (median, IQR)			
Duration of symptoms in hours	48 (24, 72)	48 (45, 78.5)	48 (24, 72)
Symptom score at enrollment	8 (6, 10)	8 (6, 10)	8 (6, 11)
Disposition from ED			
ICU admission	8 (7)	4 (7)	4 (7)
Ward admission	24 (21)	7 (12)	17 (30)
ED observation	10 (9)	7 (12)	3 (5)
Discharged from ED	74 (64)	41 (69)	33 (58)
Medications administered in ED			
Antiviral	69 (59)	37 (63)	32 (56)
Antibiotics	26 (22)	12 (20)	14 (25)
Steroids	15 (13)	8 (12)	7(12)

IQR, interquartile range; *COPD,* chronic obstructive pulmonary disease; *ED*, emergency department; *ICU,* intensive care unit.

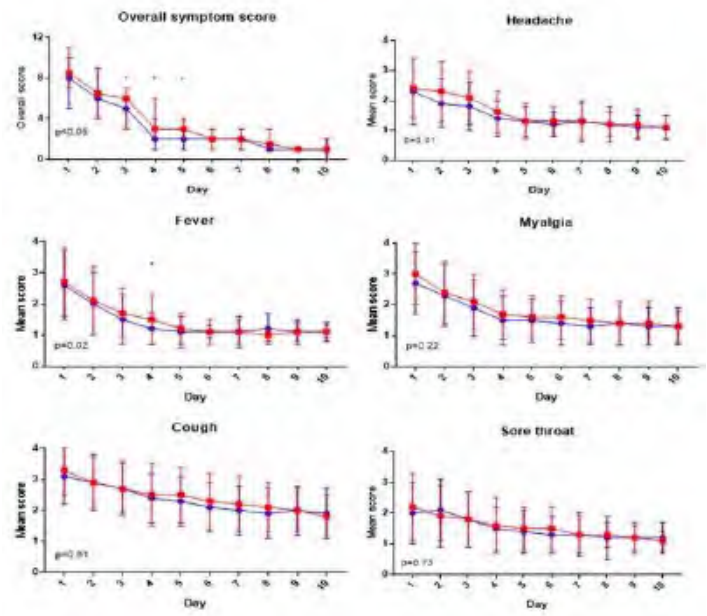

Figure 2. Biomarker mixed model analysis in a study of the effect of atorvastatin vs. placebo in acute influenza. Atorvastatin group in blue, placebo group in red.
IL, interleukin; *TNF*, tumor necrosis factor; *VCAM*, vascular adhesion molecule; *VEGF*, vascular endothelial growth factor.

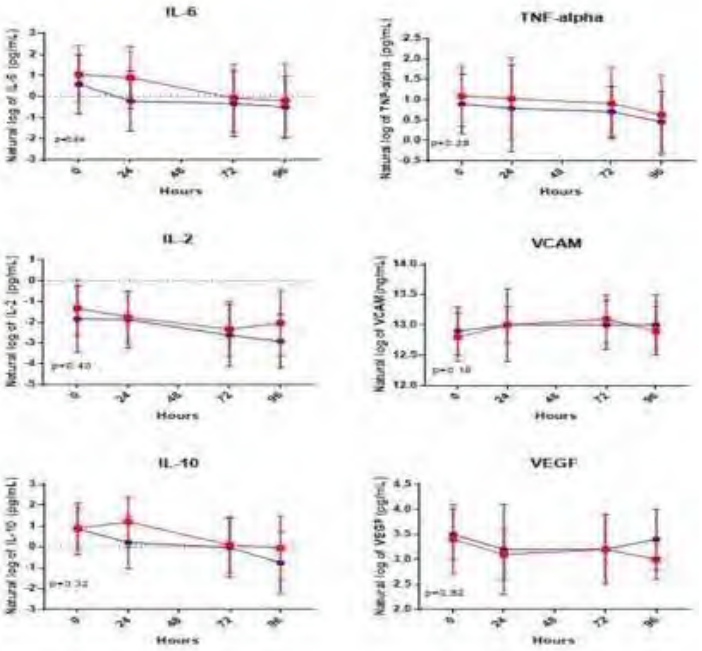

Figure 3. Influenza symptom severity mixed model analysis in this study examining the effect of atorvastatin in acute influenza. Atorvastatin group in blue, placebo group in red.
P-values reflect the model over 10 days, asterisks denote days with significant differences between groups on individual days.

sore throat, and headache components of the score in both the *intention to treat* and *per protocol* analyses. When examining median time to 50% resolution of symptoms in this subset of patients, we found that patients who received atorvastatin reported median resolution in 3 (IQR 2, 4) days vs 4 (IQR 3, 4) days in the placebo group, but this difference was not significant (P=0.36).

DISCUSSION

We did not find significant differences between the atorvastatin and placebo groups with regard to inflammatory biomarkers over time, our primary outcome. However, atorvastatin appeared to be safe for patients with acute influenza infection and, most importantly, hastened resolution of influenza symptoms with the most significant effect of atorvastatin therapy observed in patients who presented within 48 hours of symptom onset.

Biomarker Outcome

While much of the previous work assessing the effect of statins in infection has been observational or in animal models, there are several previous interventional studies in humans. These studies have generally found mixed results with respect to the effect of statin therapy on inflammatory markers and used lower doses of statin as compared to the present trial.[26–28] We based our hypothesis about the contribution of inflammatory cytokines on poor outcomes in influenza infection on the existing literature, which substantiated these associations. However, given that we did not identify any differences between groups with regard to any of the inflammatory markers tested yet did appreciate improved clinical outcomes, we have to consider other mechanisms by which statins exerted their clinical benefit in our trial. There is a body of evidence that suggests that IL-6 is critical in the transition from innate to adaptive immunity in the response to influenza infection, albeit in animal models.[29]

Mechanistically, it is possible that the improved clinical outcomes observed resulted from one or a combination of the multiple other anti-inflammatory and immunomodulatory effects of statins not captured in our biomarker analysis. Sapey et al recently published the results of a pilot clinical trial on ICU patients with pneumonia. They randomized 62 patients to simvastatin 80 mg vs placebo and examined neutrophil function on day 4 of treatment.[30] They found improved neutrophil function and lower Sequential Organ Failure Assessment scores in the simvastatin group but did not identify any significant differences in levels of inflammatory biomarkers including IL-6 and TNF-α. Alternatively, statins may have their greatest effect in a specific genotype of disease as one secondary analysis demonstrated in patients with acute respiratory distress syndrome (ARDS).[31] The HARP-2 trial demonstrated no overall mortality benefit between the statin and placebo groups, but patients with the "hyperinflammatory" sub-phenotype who received simvastatin had significant

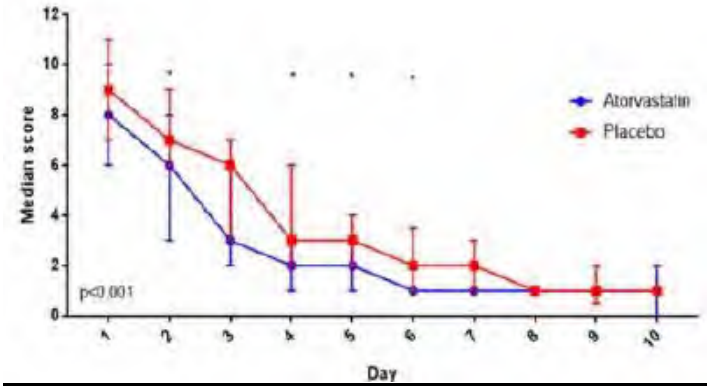

Figure 4. Influenza symptom severity score by treatment, patients with symptom duration ≤48 hours. In a study of the effect of atorvastatin vs placebo in acute influenza, this figure represents the self-reported influenza symptom severity scores in patients presenting within 48 hours of symptom onset.

improvement in 28-day survival compared to those who received placebo.

Clinical Outcomes

With regard to our secondary clinical outcome, we found consistent and positive results for patients in the atorvastatin group. Notably, our atorvastatin group felt better as compared to the placebo group after two days of study drug, and this effect persisted for an additional two days compared to placebo. Additionally, we found that this clinical improvement was most pronounced in the subset of patients who had fewer than 48 hours of influenza symptoms. However, we did not detect a significant difference in median time to 50% resolution of symptoms in the subset of patients who presented early, highlighting the disparate results in these analytic approaches (survival analysis for time to 50% resolution compared to Wilcoxon rank-sum analysis for the differences in median severity score by day).

Several observational studies have also demonstrated that earlier initiation of neuraminidase inhibitors result in improved outcomes in influenza.[32,33] In contrast, Beigel and colleagues conducted a randomized clinical trial administering oseltamivir alone or oseltamivir, amantadine, and ribavirin in combination. They observed a decrease in viral shedding on day 3, but this did not translate to improved clinical outcomes including duration of symptoms.[34] We studied atorvastatin as a possible adjunctive therapy in acute influenza treatment and are strongly encouraged by the findings that patients felt better, faster on atorvastatin as compared to placebo.

There was a difference between groups with regard to return to normal activities that did not reach statistical significance, and there may be a variety of reasons for this including our sample size and precision of the assessment (days vs hours). Nonetheless, it follows that this could potentially translate into fewer missed work days, either for the employees themselves or as caregivers for a sick household member.[35] We know that in the United States alone, the economic burden of seasonal influenza ranges from $11.2-87.1 billion annually when taking into account outpatient visits, hospitalizations, missed work days, and premature mortality.[36,37] Given the potential public health and economic impact of fewer "sick" days with influenza, for this reason alone, atorvastatin therapy in acute influenza may be worthy of further study beyond the current trial.

Subsequent to the completion of this trial, severe acute respiratory syndrome coronavirus-2 emerged causing the COVID-19 pandemic and the associated deaths of millions of people worldwide. This has been a reminder of the potential impact of respiratory viruses on both individual and global health and the importance of finding additional therapeutic options for the treatment of respiratory viruses. A number of observational studies have found a correlation between statin use and clinical outcomes in COVID-19 patients and possibly provide additional support for the potential benefit of statins as an anti-inflammatory agent with pleiotropic effects in respiratory viral disease.[38–40]

Safety

Our findings of safety mirror most trials of statin therapy in acute infection that have not found any significant safety concerns and adds data for patients with acute influenza infection who received atorvastatin, the majority (63%) of whom also received concurrent oseltamivir therapy. We are aware of a meta-analysis of six clinical trials using statin therapy in acute lung injury and ARDS. Although the authors found no benefits in any of the clinical outcomes, one trial did demonstrate potential harm with fewer days free of renal failure and fewer days free of hepatic failure in the treatment group as opposed to placebo.[41] In this trial, ICU patients diagnosed with ARDS were randomized to receive a loading dose of rosuvastatin 40 mg followed by 20 mg daily.[42] This dose is comparable to the 40 mg atorvastatin used in the present trial. While we did not observe any similar adverse effects, our trial had a small number of patients admitted to the ICU (7%); therefore, we were unable to draw any conclusions about safety in critically ill patients with acute influenza.

LIMITATIONS

The trial did not reach target enrollments within the funding period as we were unable to add enrollment sites given the constraints of rapid screening laboratory tests and both storing and dispensing study drug to a largely outpatient population. However, our power calculations were based on highly conservative pilot data with wide standard deviations. We did have several participants in each group who were lost to follow-up after enrollment, but these were evenly distributed between the groups. This trial did not distinguish between patients with influenza A or influenza B and, therefore, we are not able to comment on potential

differences between those groups. Our population was also fairly low acuity with two-thirds of them being discharged following their ED visit. Thus, our findings might not be generalizable to all populations. Because we did not have a rigorous program of monitoring study drug administration outside the hospital we cannot be certain that all study participants adhered to the scheduled dosing. However, we have no reason to believe that rates of compliance would be low given the willingness of participants to enroll in such a trial and return to the hospital for lab testing on day 3 or that there would be any difference between groups given the lack of any serious side effects reported.

CONCLUSION

In this study we did not find any difference over time in pro-inflammatory biomarkers between patients with acute influenza treated with atorvastatin vs placebo. We did find a clinical benefit for patients in the atorvastatin group, which was most pronounced for patients early in their clinical course. Given that we and others have demonstrated the safety of statin medications, further study may be warranted to explore both the mechanisms and potential benefits from statin therapy in acute influenza infection.

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Age-stratified Association Between Plasma Adiponectin Levels and Mortality in Septic Patients

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Background: Plasma adiponectin (APN) levels might be affected by age. In this study we aimed to study the association between plasma APN levels and age and the effects of APN levels on mortality in age-stratified septic patients.

Methods: We conducted this single-center, retrospective study with 173 patients with sepsis and 57 controls. Physical and demographic characteristics were recorded, and blood samples were collected to measure plasma APN levels. Using this data, we determined the association between plasma APN levels and age, and the effect of plasma APN levels on mortality in age-stratified septic patients.

Results: We stratified patients into three age groups: < 60 years (middle age); 60-80 years (advanced age); and elderly (≥ 80 years). Plasma APN levels increased with increasing age in both the control group and the sepsis group. Mortality also increased with age: 12.3% in the < 60 group; 24.6% in those 60-80 years of age; and 36.2% in elderly patients >80 years (P<0.001). In middle-aged and advanced-age patients, APN levels were found to be associated with 28-day mortality based on the receiver operating characteristic curve analysis. Furthermore, APN levels remained independently associated with 28-day mortality in patients < 80 years. However, in elderly patients the APN levels showed no significant association with 28-day mortality.

Conclusion: We found a positive association between plasma adiponectin levels and age in septic patients. Low circulating levels of APN were associated with 28-day mortality in septic patients < 80 years of age. We found no significant association between APN and mortality in sepsis patients who were > 80 years of age. [West J Emerg Med. 2025;26(3)609–616.]

INTRODUCTION

In recent years, the growing elderly population has contributed to a rise in intensive care unit (ICU) admissions and increased mortality among critically ill older patients.[1-3] Demographic changes have made older adults a significant percentage of ICU patients, with multiple comorbidities complicating their clinical status and making them particularly vulnerable to infection-related complications. Consequently, many critical care studies have increasingly focused on this demographic.

Adiponectin (APN), a peptide secreted by adipose tissue, enhances insulin sensitivity and regulates lipid metabolism.[4,5] Reduced APN activity is linked to metabolic syndrome, including obesity, type 2 diabetes, and cardiovascular diseases.[6,7] Beyond its metabolic roles, APN also has anti-inflammatory effects.[8,9] Studies have shown a negative correlation between APN, pro-inflammatory cytokines, illness severity, and mortality in septic patients.[10,11] Our previous research similarly found that low APN levels were associated with 28-day mortality in sepsis patients.[12]

Reports suggest age is associated with elevated plasma APN levels in healthy adults, despite increased cardiovascular risk in the elderly.[13-16] This age-related increase may be linked to visceral fat[15] and renal function,[14,16] although it is less clear in pathological conditions such as type 2 diabetes.[17] Given the uncertainty with regard to sepsis, we aimed to explore the relationship between plasma APN levels, age, and sepsis-related mortality across different age groups.

Population Health Research Capsule

What do we already know about this issue?
Plasma adiponectin (APN) levels may increase with age and influence mortality in septic patients, but age-specific effects remain unclear.

What was the research question?
How do plasma APN levels correlate with age and mortality in age-stratified septic patients?

What was the major finding of the study?
The APN levels predicted 28-day mortality in patients < 80 years ($P < 0.001$), but no association was found in patients ≥ 80 years.

How does this improve population health?
Identifying APN as a mortality predictor in sepsis patients < 80 might aid in early intervention and tailored treatment, possibly improving outcomes and survival rates.

METHODS

Population and Protocol

We conducted a retrospective chart review of ICU patients from January 2019–January 2022, following recommended methodological standards for retrospective studies.[18] The study was approved by the ethics review board, and informed consent was obtained from patients or their families if the patient was mechanically ventilated or had altered mental status. We included a total of 173 sepsis patients (>18 years of age) admitted to the ICU for more than 48 hours. Sepsis was defined according to consensus international guidelines as life-threatening organ dysfunction that is caused by dysregulation of the host response to infection.[19] The exclusion criteria included pregnancy, malignancy, and non-sepsis-related immunosuppression. Fifty-seven postoperative patients without sepsis served as the control group.

This study adheres to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational studies.[20]

Data Collection

Baseline clinical and laboratory characteristics included age, sex, past illness, and blood chemistry (eg, brain natriuretic peptide [BNP], C-reactive protein [CRP], procalcitonin, serum creatinine, alanine transaminase, high-sensitivity troponin T, and arterial blood gas) were measured using standard clinical methods at the China-Japan Friendship Hospital. Data was collected at the time of a diagnosis of sepsis or upon admission. Disease severity was assessed by Sequential Organ Failure Assessment (SOFA) scores and Acute Physiology and Chronic Health Evaluation II (APACHE-II) scores on the day of diagnosis.

Plasma Adiponectin Levels and Biochemical Assays

Blood samples were obtained on the day of admission or sepsis diagnosis and centrifuged at 1000×g for 15 minutes at 4°C within 30 minutes of collection. Plasma was withdrawn and stored at -80°C until analysis. Plasma APN levels were measured using an enzyme-linked immunosorbent assay (ELISA) for human APNs (human APN ELISA kit; R&D Systems, Emeryville, CA). Optical density was measured at 450 nanometers. The limit of APN detection was 0.891 nanograms per milliliter according to the manufacturer's instructions.

Statistical Analysis

We analyzed data using SPSS 23.0 (SPSS Statistics, IBM Corp, Armonk, NY) and Prism 7.0 (GraphPad, Inc, San Diego, CA). The Kolmogorov-Smirnov test assessed normality. Continuous variables are presented at mean ± SD or median (25th-75th percentile), while categorical variables are shown as numbers and percentages. We performed group comparisons using unpaired *t*-tests (normal distribution) or Mann-Whitney U tests (non-normal distribution). Sepsis patients were divided into three age groups (<60, 60-80, and ≥80 years), and we compared variables using analysis of variance (ANOVA) or Kruskal-Wallis H tests. Pearson or Spearman correlation coefficients assessed associations between APN and various parameters. Kaplan-Meier curves were used to analyze survival across age groups. Logistic regression identified risk factors for sepsis-related mortality, reported as odds ratios (OR) and 95% confidence intervals (CI). Receiver operating characteristic (ROC) curves determined the sensitivity and specificity of predicting 28-day mortality in sepsis. A *P*-value of <0.05 was considered statistically significant.

Sample size calculation was based on previous results showing that the mortality rates for the age groups were estimated as follows: <60 years (11%); 60-80 years (14.2%); and >80 years of age (18%).[21,22] We used G*Power software (Heinrich Heine University, Düsseldorf, Germany) and performed an ANOVA for three independent groups. The total required sample size for a one-way ANOVA was 144 patients

with 85% power, an alpha level of .05, and an effect size of .28. Assuming a rate of 20% for missing data or incomplete follow-up, we decided to include 173 patients.

RESULTS

Clinical Characteristics of Patients

In the sepsis or septic shock group, we included an initital total of 182 patients. Of them, five were excluded because they were already in a terminal condition upon ICU admission, and four were excluded because of long-term use of steroids. As a result, 173 sepsis patients were included with a mean age of 67.58±14.07 years. According to previous studies, age is closely associated with sepsis mortality.[22,23] Research has shown that patients ≥80 years of age have a higher in-hospital mortality rate compared to those 65-79 years of age.[23] Therefore, based on previous studies, we stratified the included patients into three age groups: <60 years (middle-aged), 60-80 years (advanced age), and >80 years (elderly). The main sources of sepsis were gastrointestinal (38.7%), pulmonary (31.8%), cholangitis (16.2%), genitourinary (8.1%), and bloodstream infection (5.2%).

Table 1 summarizes patient characteristics. Hypertension, diabetes, coronary artery disease, and chronic

Table 1. Clinical characteristics of patients with sepsis at admission.

	Middle-aged patients (< 60 years) (n=57)	Advanced age patients (60-79) (n=69)	Elderly patients (≥ 80 years) (n=47)	P
Age (years)	54 (45-56)	70 (66-75.5)	84 (81-85)	<.001
Male (n [%])	25 (43.9)	39 (56.5)	26 (55.3)	.32
Body mass index (kg/m2)	23.04 (20.96-24.54)	23.43 (21.6-25.18)	22.89 (19.63-25.28)	.59
Past illness				
Hypertension (n [%])	19 (33.3)	37 (53.6)	32 (68.1)	<.01
Diabetes (n [%])	10 (17.5)	41 (59.4)	36 (76.6)	<.001
Coronary artery disease (n [%])	17(29.8)	31(44.9)	26(55.3)	.02
Chronic kidney disease (n [%])	11(19.3)	29(42.0)	24(51.1)	<.01
Severity of illness				
APACHE II score	16 (11-24)	19 (14-23)	23 (19-28)	<.001
SOFA score	11 (7.5-15)	9 (6-13.5)	10 (7-12)	.36
Source of infection N (%)				
Gastrointestinal	14(24.5)	32(46.4)	22(46.8)	.02
Pulmonary	18(34.0)	18(26.1)	17(36.2)	.46
Cholangitis	14(25.5)	12(17.4)	5(10.7)	.15
Genitourinary	8(14.0)	6(8.7)	2(4.4)	.23
Bloodstream infection	3(5.4)	1(1.5)	1(2.1)	.40
Laboratory parameters				
Glucose (mmol/L)	11.3 (9.4-14.3)	11.7 (9.4-15.4)	10.7 (9.5-12.5)	.25
Serum creatinine (μmol/L)	106.2 (75.7-173.3)	132.2 (75.3-239.5)	174.4 (108-263.5)	<.01
ALT (IU/L)	37 (19.5-76.5)	31 (14-71)	21 (12-81)	.49
Brain natriuretic peptide (pg/mL)	840.5 (302-1442)	1,133 (545-2066)	1,328 (661.9-5053)	<.01
hsTnT (ng/mL)	0.122 (0.024-0.482)	0.056 (0.012-0.486)	0.192 (0.04-0.643)	.07
Procalcitonin (ng/mL)	6.86 (3.12-20.75)	11.96 (3.73-24.85)	8.71 (1.08-33.4)	.19
CRP (mg/L)	24.24 (13.51-55.2)	45 (15.8-96.13)	76.18 (45.26-145)	<.001
Lactic acid (mmol/L)	3.2 (1.9-4.75)	2.6 (1.6-3.9)	2.3 (1.9-4.4)	.22
APN (μg/mL)	6.34 (3.35-8.49)	8.32 (4.77-10.34)	9.87 (7.58-12.33)	<.001
Clinical outcomes				
Invasive ventilation duration (d)	4 (1-9)	5 (2-19)	15 (7-27)	<.001
28-day mortality (n [%])	7 (12.3)	17 (24.6)	17 (36.2)	.01
In-hospital mortality (n [%])	9 (15.8)	19 (27.5)	18 (38.2)	.03

The data are expressed as a median with interquartile range or number of patients.
APACHE II, Acute Physiology and Chronic Health Evaluation II; *SOFA,* Sequential Organ Failure Assessment; *ALT,* alanine transaminase; *hsTnT,* high-sensitivity troponin T; *CRP,* C-reactive protein; *APN,* adiponectin; *IQR,* interquartile range.

kidney disease were more common in the elderly. Elderly patients also had higher APACHE II scores, serum creatinine, BNP, and CRP. No significant differences were noted between age groups for gender, SOFA scores, and other laboratory parameters listed in Table 1.

Variation in Adiponectin Levels in Sepsis Patients

Plasma APN levels in each age group are shown in Table 1 and Figure 1. Plasma APN levels were significantly lower in patients with sepsis than those in patients without sepsis in all age groups and increased with age in both groups. The plasma APN level was negatively correlated with age in both the control group and the sepsis group (r = .690, *P*<.001 and r = .412, *P*<.001; Figure 2).

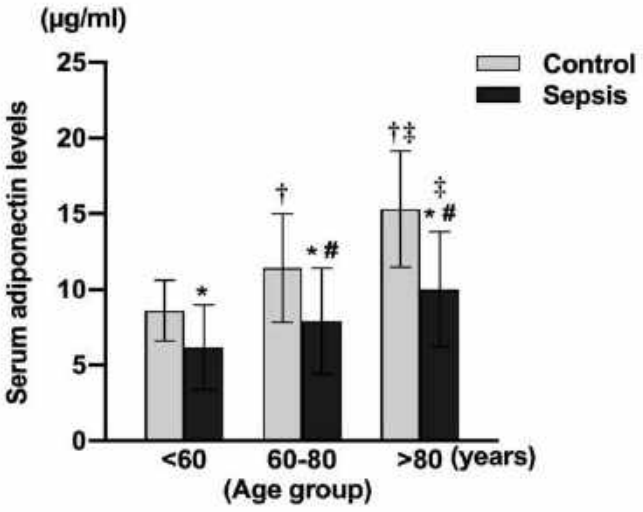

Figure 1. The plasma adiponectin levels in each age group in the control and sepsis groups.
*P <0.05 vs the control group in each age group. # P <.05 vs < 60 groups in sepsis patients, †P <.05 vs < 60 groups in controls, ‡P <.05 vs 60-80 group both in control and sepsis patients.
μg/mL, micrograms per mililiter.

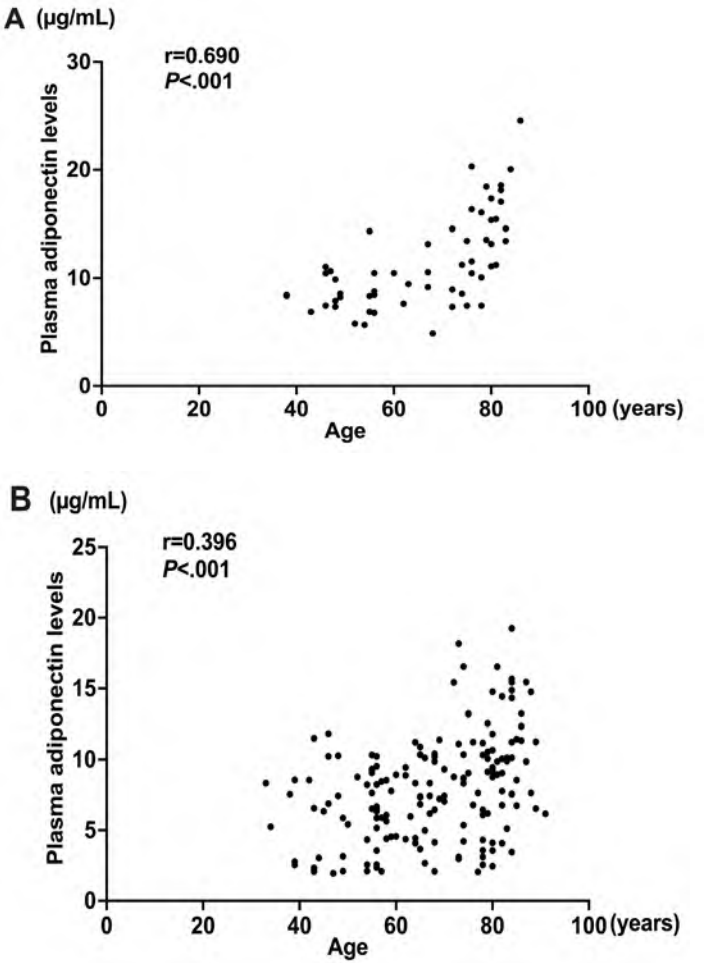

Figure 2. The positive association between age and adiponectin (APN) level in the control (A) and sepsis group (B). Correlation between the plasma APN level and age was confirmed by values of r = 0.690, P <.001 and r = 0.396, P <.001 in the control and sepsis groups, respectively.
μg/mL, micrograms per mililiter.

Comparison of Clinical Outcomes

Clinical outcomes across age groups are presented in Table 1. Elderly patients had significantly higher 28-day (36.2% vs 24.6% vs 12.3%, *P*=.01) and in-hospital mortality (38.2% vs 27.5% vs 15.8%, *P*=.03) and required longer mechanical ventilation (15, interquartile range [IQR] 7-27 vs 5 IQR, 2-19 vs 4, IQR 1-9) compared to advanced-age and middle-aged patients. Subgroup analysis of 28-day mortality is detailed in Figure 3 and Table 2. Survival was significantly lower in older age groups (Figure 3A). In deceased patients, elderly patients had higher plasma APN levels, which were negatively correlated with age (r=.386, *P*=<.01; Table 2, Figure 3B).

Association Between Adiponectin and Mortality in Different Age Stratifications

We found that both in-hospital mortality and APN levels increased with age, unlike previous studies associating low APN levels with sepsis mortality.[12] To investigate further, we analyzed the link between APN levels and 28-day mortality by age group. Univariate logistic regression (Table 3) showed that low APN levels were associated with higher 28-day mortality in patients < 60 years and 60-80 years. In these groups, APACHE II and SOFA scores were also significant, along with serum creatinine, BNP, and CRP in the 60-80 group. In patients > 80 years, only APACHE II scores and BNP levels were significantly related to 28-day mortality, with no association found for APN.

The multivariate regression analysis of significant parameters revealed that among patients < 60 years of age, only APN and APACHE II scores were independently associated with 28-day mortality. In the 60-80 years group, APN, APACHE II, and BNP were also significant independent

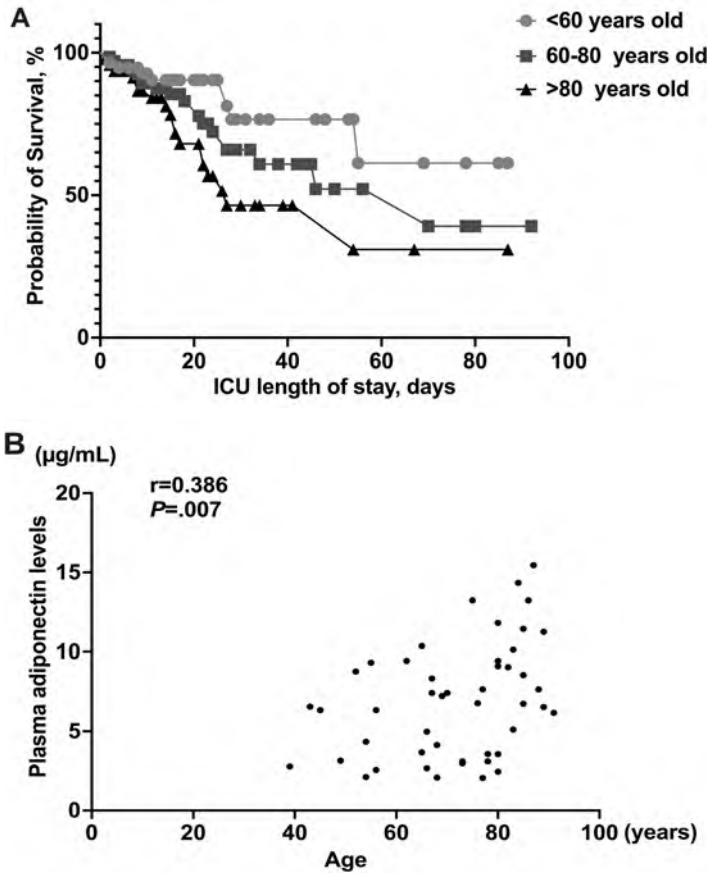

Figure 3. A. Survival curves were generated by the Kaplan-Meier method for middle-aged, advanced, and elderly patients with sepsis. B. The positive association between age and adiponectin (APN) level in deceased patients. Correlation between APN level and age was confirmed by values of r =.386 and P<.001.
ICU, intensive care unit.

predictors of 28-day mortality (Table 4).

We conducted ROC curve analyses to assess the association between APN levels and 28-day mortality across the three age groups. The AUC values, as well as the sensitivity and specificity of APN in association with sepsis related mortality, decreased with age. In elderly patients, APN was not significantly associated with mortality. However, in middle-aged and advanced age patients, APN showed strong discriminative ability (AUC = 0.872 and AUC = 0.774). APN cutoff values of 3.355 μg/ml and 7.985 μg/ml predicted mortality with sensitivities of 88.89% and 83.33%, and specificities of 87.5% and 62.75%, respectively (Table 5, Figure 4).

DISCUSSION

In this study we found that plasma APN levels were significantly lower in sepsis patients. Both control and sepsis groups exhibited a positive correlation between plasma APN levels and age. Mortality rates were notably higher in patients ≥ 60 years of age, with those ≥ 80 years experiencing even greater mortality. The APN levels were associated with 28-day mortality in patients < 80 years, as indicated by the AUC, where lower APN levels correlated with higher mortality. However, no significant association with 28-day mortality was observed in patients aged ≥ 80 years.

Table 2. Comparison of adiponectin levels in sepsis patients of different ages according to the patient outcome.

Patients with sepsis	APN (μg/mL) < 60 years	60-80 years	> 80 years	*P*
Surviving patients	6.53 (4.4-8.54)	8.91 (6.19-10.45)	9.9 (8.28-14.6)	<.001
Deceased patients	4.98 (3.1-7.65)	5.34 (2.73-9.33)	9.08 (6.45-11.53)	<.01

APN, adiponectin.

Adiponectins have anti-inflammatory effects and may play a role in acute inflammatory diseases through direct effects on inflammatory cells and interactions with tumor necrosis factor-alpha.[24] Early data in septic patients indicated decreased APN levels, but it is unclear whether this results from the disease or whether lower levels predispose patients to critical illness.[24] Soares et al noted that oxidative stress in adipose cells leads to reduced APN secretion and higher lactate levels in sepsis.[25] Our studies found lower APN levels linked to greater sepsis severity; however, prior research reported conflicting results, showing either increased or similar APN levels compared to controls.[26,27] These discrepancies could stem from differences in study design, sepsis stages, and patient characteristics, such as age, gender, and exclusion criteria.[28]

Several studies show a correlation between APN levels and survival in sepsis patients. APN levels showed a stronger association with 28-day survival than other factors, including the APACHE II score.[12,26] Hillenbrand et al found significant changes in plasma adipokine levels in severe sepsis, with higher pro-inflammatory and lower anti-inflammatory factors.[28] In our study, multivariate regression analysis indicated that 28-day mortality was significantly correlated with APN levels in patients <80 years of age. These findings highlight the potential utility of APN as a biomarker for early risk stratification and therapeutic targeting in sepsis.

A large observational cohort reported higher mortality among patients > 85 compared to the general population.[29] Additionally, age > 60 was linked to mortality in ICU patients with intra-abdominal infections, and patients ≥80 of age faced the worst prognosis.[30] Our study also found increased mortality with age, particularly in those ≥ 80. Statistical analysis using multivariate regression models demonstrated that age was an independent predictor of 28-day mortality ($P < .05$). When stratified by age groups (< 60 years, 60–79 years, and ≥ 80 years), the mortality rates were observed to increase progressively, with rates of 12.3%, 24.6%, and 36.2%, respectively. Factors contributing to this increase include altered immunity, chronic diseases, malnutrition, and frailty.[30] The findings underscore the

Table 3. Univariate logistic regression analysis of factors associated with 28-day mortality in different age stratifications.

	< 60 years			60-80 years			> 80 years		
	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
Sex	.825	.189-3.274	.79	.805	.276-2.356	.69	1.467	.448-5.003	.53
Body mass index	1.032	.791-1.368	.82	1.024	.839-1.254	.82	0.979	.813-1.176	.83
Hypertension	.830	.162-3.442	.29	1.269	.439-3.787	.66	1.368	.388-5.258	.63
Diabetes	.756	.148-3.122	.71	2.800	.918-9.743	.08	0.678	.171-2.763	.58
Coronary artery disease	2.917	.702-12.29	.13	2.063	.712-6.207	.18	1.467	.448-5.003	.53
Chronic kidney disease	2.089	.388-9.389	.37	2.593	0.879-7.843	.08	0.650	.194-2.115	.47
Glucose	0.889	.709-1.068	.22	.984	0.862-1.114	.80	1.030	.842-1.259	.77
APACHE II	1.122	1.109-1.253	.02	1.234	1.115-1.414	< .001	1.121	1.027-1.242	.02
SOFA	1.221	1.040-1.480	.02	1.158	1.023-1.326	.03	1.219	1.047-1.456	.02
Serum creatinine	1.012	1.004-1.022	.01	1.007	1.001-1.013	.01	0.997	0.991-1.001	.18
Alanine transaminase	1.001	.991-1.008	.84	.998	0.991-1.003	.48	1.001	0.999-1.004	.11
BNP	.649	.236-1.364	.28	1.780	1.133-2.950	.01	2.165	1.359-3.858	<.001
hsTnT	.842	.227-1.931	.73	1.305	0.809-2.089	.26	3.785	1.21-18.38	.02
Procalcitonin	.983	.927-1.024	.45	.998	.972-1.020	.85	1.000	0.975-1.024	.99
C-reactive protein	1.008	.992-1.022	.29	1.013	1.004-1.022	.004	1.009	0.999-1.019	.08
Lactic acid	1.014	.841-1.158	.85	.985	.788-1.178	.88	1.113	0.886-1.415	.35
Adiponectin	.389	.181-0.632	< .001	.687	.540-.840	< .001	.882	.735-1.036	.13
Infection source									
Gastrointestinal	.903	.544-10.46	.22	1.541	.881-7.99	.09	.572	.543-5.961	.35
Pulmonary	.452	.356-6.397	.54	1.622	.640-6.523	.22	.347	.405-4.889	.58

Odds ratios, 95% CIs, and P-values were obtained by univariate logistic regression analysis.
OR, odds ratio; *CI,* confidence interval; *APACHE II,* Acute Physiology and Chronic Health Evaluation II; *SOFA,* sequential organ failure assessment; *BNP,* brain natriuretic peptide; *hsTnT,* high-sensitivity troponin T.

Table 4. Multivariate logistic regression analysis of factors associated with 28-day mortality in different age stratification.

	< 60 years			60-80 years			> 80 years		
	OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
APACHE II	1.24	1.072-1.508	.01	1.282	1.101-1.585	.006	1.186	1.048-1.383	.01
SOFA	1.037	.817-1.316	.76	1.200	.993-1.503	.076			
Serum creatinine				1.009	1.000-1.021	.069			
BNP				3.690	1.656-11.17	.005	1.957	1.167-3.646	.02
C-reactive protein				1.002	.988-1.016	.748			
Adiponectin	.296	.079-.599	.01	0.651	.411-0.907	.027			

Odds ratios, 95% CIs, and P-values were obtained by multivariate logistic regression analysis.
OR, odds ratio; *CI,* confidence interval; *APACHE II*, Acute Physiology and Chronic Health Evaluation II; *SOFA,* sequential organ failure assessment; *BNP,* brain natriuretic peptide.

Table 5. Receiver operating characteristic analysis of adiponectin levels for predicting 28-day mortality in septic patients across different age groups.

Patients with sepsis	Cutoff value	AUC (95% CI)	Sensitivity	Specificity	P
<60 years	3.355	0.872 (.759-.983)	88.89	87.50	<.001
60-80 years	7.985	0.774 (.658-.890)	83.33	62.75	<.001

The cutoff value was determined using receiver operating characteristic curve analysis.
AUC, the area under the curve; *CI,* confidence interval.

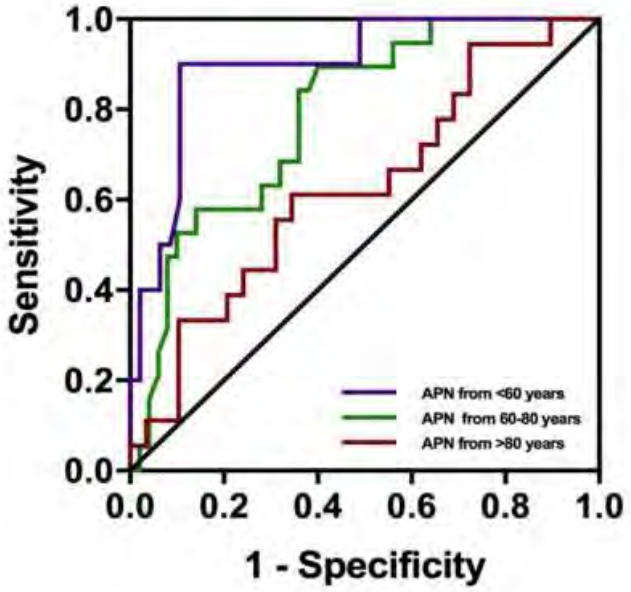

Figure 4. Receiver operating characteristic curve analysis of the association of adiponectin with 28-day mortality in septic patients at the age 80 years.
APN, adiponectin.

importance of incorporating age as a critical variable in the risk stratification of sepsis patients. Tailored interventions targeting older adults, including early recognition, aggressive supportive care, and personalized management plans, are essential to mitigate the impact of age-related mortality risk.

We further examined the relationship between APN levels and age in sepsis patients. Previous research indicated increased plasma APN levels in older individuals.[13-15,31] Obata et al showed that APN levels positively correlated with age, independent of renal function and body fat.[17] Consistent with these findings, we observed a statistically significant positive correlation between age and APN levels (r=.386, P=.01). When stratified by age groups, the APN levels showed a stepwise increase, with levels of 0.389 (0.181-0.632) μg/ml, 0.687 (0.540-0.840) μg/ml, 0.882 (0.735-1.036) μg/ml, respectively. The mechanisms behind the age-related increase in APN levels remain unclear. Some studies suggest a link to declining renal function,[14] while others report no association.[16] Our findings align with hypotheses that aging-related changes in metabolism and inflammation may play a role in regulating APN levels. Given the known anti-inflammatory and insulin-sensitizing properties of APN, these results highlight its potential involvement in age-related metabolic and inflammatory processes in sepsis.

Although APN levels increase in chronic kidney disease,[32] type 1 diabetes,[33] and heart failure,[34] hypoadiponectinemia remains an independent risk factor due to arteriosclerosis progression. The rise in APN levels with age appears paradoxical, as high APN in the elderly may not provide benefits due to advanced atherosclerosis.[35] Our findings support this paradoxical relationship. Specifically, multivariate regression analysis indicated that APN levels were significantly associated with 28-day mortality in patients <60 years and 60-80 years of age (OR .296, 95% CI .079-0.599, *P*=.01, and OR .651, 95% CI .411-.907, *P*=.03, respectively), but not in patients ≥80 years. These results suggest that while elevated APN levels may have protective effects in younger sepsis patients, their role in the elderly is likely diminished due to the presence of advanced atherosclerosis and other age-related comorbidities. Further research is needed to clarify APN's role in elderly sepsis patients, particularly to explore potential interventions targeting APN pathways to improve outcomes.

LIMITATIONS

Limitations of this study include its single-center design and small sample size, which may affect the generalizability of findings. We also lacked comprehensive longitudinal data with multiple plasma measurements, and selection bias may exist due to missing data, particularly among elderly patients. Larger multicenter trials are needed to better understand APN's role in sepsis.

CONCLUSION

We found a significant positive association between plasma adiponectin levels and age in septic patients. Low circulating APN levels were associated with a higher risk of death in septic patients < 80 years of age, serving as an independent predictor of mortality in this group. However, the association between APN and mortality was not significantly higher in patients > 80 years of age. Based on these results, clinicians should consider age-related changes in plasma APN levels when interpreting a patient's levels in clinical practice.

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Developing Machine-Learning Models to Predict Bacteremia in Febrile Adults Presenting to the Emergency Department: A Retrospective Cohort Study from a Large Center

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Introduction: Bacteremia, a common disease but difficult to diagnose early, may result in significant morbidity and mortality without prompt treatment. We aimed to develop machine-learning (ML) algorithms to predict patients with bacteremia from febrile patients presenting to the emergency department (ED) using data that is readily available at the triage.

Methods: We included all adult patients (≥18 years of age) who presented to the emergency department (ED) of National Taiwan University Hospital (NTUH), a tertiary teaching hospital in Taiwan, with the chief complaint of fever or measured body temperature more than 38°C, and who received at least one blood culture during the ED encounter. We extracted data from the Integrated Medical Database of NTUH from 2009–2018.The dataset included patient demographics, triage details, symptoms, and medical history. The positive blood culture result of at least one potential pathogen was defined as bacteremia and used as the binary classification label. We split the dataset into training/validation and testing sets (60-to-40 ratio) and trained five supervised ML models using K-fold cross-validation. The model performance was evaluated using the area under the receiver operating characteristic curve (AUC) in the testing set.

Results: We included 80,201 cases in this study. Of them, 48120 cases were assigned to the training/validation set and 32,081 to the testing set. Bacteremia was identified in 5,831 (12.1%) and 3,824 (11.9%) cases of the training/validation set and test set, respectively. All ML models performed well, with CatBoost achieving the highest AUC (.844, 95% confidence interval [CI] .837-.850), followed by extreme gradient boosting (.843, 95% CI .836-.849), gradient boosting (.842, 95% CI .836-.849), light gradient boosting machine (.841, 95% CI .834-.847), and random forest (.828, 95% CI .821-.834).

Conclusion: Our machine-learning model has shown excellent discriminatory performance to predict bacteremia based only on clinical features at ED triage. It has the potential to improve care quality and save more lives if successfully implemented in the ED. [West J Emerg Med. 2025;26(3)617–626.]

INTRODUCTION

Bacteremia, defined as the existence of bacteria in the bloodstream, is a serious and potentially life-threatening condition associated with mortality rates ranging from 13-35%.[1-3] The timely and accurate diagnosis of bacteremia is crucial for appropriate treatment and management of patients who present with fever to the emergency department (ED). Emergency physicians often order blood culture tests for patients suspected of bacterial infections based on the presence of fever. However, excessive and unnecessary blood culture tests can lead to extended hospital length of stay, increased antibiotic use, additional laboratory testing, and even higher rates of side effects related to blood collection and antibiotic administration.[4]

Despite the advancements in modern medical technology, blood culture remains the gold standard for diagnosing bacteremia and determining antimicrobial susceptibility. However, it often takes more than 24 hours to achieve a detectable colony size, preventing emergency physicians from obtaining real-time blood culture results. This delay can lead to the administration of ineffective antibiotics or the premature discharge of patients with bacteremia, which may become evident later on. While detailed evaluations by emergency physicians may not always lead to irreparable consequences, bacteremia caused by specific bacteria can indeed result in unfavorable outcomes.[5-7]

Previous studies have identified various variables, including vital signs, clinical symptoms, comorbid conditions, and laboratory values, which are independently associated with bacteremia.[8-10] Several prediction models have also been developed, with area under the receiver operating characteristic curve (AUC) values ranging from .71-.854.[11-15] In recent years, machine-learning (ML) techniques have been applied to predict bacteremia, but most studies have primarily focused on hospitalized patients,[16-19] with limited research involving ED patients.[20,21] Furthermore, many of these studies rely on laboratory results that are not immediately available in the ED. In the ED setting, physicians typically rely solely on demographics, ED triage data, symptoms, and past medical history to make early predictions of bacteremia, emphasizing the critical role of ordering necessary blood cultures.[21,22]

In light of these challenges, we sought to create a predictive model that can assist emergency physicians in making timely and informed decisions regarding the need for blood culture tests and appropriate treatment strategies. By harnessing the power of ML and incorporating a wide range of clinical, demographic, and other accessible variables during the ED encounter collected from electronic medical records (EMR), our study aimed to develop the ML algorithms that can predict bacteremia in febrile patients presenting to the ED using data readily available during the triage and history-taking stages. Additionally, we discuss the potential implications of our findings, acknowledge the study's limitations, and outline future directions for research in this critical field of emergency medicine.

Population Health Research Capsule

What do we already know about this issue?
Early diagnosis of bacteremia is challenging, yet delayed treatment increases morbidity and mortality in febrile emergency department (ED) patients.

What was the research question?
Can machine-learning methods predict bacteremia in febrile ED patients using triage data?

What was the major finding of the study?
CatBoost achieved the highest AUC (.844, 95% CI .837-.850) for bacteremia prediction at ED triage.

How does this improve population health?
Early bacteremia prediction by machine-learning at triage has the potential to enable timely treatment, improving outcomes and reducing mortality in ED patients.

METHODS

Study Design and Setting

We conducted this retrospective cohort study using EMR data extracted from the integrated Medical Database (iMD) of National Taiwan University Hospital (NTUH), a 2,500-bed, university-affiliated teaching hospital providing primary, secondary, and tertiary care in northern Taiwan. The hospital has various departments covering all major specialties, including transplantation and oncology. The ED of this hospital sees an annual average of 110,000 patient visits, with approximately 91,600 visits when excluding pediatric (<18 years of age) cases. This study was approved by the Institutional Review Board of NTUH (202104109RINC) with a waiver of informed consent. This study protocol followed the guidelines of "Minimum information about clinical artificial intelligence modeling: the MI-CLAIM checklist".[23]

Study Population

We included all adult patients (≥18 years of age) who presented to the ED of NTUH over a 10-year period (January 2009–December 2018) with the chief complaint of fever or measured body temperature of more than 38° Celsius at triage, and received at least one blood culture during the ED

encounter. Repeat ED visits by the same patient within a 30-day period were considered as the same index visit, and duplicate visits were eliminated from the analysis.

Collection of Variables (Features)

From the iMD, we obtained patient demographics, including age, sex, height, and body mass index (BMI), that are readily available during triage. We also collected ED triage data, which encompassed the five-level Taiwan Triage and Acuity Scale (TTAS), details of emergency medical services (EMS) transport, and transfer status.[24] The initial ED presenting vital signs, including the Glasgow Coma Scale (GCS) score, body temperature, pulse rate, respiratory rate, oxygen saturation (SpO2), pain index, and acute changes in consciousness, were also retrieved. The GCS scores were further categorized into clear consciousness (GCS 15), minor coma (GCS 13-14), moderate coma (GCS 9-12), severe coma (GCS 3-8), and other (intubated, tracheostomy, or aphasia). Furthermore, we extracted clinical symptoms from the TTAS documentation, which encompassed a total of 179 structured chief complaints (CC) recorded during patient encounters by the triage nurse. Incorporating past medical histories (PMH) as input features for this study involved two different sources of information. First, PMHs were obtained through direct patient reporting during their current ED encounters as part of the interview conducted by the triage nurse while enquiring their CCs. The second source of PMH data was derived from patients' prior chart records, spanning outpatient, inpatient, or previous ED admissions, and subsequently coded using the *International Classification of Diseases*, *10th Rev* (ICD-10) codes.[25]

Outcome Measures

The primary outcome of this study —the presence of true bacteremia—was also employed as the classification label for our binary classification task. Patients were labeled as having true bacteremia when either a single blood culture yielded pathogenic bacteria or when two or more sets of blood cultures collected from distinct sites revealed the same bacterial species. Contaminants, including coagulase-negative staphylococci, *Corynebacterium* species, *Bacillus* species (except for *B anthracis*), *Propionibacterium* species, *Micrococcus* species, and *Clostridium perfringens*, were identified and excluded based on prior studies, except in cases where a significant indwelling catheter was present.[26]

Data Analysis and Feature Selection

We used Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA) for data entry and processing. The data was further analyzed with SPSS Statistics for Windows v24.0 (IBM Corp, Armonk, NY). The variables with missing values were imputed by replacing them with the mean, median, or mode of their respective class if the missing rate was less than 20% for that variable. We presented the results as percentages for categorical variables, standard deviations for continuous variables, and medians with interquartile ranges (IQR) for time variables. Our feature selection approach involved univariate analyses, where we assessed outcome differences between groups using statistical tests such as Student *t*-test, chi-squared test, Fisher exact test, or Mann-Whitney U test, depending on the distribution of the data. We selected variables with a significance level of $P<.05$ in the training cohort as the input features for constructing the ML models.

Machine-Learning Model Construction

We employed supervised ML algorithms using random forest (RF), gradient boosting (GB), CatBoost (CB), light gradient boosting machine (LGBM) and extreme gradient boosting (XGB) to construct the prediction models. The dataset was randomly split into the training/validation and testing cohorts at a ratio of 60:40. To train our model, we employed K-fold cross-validation, with the value of K ranging from 7-10. The model's performances were evaluated through the area under the receiver operating characteristic curve (AUC) on the test set. We selected the K value that resulted in the highest AUC performance as our final choice. In addition to AUC, we also reported the classification performances on the testing cohort using F1-score, precision (or positive predictive value [PPV]), recall (sensitivity), specificity, negative predictive value (NPV), and area under the precision-recall curve (AUPRC) for each model. Furthermore, we incorporated SHAP (Shapley additive explanations) value analysis alongside feature importance to enhance the interpretability and transparency of the ML models we developed.[27] All ML analyses were performed using Python 3.8 programming language (Python Software Foundation, Wilmington, DE) with package scikit-learn 0.23.1 installed.

RESULTS

During the study period, a total of 124,158 adult ED visits with at least one blood culture performed were retrieved from the iMD. After excluding records of repeat ED visits within 30 days and patients without fever, we included 80,201 records for analysis. The flow chart of case inclusion and exclusion process is shown in Figure 1. We assigned 48,120 cases to the training/validation cohort and 32,081 to the testing cohort. True bacteremia was identified in 5,831 (12.1%) and 3,824 (11.9%) cases of the training/validation cohort and testing cohort, respectively.

The characteristics of the study population, including patient demographics and ED triage data for both the training/validation and testing cohorts, are presented in Table 1. A comprehensive breakdown of population characteristics, including past medical histories (PMH) and ED presenting symptoms across groups, can be found in Supplementary Table S1. Univariate analyses of features distinguishing patients with and without bacteremia are partially summarized in Table 2 for the training/validation and testing sets. Full details are provided in Supplementary Table S2.

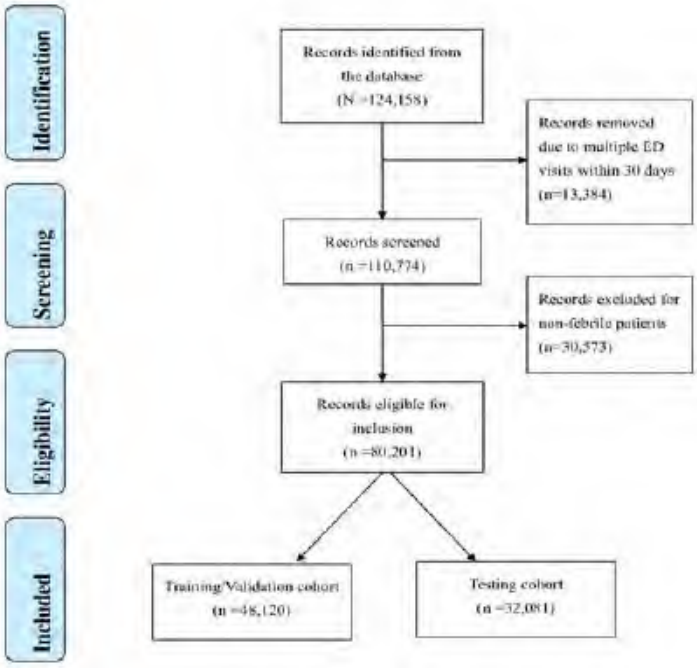

Figure 1. The case inclusion and exclusion flow chart. *ED,* emergency department.

A total of 395 clinical features were selected by setting the *P*-value <0.05 from the training/validation cohort. These features comprised six demographic factors, 10 triage-related variables, and 25 symptoms. Additionally, there were 354 PMHs sourced from two distinct origins: 98 features were gathered through direct patient interviews conducted by triage nurses, while 256 features were extracted from EMR-based ICD-10 codes. Five ML models, including RF, LGBM, XGB, CB, and GB, were constructed for predicting bacteremia. By selecting 9-fold cross validation, the constructed models showed excellent discrimination ability on the training/validation cohort and maintained their discriminatory performances on the testing cohort in terms of AUC (Figure 2).

As illustrated in Table 3, the ML model constructed using 9-fold cross-validation in the testing cohort achieved the better area under the curve (AUC) with CB at 0.844 (95% CI 0.837-0.850), closely followed by XGB at 0.843 (95% CI 0.836-0.839), GB at 0.842 (95% CI 0.836-0.849), LGBM at 0.841 (95% CI 0.834-0.847), and RF at 0.828 (95% CI 0.821-0.834). When considering the balance between precision and recall by calculating the AUPRC, CB exhibited performance at 0.540 (95% CI 0.525-0.555), followed by XGB at 0.537 (95% CI 0.522-0.552), GB at 0.536 (95% CI 0.521-0.550), LGBM at 0.533 (95% CI 0.518-0.548), and RF at 0.473 (95% CI 0.458-0.489). Except for RF, the differences

Table 1. Patient demographics, ED triage data of the training/validation cohort and testing cohort.

Variables (features)	Total (N=80,201)		Training cohort (n=48,120)		Testing cohort (n=32,081)		*P-value*
Sex							0.87
Female	40,220	(50.1)	24,143	(50.2)	16,077	(50.1)	
Male	39,981	(49.9)	23,977	(49.8)	16,004	(49.9)	
Age, Mean (SD)	59.3	(20.0)	59.3	(20)	59.4	(20.1)	0.36
Temperature, Mean (SD)	38.4	(1.4)	38.4	(1.3)	38.4	(1.5)	0.25
Acute change							0.47
No	71,876	(89.6)	43,142	(89.7)	28,734	(89.6)	
Yes	2,570	(3.2)	1,561	(3.2)	1,009	(3.1)	
NA	5,755	(7.2)	3,417	(7.1)	2,338	(7.3)	
EMS transfer							0.12
No	64,486	(80.4)	38,686	(80.4)	25,800	(80.4)	
Yes	68	(0.1)	47	(0.1)	21	(0.1)	
NA	15,647	(19.5)	9,387	(19.5)	6,260	(19.5)	
Triage							0.83
1	3,477	(4.3)	2,118	(4.4)	1,359	(4.2)	
2	20,770	(25.9)	12,448	(25.9)	8,322	(25.9)	
3	54,769	(68.3)	32,851	(68.3)	21,918	(68.3)	
4	1,127	(1.4)	669	(1.4)	458	(1.4)	
5	58	(0.1)	34	(0.1)	24	(0.1)	

ED, emergency department; *EMS*, emergency medical service; *BP*, blood pressure; *BMI*, body mass index; *GCS*, Glasgow Coma Scale; *NA*, not available

Table 1. Continued

Variables (features)	Total (N=80,201)		Training cohort (n=48,120)		Testing cohort (n=32,081)		*P-value*
Systolic BP, Mean (SD)	132.5	(27.1)	132.5	(27)	132.6	(27.2)	0.88
DiastolicC BP, Mean (SD)	75.7	(15.1)	75.7	(15.1)	75.7	(15.2)	0.97
Pulse, Mean (SD)	106.2	(19.7)	106.4	(19.7)	105.9	(19.7)	0.003
Oxygen, Miean (SD)	95.9	(3.6)	95.9	(3.5)	95.9	(3.7)	0.97
Respiration rate, Mean (SD)	19.6	(5.5)	19.6	(4.8)	19.6	(6.4)	0.77
Pain Index							0.19
0	58,424	(72.8)	35,085	(72.9)	23,339	(72.8)	
1	49	(0.1)	22	(0.0)	27	(0.1)	
2	314	(0.4)	187	(0.4)	127	(0.4)	
3	847	(1.1)	510	(1.1)	337	(1.1)	
4	2,430	(3.0)	1,444	(3)	986	(3.1)	
5	5,315	(6.6)	3,182	(6.6)	2,133	(6.6)	
6	2,749	(3.4)	1,659	(3.4)	1,090	(3.4)	
7	3,867	(4.8)	2,387	(5)	1,480	(4.6)	
8	2,549	(3.2)	1,488	(3.1)	1,061	(3.3)	
9	494	(0.6)	289	(0.6)	205	(0.6)	
10	596	(0.7)	351	(0.7)	245	(0.8)	
NA	2,567	(3.2)	1516	(3.2)	1051	(3.3)	
Height, Mean (SD)	161.8	(10.4)	161.8	(10.5)	161.8	(10.2)	0.88
Weight, Mean (SD)	61.1	(19.4)	61.1	(22.5)	61.1	(13.5)	0.73
BMI, Mean (SD)	23.2	(4.4)	23.2	(4.4)	23.2	(4.4)	0.79
GCS TYPE							0.32
Clear consciousness	65,917	(82.2)	39,514	(82.1)	26,403	(82.3)	
Minor coma	1,240	(1.5)	766	(1.6)	474	(1.5)	
Moderate coma	3,553	(4.4)	2,155	(4.5)	1,398	(4.4)	
Severe coma	1,747	(2.2)	1,047	(2.2)	700	(2.2)	
others	1,686	(2.1)	1,043	(2.2)	643	(2.0)	
NA	6,058	(7.6)	3,595	(7.5)	2,463	(7.7)	

ED, emergency department; *EMS*, emergency medical service; *BP*, blood pressure; *BMI*, body mass index; *GCS*, Glasgow Coma Scale; *NA*, not available

in AUC and AUPRC among the ML models were not statistically significant. Additional performance metrics, including sensitivity (or recall), specificity, negative predictive value (NPV), and positive predictive value (PPV, or precision), are shown in Table 3.

A heat map of the computed top 30 features ordered by median normalized importance across all models of the constructed five different ML models are shown in Figure 3A. The top 100 important features visualized as a heat map are available in Supplementary Figure S1. Of them, the eight most important features selected for constructing the ML models are respiratory rate, body temperature, height, BMI, age, cough, weight, and pulse rate. Using the SHAP values approach, we present the outcomes of our analysis conducted with a 9-fold cross-validation in Figure 3B. This figure visually represents the top 30 importance scores assigned to each feature in predicting outcomes within the CB model we constructed. For the results pertaining to the other four models, please refer to Supplementary Figure S2.

DISCUSSION

In this study, we used ML methods to predict the presence of bacteremia in febrile patients presenting to the ED. Using 395 clinical features that are readily available at the ED triage, all five ML models we constructed showed excellent discriminatory performance in predicting bacteremia, with AUC ranging from 0.828 to 0.844.

Bacteremia is a serious and potentially life-threatening condition that can lead to severe complications and increased

mortality. The diagnosis of bacteremia relies on a high index of suspicion by the emergency physician to order for blood culture tests based on the patient's demographics, triage data, CCs, PMH, and physical examination. Predicting bacteremia has been studied for decades. However, previous studies have found that the accuracy of clinician impressions was poor,[28] leading to

Table 2. Univariate analyses of features between patients with or without bacteremia on the on the training/validation and testing cohorts.

Cohort	Training/validation					Testing cohort				
Variables (features)	Bacteremia (-) (n=42,298)		Bacteremia (+) (n=5,822)		*P-value*	Bacteremia (-) (n=28,248)		Bacteremia (+) (n=3,833)		*P-value*
Sex					0.04					0.04
Female	21,147	(50.0)	2,996	(51.5)		14,097	(49.9)	1,980	(51.7)	
Male	21,151	(50.0)	2,826	(48.5)		14,151	(50.1)	1,853	(48.3)	
Age, Mean (SD)	58.3	(20.3)	66.4	(16.3)	<.001	58.4	(20.3)	66.6	(16.4)	<0.001
Body temperature, Mean (SD)	38.4	(1.3)	38.8	(1.4)	<.001	38.4	(1.5)	38.8	(1.3)	<0.001
Acute change					<.001					<0.001
No	38,090	(90.1)	5,052	(86.8)		25,425	(90.0)	3,309	(86.3)	
Yes	1,229	(2.9)	332	(5.7)		780	(2.8)	229	(6.0)	
NA	2,979	(7.0)	438	(7.5)		2,043	(7.2)	295	(7.7)	
EMS					0.005					0.72
No	33,974	(80.3)	4,712	(80.9)		22,687	(80.3)	3,113	(81.2)	
Yes	35	(0.1)	12	(0.2)		19	(0.1)	2	(0.1)	
NA	8289	(19.6)	1098	(18.9)		5542	(19.6)	718	(18.7)	
Triage					<0.001					<0.001
1	1,616	(3.8)	502	(8.6)		1,038	(3.7)	321	(8.4)	
2	10,618	(25.1)	1,830	(31.4)		7,133	(25.3)	1,189	(31.0)	
3	29,392	(69.5)	3,459	(59.4)		19,619	(69.5)	2,299	(60.0)	
4	639	(1.5)	30	(0.5)		434	(1.5)	24	(0.6)	
5	33	(0.1)	1	(0.0)		24	(0.1)	0	(0.0)	
Systolic BP, Mean (SD)	132.7	(26.4)	131.2	(30.8)	<0.001	132.8	(26.7)	130.7	(30.6)	<0.001
Diastolic BP, Mean (SD)	76.1	(14.9)	72.8	(16.2)	<0.001	76.1	(14.9)	72.4	(16.4)	<0.001
Pulse, Mean (SD)	105.7	(19.3)	111.1	(21.5)	<0.001	105.3	(19.4)	110.5	(21.6)	<0.001
Oxygen, Mean (SD)	96	(3.5)	95.6	(4.1)	<.001	96	(3.6)	95.7	(4.2)	<0.001
Respiration, Mean (SD)	19.5	(4.7)	20.1	(5.2)	<.001	19.5	(6.7)	20	(3.8)	<0.001
Pain index					<.001					<0.001
0	30,657	(72.5)	4,428	(76.1)		20,397	(72.2)	2942	(76.8)	
1	21	(0.0)	1	(0.0)		25	(0.1)	2	(0.1)	
2	179	(0.4)	8	(0.1)		114	(0.4)	13	(0.3)	
3	460	(1.1)	50	(0.9)		315	(1.1)	22	(0.6)	
4	1,303	(3.1)	141	(2.4)		897	(3.2)	89	(2.3)	
5	2,879	(6.8)	303	(5.2)		1,939	(6.9)	194	(5.1)	
6	1,494	(3.5)	165	(2.8)		974	(3.4)	116	(3.0)	
7	2,112	(5.0)	275	(4.7)		1,333	(4.7)	147	(3.8)	
8	1,323	(3.1)	165	(2.8)		940	(3.3)	121	(3.2)	
9	246	(0.6)	43	(0.7)		184	(0.7)	21	(0.5)	
10	311	(0.7)	40	(0.7)		203	(0.7)	42	(1.1)	
NA	1,313	(3.1)	203	(3.5)		927	(3.3)	124	(3.2)	
Height, Mean (SD)	162	(10.4)	160.4	(11.5)	<.001	162.1	(10.2)	160.3	(10.6)	<0.001
Weight, Mean (SD)	61.2	(23.5)	60.3	(13.3)	0.01	61.1	(13.6)	60.4	(12.9)	0.001
BMI, Mean (SD)	23.2	(4.4)	23.4	(4.6)	0.003	23.2	(4.4)	23.3	(4.4)	0.04

EMS, emergency medical service; *BP*, blood pressure; *BMI*, body mass index; *NA,* not available

Table 2. Continued

Cohort	Training/validation					Testing Cohort				
Variables (Features)	Bacteremia (-) (n=42,298)		Bacteremia (+) (n=5,822)		*P-value*	Bacteremia (-) (n=28,248)		BACTEREMIA(+) (n=3,833)		*P-value*
GCS type					<.001					<0.001
NA	3,134	(7.4)	461	(7.9)		2,157	(7.6)	306	(8.0)	
Clear consciousness	34,958	(82.6)	4,556	(78.3)		23,390	(82.8)	3013	(78.6)	
Minor coma	634	(1.5)	132	(2.3)		384	(1.4)	90	(2.3)	
Moderate coma	1,768	(4.2)	387	(6.6)		1,147	(4.1)	251	(6.5)	
Other	929	(2.2)	114	(2.0)		575	(2.0)	68	(1.8)	
Severe coma	875	(2.1)	172	(3.0)		595	(2.1)	105	(2.7)	

GCS, Glasgow Coma Scale; *NA,* not available

subsequent studies to include laboratory testing results as predicting variables. However, laboratory results are not readily available at the initial triage and history-taking stage. Even in studies that adopted laboratory values as predicting features, these prediction models still exhibit suboptimal performance in predicting bacteremia with small sample sizes and often lack a validation group for confirmation.[11-14]

In the era of big data and ML, Choi et al developed and validated ML models to predict bacteremia in the ED during triage stages.[20] The best performing model, the "Triage XGB model," demonstrated only acceptable discrimination performance with an AUC of 0.718 by using demographics, triage data, and CCs as predicting variables. However, comorbidity is also an important reference for emergency physicians to assess patients' prognosis and whether they have bacteremia.[29] Our study included 80,201 ED visits during a 10-year period, including demographics, triage data, CCs, and PMH obtained through patient interviews by the triage nurse and retrieved from the patients' EMRs. The AUC of our five ML models all demonstrated excellent results, with the CB model achieving the best performance (0.844).

Furthermore, by using SHAP analysis, our study offers additional evidence highlighting the importance of triage vital signs such as respiratory rate, body temperature, and pulse rate in predicting bacteremia, as depicted in both Figure 3B and Supplementary Figure S2. Notably, our findings reveal that advanced patient age and the presence of chills are also associated with positive predictors of bacteremia. These observations emphasize the importance of vigilance among emergency physicians when encountering such patients, warranting prompt action, including the ordering of blood culture tests.[13] In contrast, the symptom of cough is a negative predictor of bacteremia possibly from patients experiencing upper respiratory infection due to viral infection.[30]

In addition to the AUC, we also evaluated the performance of our models using a range of available performance metrics, including sensitivity, specificity, PPV, and NPV. Prediction models from previous studies always showed high sensitivity and NPV but low specificity and PPV; thus, they can only be used clinically to rule out the possibility of bacteremia. The low specificity and PPV may lead to many false positive results, resulting in antibiotic overuse, prolonged length of stay in the ED, and even higher hospitalization rates. While the models we developed exhibit low F1 and recall scores, indicating challenges in identifying true positive cases, they can still serve valuable roles when carefully contextualized. For instance, the models can act as screening tools for bacteremia or provide supporting diagnostic insights. Additionally, our models demonstrate excellent specificity and NPV while also achieving good PPV and AUPRC, which suggests robust overall diagnostic performance, particularly in their ability to balance ruling out negative cases and identifying positive cases effectively.

LIMITATIONS

There are several limitations in this study. Firstly, this was a retrospective database analysis relying on data collected exclusively from patients who underwent blood culture examinations. We could have missed those patients who might have had bacteremia but did not receive blood culture examination, potentially introducing selection bias. Secondly, the acquisition of patients' PMHs was reliant on interviews conducted by triage nurses and the EMR. In cases where patients had no prior hospital visits, the PMH was solely obtained through interviews with triage nurses, which might have introduced recall bias.

Thirdly, our models achieved low F1 score and recall, indicating the potential of missed diagnoses. Further strategies—such as addressing class imbalance with techniques like oversampling or undersampling, or optimizing decision thresholds—could be implemented to enhance these metrics and make the models even more reliable for diagnostic tasks. Fourthly, it's important to note that the dataset used in this study was derived from a single, tertiary teaching hospital's ED, and external validation from other healthcare settings is lacking. Our future works will expand our study to a regional, multicenter cohort to validate our model's performance and improve its generalizability.

Table 3. Comparison between model performances on the training/validation and testing cohorts.

Model	AUC (95% CI)	AUPRC (95% CI)	F1	Kappa	Sensitivity (Recall)	Specificity	PPV (Precision)	NPV
Training/validation cohort								
CatBoost	0.890 (0.886-0.895)	0.670 (0.659-0.681)	0.462	0.428	0.307	0.997	0.932	0.913
XGBoost	0.897 (0.893-0.901)	0.663 (0.651-0.674)	0.439	0.404	0.289	0.996	0.909	0.911
Gradient boosting	0.885 (0.880-0.889)	0.643 (0.631-0.654)	0.440	0.404	0.292	0.995	0.891	0.911
Light GBM	0.898 (0.894-0.903)	0.661 (0.649-0.672)	0.412	0.379	0.266	0.997	0.914	0.908
Random forest	0.955 (0.952-0.957)	0.818 (0.810-0.827)	0.699	0.649	0.839	0.923	0.599	0.977
Testing cohort								
CatBoost	0.844 (0.837-0.850)	0.540 (0.525-0.555)	0.378	0.339	0.249	0.990	0.779	0.906
XGBoost	0.843 (0.836-0.849)	0.537 (0.522-0.552)	0.372	0.334	0.244	0.991	0.785	0.906
Gradient boosting	0.842 (0.836-0.849)	0.536 (0.521-0.550)	0.380	0.341	0.252	0.990	0.773	0.907
LightGBM	0.841 (0.834-0.847)	0.533 (0.518-0.548)	0.361	0.325	0.233	0.992	0.803	0.905
Random forest	0.828 (0.821-0.834)	0.473 (0.458-0.489)	0.455	0.370	0.518	0.897	0.406	0.932

Note: The best parameters for CatBoost are {'depth': 4, 'learning_rate': 0.12, 'random_seed': 0, 'loss_function': 'Logloss', 'iterations': 700}; for XGBoost are {'learning_rate': 0.14, 'max_depth': 4, 'n_estimators': 300}; for Gradient boosting are {'max_depth': 3, 'learning_rate': 0.1, 'n_estimators': 600, 'random_state': 0}: for Light GBM are {'learning_rate': 0.1, 'n_estimators': 100, 'max_depth': 30, 'random_state': 0}: for Random forest are {'max_depth': 35, 'n_estimators': 1000, 'random_state': 0, 'max_leaf_nodes': 1000, 'class_weight': 'balanced'}.
AUC, area under the receiver operating characteristic curve; *AUPRC*, area under the precision recall curve; *CI,* confidence interval; *PPV*, positive predictive value; *NPV*, negative predictive value; *GBM,* gradient boosting machine; *XGBoost,* eXtreme Gradient Booting.

CONCLUSION

We have developed ML models to predict bacteremia, achieving excellent discrimination performance by using clinical features readily accessible during ED triage. These models demonstrate potential for identifying low-risk patients, which could help reduce unnecessary healthcare costs. Furthermore, they may assist emergency physicians in making more informed decisions regarding blood cultures orders and antibiotics administration for high-risk patients, potentially improving patient safety. However, as this study lacks external validation, the generalizability of our findings to other settings remains uncertain. Future work should focus on validating these models with external datasets to confirm their robustness and applicability across diverse clinical environments.

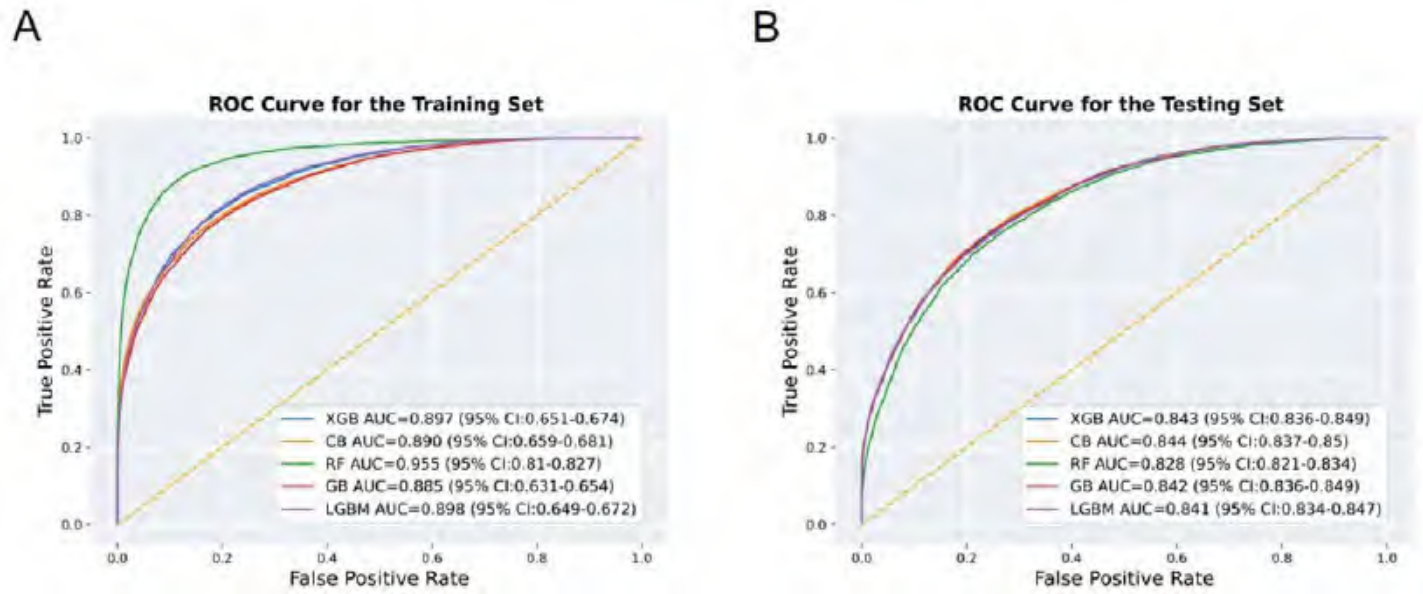

Figure 2. Results and the comparisons of the five machjine-learning models on the training/validation (A), and Testing (B) cohorts, based on the performances of area under the receiver operating characteristic (ROC) curves (AUC).
RF, random forest; *GB*, gradient boosting; *CB*, CatBoost; *LGBM*, light gradient boosting machine; *XGB*, extreme gradient boosting; *ROC*, receiver operating characteristic; *AUC*, area under the curve.

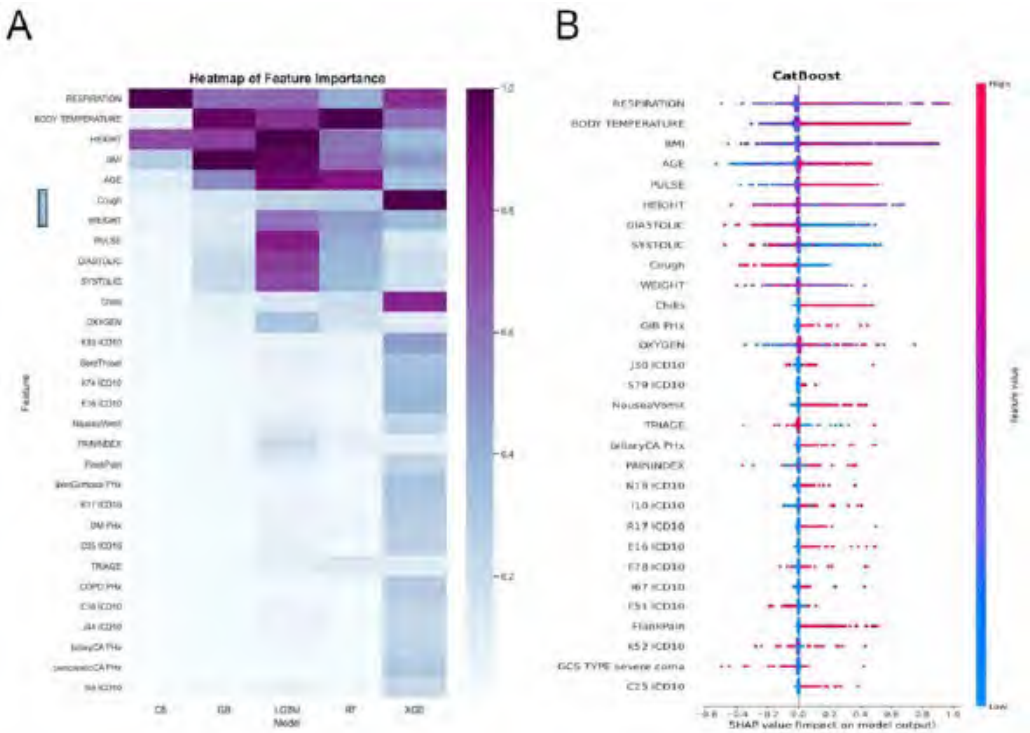

Figure 3. A heat map of the computed top 30 features ordered by median normalized importance across all models of the constructed five different machine-learning (ML) models (A). The Shapley additive explanations of the top 30 important features as a way to explain the output of the constructed ML models by selecting 9-fold cross validation using CB classifiers (B).
PHx, past history; *ICD-10, International Classification of Diseases* 10th Rev; *DM*, diabetes mellitus; *COPD*, chronic obstructive pulmonary disease; *BMI*, body mass index; CB, CatBoost; *GIB*, gastrointestinal bleeding; *GCS*, Glasgow Coma Scale.

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A Review of Sports-Related, Life-Threatening Injuries Presenting to Emergency Departments, 2009-18

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Introduction: In the United States, 3.7 million people present to an emergency department (ED) annually with an injury related to sports or athletic activity. A prior study a decade ago revealed that 14% of life-threatening injuries presenting to EDs were sports related, with this percentage being higher in the pediatric population. However, with changes in sports participation and regulatory changes over the past decade, it is unclear whether the proportion of life-threatening sports-related injuries has changed.

Methods: We conducted a cross-sectional study using the National Hospital Ambulatory Medical Care Survey (NHAMCS), consisting of patients from years 2009–2018. Life-threatening injuries were defined as International Classification of Diseases 9 and 10 codes for skull fracture, cervical spine fractures, intracranial hemorrhage, traumatic pneumothorax/hemothorax, liver lacerations, spleen lacerations, traumatic aortic aneurysm or rupture, gastric/duodenal rupture, heat stroke, and commotio cordis. Injuries were classified as sports related based on external cause of injury codes. We examined the relationship between demographic variables and sports-related injuries using Pearson chi-square analysis.

Results: From the years 2009–2018 there were 256,564 observed ED visits. Of these, 646 were for life-threatening injuries, representing a national estimate of 3,456,166 patients over the 10-year period. Thirteen percent were sports related. Of the life-threatening injuries, 77.5% were injuries to the head and neck, and 9.1% of these were sports related. The proportion of life-threatening injuries due to sports and recreation was higher among pediatric patients than adult patients (30.4% vs 9.9%, P<0.001). The proportion of sports-related life-threatening injuries to the head and neck was also higher among pediatric patients than adult patients (23.3% vs 6.4%, P<0.001)

Conclusion: A substantial proportion of life-threatening injuries occur during sports and recreation, especially among pediatric patients. Compared to a similar study a decade ago, there is a similar proportion of life-threatening injuries that are sports related, however; there does seem to be a decrease in the proportion of life-threatening sports-related injuries to the head and neck. Sports medicine physicians and sports organizations should continue to find effective ways to prevent life-threatening injuries in sports. [West J Emerg Med. 2025;26(3)627–631.]

INTRODUCTION

In the United States, approximately 3.7 million people present to an emergency department (ED) annually with an injury related to sports or athletic activity.[1] Over two-thirds of these injuries are in patients 5-24 years of age.[1] From 2010–2016, this age group alone had 2.7 million ED visits due to injuries related to sports and athletic activity.[2] Football, basketball, pedal cycling, soccer, and skating/skateboarding led to the most ED visits for sports-related injury within this age group.[1,2] According to a prior analysis of life-threatening injuries in sport using the National Hospital Ambulatory Medical Care Survey (NHAMCS) 1999–2008, 14% of all life-threatening injuries presenting to EDs and ambulatory care centers in the US were sports related.[3] In pediatric patients, this number increased to 32%, compared to 9% in adults.[3]

Over the last decade there have been developments in sports that may serve to decrease the percentage of sports-related life-threatening injuries. According to the National Federation of State High School Associations, participation in high school football has decreased from 2009–2018.[4] In addition, various rule changes have been implemented in the past decade to make sports safer. For example, youth ice hockey in some areas has increased the age limit of when body checking is allowed from 11 to 13 years of age, which has decreased the overall number of injuries.[5] Furthermore, the use of safety equipment such as bicycle helmets has increased over time.[6,7] We used the NHAMCS database to describe the proportion of all life-threatening injuries presenting to EDs in the US that are related to sports or athletic activity.

METHODS

We conducted a cross-sectional study using the NHAMCS database, focusing on the years 2009–2018.[8] The NHAMCS is an annual survey of hospital emergency and outpatient departments designed by the National Center for Health Statistics. It is designed to gather data on utilization and provision of ambulatory care services. Every year, a nationally representative sample is created representing visits to EDs in non-institutional general and short-stay hospitals, exclusive of federal, military, and Veterans Administration hospitals, located in the 50 states and the District of Columbia. This survey uses a three-stage probability sampling design. Data collected in the sample consists of approximately 25,000 visits to approximately 500 hospitals; these visits are then weighted by the survey staff, which are then used to derive national estimates.

Data is collected from hospitals during a randomly selected four-week reporting period. Trained interviewers collect data using a standardized patient record form. The NHAMCS dataset is publicly available via the internet. This study was approved by our institutional review board.

The inclusion criteria were patients seen in an ED and diagnosed with life-threatening injuries. Our focus was the 10-year period of 2009–2018, during which NHAMCS changed from International Classification of Diseases Rev 9 (ICD-9) to ICD-10 in 2016. We defined life-threatening injuries using ICD-9/ICD-10 codes for skull fracture (ICD-9 800.x-801.xx, 803.x-804.xx/ ICD-10 S02.0x, S02.1x); cervical spine fractures [ICD-9 805.xx-805.1x, 806.1x/ ICD-10 S12.0x-S12.7x, S12.9x]; intracranial hemorrhage (ICD-9 852.xx-853.xx/ ICD-10 S06.3x-S06.9x); traumatic pneumothorax/hemothorax (ICD-9 860.00-860.50/ ICD-10 S27.0x-S27.2x); liver lacerations [ICD-9 864.xx/ ICD-10 S36.11x]; spleen lacerations [ICD-9 865.xx/ ICD-10 S36.03x]; traumatic aortic aneurysm or rupture (ICD-9 901.0, 902.0/ ICD-10 S25.0x, S35.0x); gastric/duodenal rupture (ICD-9 537.89/ ICD-10 S36.3x, S36.4x); heat stroke (ICD-9 992.0/ ICD-10 T67.0x); and commotio cordis [ICD-9 861.01/ ICD-10 S26.11, S26.91)—all of which were used for a similar analysis examining the prior decade.[3] We excluded some diagnosis codes included in the prior study, specifically codes ICD-9 802.xx, as these represent facial fractures, which are unlikely to represent life-threatening injuries. In addition, we excluded all 805.xx codes after 805.1x as these injuries represented spinal fractures not localized to the cervical spine and, therefore, are also unlikely to represent life-threatening injuries.

We characterized life-threatening injuries as sports related using external cause of injury codes (E-codes), noted in the Appendix. We only included E-codes that were unique to sports and athletic activity, as described in Rui et al.[2] In prior studies researchers could conduct a verbatim text search of the NHAMCS dataset in addition to using the E-code to confirm that an E-code truly represented a sports-related cause of injury, as well as further capture sports-related injuries that may not have been captured by coding.[2,3] However, after 2009 the NHAMCS no longer included a verbatim cause of injury for patients in their public use database. Thus, we were unable to perform a text search on E-codes that may have been sports related, but the injury itself was not unique to sports (eg, ICD-9 E880-E888; accidental fall). To keep our estimate conservative, we did not categorize such E-codes as sports related.

We examined demographic data (age, sex race, geographic location) as described in the NHAMCS dataset. All patients >18 of age were categorized as adults. Patients were further characterized into these age groups: preschool (0-5 years); school aged (6-18); young adult (19-44); middle-aged adults (45-74); and elderly (75 and older). We used weights, strata, and primary sampling unit design variables provided by NHAMCS for all analyses. We used descriptive statistics, with appropriate weighting to account for survey sampling methodology, using SPSS Statistics version 29 (IBM Corp, Armonk, NY). The relationship between demographic variables and sports-related injuries was examined using Pearson chi-square analysis.

RESULTS

From 2009–2018, there were a total of 256,564 observed ED visits in the NHAMCS database. Of these, 646 represented life-threatening injuries which, when accounting for weighting, yields an estimate of 3,456,166 patients with

life-threatening injuries over the 10-year period. Of the life-threatening injuries, 13.0% were sports related, representing an estimated 449,957 patients nationally over the time period. A higher proportion of life-threatening injuries were sports related in the pediatric population compared to adults (30.4% vs 9.9%, $P<0.001$ (see Table). The highest proportion of sports-related life-threatening injuries was observed in patients 6-18 years old; however, patients 19-44 years of age accounted for the highest absolute number of sports-related life-threatening injuries (Table).

Head and neck injuries made up 77.5% of the life-threatening injuries. Of the head and neck injuries, 9.1% were sports related, representing a national estimate of 243,387 patients. Among pediatric patients, a higher proportion of life-threatening head and neck injuries were sports related when compared to adults (23.3% vs 6.4%, $P<0.001$).

DISCUSSION

Approximately 1 in 7 life-threatening injuries presenting to EDs in the US are related to sports and athletic activity. Children have a higher percentage of sports-related life-threatening injuries compared to adults. Our main purpose in this study was to determine whether the prevalence of sports-related life-threatening injuries has changed in the last decade. When comparing to a similar study using NHAMCS 1999–2008, we found similar rates of sport-related life-threatening injuries.[3]

Almost 80% of the life-threatening injuries in this cohort were injuries to the head and neck. Of these injuries, 1 of 10 were sports related. The 38th annual report from the National Center for Catastrophic Injury notes that injuries to the head/brain and spine account for a high proportion of traumatic catastrophic sports injuries.[9] However, when comparing to the 2013 study, we found a lower percentage of sports-related life-threatening injuries of the head and neck.[3] In our cohort, this percentage is 9.1%; this has been reported in the past in a similar study to be 14%.

Children had a higher percentage of sports-related head and neck life-threatening injuries than adults. This trend has also been described recently in a study of emergency medical

Table. Proportion of life-threatening injuries related to sports from 2009–2018.

Demographic	Total life-threatening injuries	Sports related-injuries (weighted %)*	National estimate (in thousands)	P-value
Sex				
Female	237	12 (7.5%)	94	<.001
Male	409	52 (16.2%)	356	
Age				
Adult	540	37 (9.9%)	288	<.001
Pediatric	106	27 (30.4%)	162	
Age group				
Under 6 years of age	45	1 (8.7%)	19†	<.001
6 to 18 years of age	61	26 (45.9%)	142	
19 to 44 years of age	174	20 (18.1%)	165	
45 to 74 years of age	206	15 (10.1%)	114	
≥75 years of age	160	2 (1.0%)	8†	
Race				
Black	68	5 (7.4%)	22†	<.001
White	538	56 (14.0%)	416	
Other	40	3 (6.5%)	12†	
Region				
Midwest	156	20 (16.8%)	142	<.001
Northeast	144	13 (6.4%)	42	
South	202	14 (11.1%)	134	
West	144	17 (18.0%)	131	

*This column demonstrates the number of cases in the dataset per demographic group that were classified as sports related. Using weights provided by the National Hospital Ambulatory Medical Care Survey to calculate national estimates, weighted percentages were obtained.

†Given lower number of observed cases, national estimate could not be accurately derived.

services activations for sports-related injuries in 2017–2018.[10] This trend may reflect a higher risk of injury during sports participation for children than adults; however, it is also possible that a higher proportion of children participate in sports and athletic activities than adults, thus accounting for the findings. We could not determine the reasons for this discrepancy using the NHAMCS dataset as the number of participants in sports and recreational activities is unknown.

The results of this study suggest that even though the percentage of life-threatening injuries to the head and neck has decreased, there remains a continued need to focus on decreasing the prevalence of these injuries, especially in the pediatric population. Further research efforts should focus on continuing to collect data on these injuries in all age groups and sports levels to identify trends and patterns in injury occurrence. Also, while rule changes have helped to make sports safer, a continued commitment to sportsmanship and vigilance in preventing flagrant rule offenses, as well as injury prevention programs such as training athletes how to fall safely and practice neuromuscular control, have shown promise in preventing injury.[5,11,12]

LIMITATIONS

Although we used a similar study from a decade ago to compare the prevalence of sports-related life-threatening injuries, this study was not a direct comparison between the two datasets given differences in coding and included data. Like the prior dataset, we did include ICD codes for intracranial hemorrhage, including the ICD-10 code, S06.9. This code does describe injuries coded as unspecified intracranial injuries; so it is possible that some of these injuries may represent concussions. However, given that we excluded the code specific for concussions, (S06.0 codes), we felt a majority of these codes would not represent concussions. In addition, there are some limitations in the capture of the injuries classified as sports related. As mentioned previously, the NHAMCS no longer included a verbatim cause of injury in their public use database after 2009, precluding us from capturing sports-related injuries that were not captured using the E-codes alone. Additionally, the care team at the time of initial ED presentation may not have coded all activities related to sports and athletics.

While it has not been investigated in the NHAMCS dataset, there may be an initial coding bias with regard to external cause of injuries, as a youth athlete presenting from an organized sport may be more likely to receive a sports-related, external cause of injury code than an older patient who is more likely to participate in individual athletic activity instead of an organized sport. Given that this study is an analysis of a publicly available dataset, it does have the caveat that some initial presentations may have been miscoded initially. The NHAMCS dataset was developed specifically to estimate the incidence of injuries and illness and has been used numerous times in the literature to this effect; however, our study findings should be interpreted with this in mind. Given that prior analyses of sports-related injuries, including one in the prior decade, also used the NHAMCS dataset, we do not expect miscoding to bias this analysis more than prior analyses described in the literature.

CONCLUSION

The results of this study suggest that the overall proportion of life-threatening injuries directly related to sports and athletic activities has overall remained steady over the past decade. This data does suggest that with an increased focus on injury prevention over the past decade, sports-related life-threatening head and neck injuries have decreased when compared to the findings in prior literature. This could represent a change in the pattern of injury; further studies should be done to investigate whether this pattern is seen in other datasets and its potential causes. We emphasize that there is still a need for sports medicine physicians, researchers, and sports organizations to continue to find effective ways to prevent these injuries and improve the safety of sports for all participants.

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National Study of Firearm Presence and Storage Practices in Homes of Rural Adolescents

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Introduction: Firearm-related unintentional and suicide death rates in adolescents are higher in rural areas. In 2020, the overall rural firearm death rate was 28% higher than the urban rate. Firearm access significantly increases the risk. The study objective was to evaluate firearm exposure and storage practices in the homes of rural adolescents.

Methods: We conducted a cross-sectional, anonymous survey of attendees at the 2021 National FFA (formerly Future Farmers of America) Convention & Exposition. Descriptive, bivariate, and multivariable logistic regression analyses were performed.

Results: A total of 3,296 adolescents 13-18 years of age participated in our survey. Overall, 87% of respondents reported having rifles/shotguns, 71% had handguns, and 69% had both rifles/shotguns and handguns in their homes. The odds of those living on farms having rifles/shotguns and handguns were 7.5 and 2 times higher, respectively, as compared to those from towns. Rifles/shotguns and handguns were stored unlocked and/or loaded at least some of the time in 63% and 64% of homes, respectively. Respondents from farms had 1.5 and 1.7 times greater odds of having rifles/shotguns and handguns stored unlocked and loaded, respectively, as compared to those from town. The South, West and Midwest had odds that were 5.9, 3.2, and 2.8 times higher for rifles/shotguns and 8.1, 5.2, and 4.3 times greater for handguns to be stored loaded and unlocked, respectively, as compared to the Northeast. Only 43% of respondents reported ammunition being locked and stored separately from firearms.

Conclusion: Most rural adolescents surveyed lived in homes with firearms, and a large proportion of those firearms were not stored safely. Firearm presence and storage differed by region and home setting. Unsafe storage practices could be contributing to the higher unintentional and suicide death rates seen in rural areas. [West J Emerg Med. 2025;26(3)632–642.]

INTRODUCTION

Firearm-related injuries are the leading cause of death in the United States for children and adolescents.[1] There were 4,357 firearm-related deaths in this age group in 2020, which was a 30% increase from the previous year and more than double the rate of increase for other ages.[2,3] Increases were seen for all types of firearm-related deaths—suicides, homicides, unintentional, and those undetermined.[2,3] The US stands alone among developed countries for firearms being the leading cause of youth fatalities.[3]

Studies have shown that the presence of firearms in the home is associated with increased risk of firearm-related unintentional, homicide, and suicide deaths.[4-7] Over half of all youth unintentional firearm deaths occur in the victim's home, and the firearms used were stored loaded and unlocked in over 70% of the cases with known storage information.[8] In addition, approximately 85% of firearm-related homicides in children ≤12 years of age have occurred in the home.[9]

Rural households are more likely to have firearms as compared to urban areas.[10-12] Youth firearm-related suicide and unintentional death rates are also significantly higher in rural communities as compared to urban areas.[5,13-16] In 2020, the rural firearm death rate was 28% higher than the urban rate, largely driven by rural firearm suicide deaths including youth.[17] In fact, over the past three decades, over half of all adolescent suicides have been committed with firearms.[18-20] In addition, the hospitalization rate for pediatric firearm-related injuries is higher for rural than for urban youth with unintentional injuries being the leading cause.[5] Furthermore, the unintentional firearm death rate for rural teenagers aged 14-17 years is double the rate for urban adolescents.[15]

The American Academy of Pediatrics (AAP) guidelines for firearm-related anticipatory guidance states that firearms should be unloaded and locked, with ammunition locked separately from the firearm.[21] It has been estimated that locking all firearms could reduce youth firearm deaths by up to 32%.[22] Understanding demographic differences in firearm ownership and storage practices is important when developing strategies for effective anticipatory guidance and firearm-injury prevention programs. Our objective in this study was to determine firearm exposure and storage practices in the homes of rural adolescents, and to identify factors associated with unsafe firearm storage. This expands upon our earlier study conducted among rural adolescents in Iowa.[12]

Population Health Research Capsule

What do we already know about this issue?
Rural households are more likely to have firearms in the home compared to urban. Youth firearm suicide and unintentional death rates are higher in rural areas.

What was the research question?
What factors are associated with unsafe firearm storage in the homes of rural adolescents?

What was the major finding of the study?
Nearly 90% of rural adolescents surveyed reported having at least one firearm in their home and over 60% endorsed some form of unsafe storage.

How does this improve population health?
Most rural youth live in households with unsafe firearm storage. Targeted efforts to increase safe storage may prevent youth unintentional injury and suicide.

METHODS

Study Population

A cross-sectional survey was conducted of a convenience sample of adolescents attending the 2021 National FFA (formerly Future Farmers of America) Convention & Exposition in Indianapolis, Indiana. The FFA has nearly 950,000 members in over 9,000 chapters in all 50 states, Puerto Rico, and the US Virgin Islands. Members are typically in the 5th-12th grade. Around 60,000 students, teachers, administrators, former FFA members, exhibitors, and guests attended the conference. Conference attendees completed an anonymous survey at the study institution's injury prevention booth. Team members administered the surveys to respondents who were instructed to complete them independently. Survey data was entered into Qualtrics (Qualtrics International, Inc, Provo, UT). As an incentive for completing the survey, participants were provided a modest prize (eg, lip balm, trucker cap) as determined by chance via a spinning wheel.

Survey

The survey was developed by the study institution's Firearm Safety Task Force. Demographic data collected included age (years), gender (male, female, other, choose not to respond), residence (on a farm, in the country but not on a farm, in town), race/ethnicity (White, Black, Hispanic Latinx, Asian, Native Hawaiian/Pacific Islander, Native American/Alaska Native, mixed, other) and the state of residence. In the survey, the term "firearm" was defined as a weapon "from which a bullet or other projectile is fired by gunpowder," and did not include BB guns, pellet guns, or dart guns. The term "home" included "the place you sleep and all other buildings your family owns on the same property." A firearm was considered "loaded" if there was ammunition in the firearm including the magazine, tube, chamber or other. A firearm was considered "unlocked" if it was "not locked in a storage place or not stored with a trigger lock or cable."

The survey asked whether there were any rifles/shotguns or handguns in the home. Answer choices included "yes" and "not that I know of." For respondents who answered "yes," they were then asked if the firearms were stored "loaded," "unlocked," or "both loaded and unlocked." Respondents could select "yes, always," "yes, sometimes," "no, never," or "not sure" for each of the storage questions. The survey asked how the ammunition was stored with answer options including "locked with firearms," "locked separately," "not locked," and "not sure." For the purposes of analysis, safe storage was defined as the firearm being stored unloaded and locked.

Data Analysis

Completed surveys were provided by the Firearm Safety Task Force to the research team for analysis. The study institution's institutional review board deemed the research exempt as the analysis was performed on an anonymously collected existing dataset. Aggregate survey results were exported as an Excel spreadsheet (Microsoft Corp, Redmond, WA) and imported into Stata 15.1 (StataCorp, College Station, TX). Analysis was limited to those ages 13-18 years. We performed descriptive (frequencies), bivariate (chi square, Fisher exact test), and multivariable logistic regression analyses. All *P*-values were two-tailed, and a value <0.05 was considered statistically significant. Missing data were not included in the analyses.

RESULTS

Subject Demographics

A total of 3,296 adolescents completed the survey. The proportion of males and females was nearly equivalent, and 66% were 16-18 years of age (Table 1). Nearly three-quarters lived outside of a town. Over 90% were non-Hispanic (NH) White. Respondents were from Puerto Rico and every US state except Maine, Massachusetts, New Hampshire, and Vermont. About two-thirds of participants lived in the Midwest US Census Region, one-fifth lived in the South, and <10% each lived in the West and Northeast.

Table 1. Demographic and firearm-related variables of adolescent survey respondents.

	n (column %)[a]
Group N	3,296
Sex	
Male	1,623 (50)
Female	1,639 (50)
Other	16 (<1)
Age	
13 years	60 (2)
14 years	327 (10)
15 years	710 (22)
16 years	890 (27)
17 years	947 (29)
18 years	353 (11)
Residence	
Farm	1,495 (45)
Country/not a farm	1,116 (34)
Town	679 (21)
Race/Ethnicity	
Non-Hispanic White	3,025 (92)
Other races/ethnicities	261 (8)
US Census regions	
South	692 (21)
West	294 (9)
Midwest	2,173 (67)
Northeast	11 (3)
Rifle/shotgun in home	
Yes	2,856 (87)
Not that I know of	436 (13)
Handgun in home	
Yes	2,342 (71)
Not that I know of	946 (29)
Combined firearms in home	
Both rifle and handgun	2,275 (69)
Rifle/shotgun only	581 (18)
Handgun only	67 (2)
None that I know of	369 (11)

[a] The sum of n may not equal the total Group N due to missing values.

Firearms in the Home

The vast majority (87%) reported having at least one rifle/shotgun, and 71% reported having at least one handgun in their home. Approximately 70% of respondents reported the presence of both a rifle/shotgun and a handgun in the home. A small percentage reported having handguns only, and 18% reported having rifles/shotguns only. Overall, 89% reported having at least one firearm (rifle/shotgun and/or handgun) in the home.

Demographic Comparisons of Rifle/Shotgun Presence in the Home

Males, those living on a farm or in the country/not a farm, and NH Whites all had higher proportions with rifles/shotguns in their home relative to their peers (Table 2). The odds of males reporting rifles/shotguns in their homes was twice as high as females. Individuals living on a farm and living in the country/not a farm had odds that were 7.6 and 3.5 times greater than those living in town, respectively. Individuals identifying as other races than NH White had odds that were 70% lower than respondents who identified as NH White. The odds of rifles/shotguns in the home were more than twice as high for those residing in the Midwest, South, or West US Census regions as compared to those in the Northeast.

Table 2 Bivariate and multivariate logistic regression analyses regarding the presence of rifles/shotguns and handguns in the homes of adolescent survey respondents.

	Rifle/shotgun in the home			Logistic regression analysis[a]	
	Yes n (row %)[c]	No[b] n (row %)[c]	*P*-value	Odds ratio	Confidence interval
Group N	2,856 (87)	436 (13)			
Sex					
Male	1,483 (92)	138 (9)	<0.001	2.08	1.65-2.62
Female	1,350 (83)	287 (18)		1.0 (ref)	
Age					
16-18 years	1,887 (86)	301 (14)	0.20	0.91	0.71-1.15
13-15 years	962 (88)	133 (12)		1.0 (ref)	
Residence					
Farm	1,407 (94)	86 (6)	<0.001	7.56	5.69-10.05
Country/not a farm	988 (89)	128 (12)		3.64	2.81-4.70
Town	456 (67)	221 (33)		1.0 (ref)	
Race/ethnicity					
Non-Hispanic White	2,671 (88)	352 (12)	<0.001	1.0 (ref)	
Other races/ethnicities	178 (68)	83 (32)		0.30	0.21-0.41
U.S. Census Region					
South	600 (87)	92 (13)	0.01	2.51	1.47-4.29
West	255 (87)	39 (13)		2.76	1.50-5.07
Midwest	1,900 (88)	271 (12)		2.34	1.43-3.84
Northeast	85 (77)	26 (23)		1.0 (ref)	
	Handgun in the home			Logistic Regression Analysis[a]	
	Yes n (row %)[c]	No[b] n (row %)[c]	*P*-value	Odds ratio	Confidence Interval
Group N	2,342 (71)	946 (29)			
Sex					
Male	1,231 (76)	387 (24)	<0.001	1.51	1.29-1.77
Female	1,092 (67)	544 (33)		1.0 (ref)	
Age					
16-18 years	1,539 (70)	647 (30)	0.13	0.87	0.73-1.03
13-15 years	797 (73)	296 (27)		1.0 (ref)	
Residence					
Farm	1,114 (75)	377 (25)	<0.001	2.02	1.65-2.46
Country/not a farm	829 (74)	285 (26)		1.97	1.60-2.44
Town	395 (58)	282 (42)		1.0 (ref)	
Race/ethnicity					
Non-Hispanic White	2,173 (72)	846 (28)	0.001	1.0 (ref)	
Other races/ethnicities	162 (62)	99 (38)		0.61	0.46-0.82
US Census Region					
South	564 (82)	128 (18)	p<0.001	3.55	2.30-5.48
West	229 (78)	64 (22)		3.00	1.85-4.86
Midwest	1,474 (68)	694 (32)		1.59	1.07-2.37
Northeast	63 (57)	48 (43)		1.0 (ref)	

[a] This analysis controlled for all other variables in the table.
[b] The actual response was "Not that I know of" as homes may have had firearms, but the adolescent respondent may not have known that they were present.
[c] The sum of n for a variable may not equal the total Group N due to missing values.

Table 3 Storage of firearms and of handguns in the homes of adolescent survey respondents.

	Rifles/shotguns n (column %)[a]	Handguns n (column %)[b]
Stored loaded		
No	1,680 (64)	1,131 (52)
Yes, always	332 (13)	469 (21)
Yes, sometimes	632 (24)	578 (27)
Stored unlocked		
No	1,357 (50)	1,126 (51)
Yes, always	486 (18)	401 (18)
Yes, sometimes	859 (32)	674 (31)
Stored loaded and unlocked		
No	2,055 (78)	1,466 (68)
Yes, always	164 (6)	246 (11)
Yes, sometimes	426 (16)	452 (21)
Overall storage		
Safe storage[c]	950 (37)	764 (36)
Unsafe storage[d]	1,603 (63)	1,348 (64)

[a]Does not include those who had no rifles/shotguns in the home or were unsure of storage.
[b]Does not include those who had no handguns in the home or were unsure of storage.
[c]Firearms always stored unloaded and locked.
[d]Firearms stored at least sometimes loaded and/or unlocked.

Demographic Comparisons of Handgun Presence in the Home

For the presence of handguns in the home, males, those living on a farm or in the country/not a farm, and NH Whites all had higher proportions relative to their peers (Table 2). Males had odds about 1.5 times greater than females of having a handgun in the home. Those living on a farm or in the country/not a farm both had odds that were twice that of those living in town. Respondents of other races than NH White had odds about 40% lower than NH Whites. The odds of handguns in the home were 1.6, 3.0, and 3.6 times higher for respondents from the Midwest, West, and South US Census regions, respectively, as compared to the Northeast.

Firearm Storage Practices in the Home

Over one-third of respondents reported that rifles/shotguns were stored loaded at least some of the time, and half reported they were sometimes or always stored unlocked (Table 3). Among all respondents aware of rifle/shotgun storage practices in their homes, over one-fifth reported they were stored locked and unloaded at least some of the time. Overall, over three-fifths of respondents reported unsafe rifle/shotgun storage in the home. For those reporting handguns in the home, nearly half reported their handguns being stored loaded at least some of the time (Table 3). About half also reported handguns being stored unlocked at least sometimes. Moreover, just under one-third of respondents reported handguns being stored both loaded and unlocked at least some of the time. Overall, nearly two-thirds of participants reported unsafe handgun storage in the home.

Demographic Comparisons of Rifle/Shotgun Storage in the Home

Males had higher proportions of reporting rifles/shotguns being stored unlocked in the home (Table 4). The odds of males reporting rifles/shotguns being stored unlocked and stored loaded/unlocked were 1.7 and 1.3 times greater, respectively, than females. Older teens (16-18 years) had higher proportions and greater odds (1.3 times) of reporting rifles/shotguns as being stored unlocked as compared to younger teens. Those living on a farm had higher proportions reporting unsafe rifle/shotgun storage than those who lived elsewhere. The odds of having rifles/shotguns stored loaded, unlocked, and loaded and unlocked were 1.4, 1.7 and 1.5 times greater, respectively, for those living on a farm vs those from towns.

There were differences in rifle/shotgun storage by US Census Region with respondents from the South having higher proportions and those from the Northeast having lower proportions reporting unsafe storage. Moreover, youth from the South had 3.4 and 1.9 times higher odds of reporting rifles/shotguns being stored loaded and being stored unlocked, respectively, as compared to those from the Northeast. Similarly, respondents from the West had 1.8 times higher odds of reporting rifles/shotguns being stored unlocked relative to those from the Northeast. Finally, the odds of youth reporting having firearms being stored both loaded and unlocked for the Midwest, West and South were 2.8, 3.2 and 5.9 times greater, respectively, as compared to respondents from the Northeast.

Demographic Comparisons of Handgun Storage in the Home

Many similarities were seen in the demographics of reporting unsafe rifle/shotgun and unsafe handgun storage (Table 5). There were higher proportions of males reporting unsafe handgun storage with the odds of males reporting handguns being stored loaded, unlocked, and loaded/unlocked being 1.2, 1.5 and 1.7 times greater, respectively, than females. Older teens had higher proportions reporting unsafe handgun storage in the home, with the odds of older teens reporting handguns being stored unlocked and loaded/unlocked being 1.5 and 1.4 times higher, respectively, than younger teens. The odds of having handguns stored unlocked were 1.8 times greater for those from farms and 1.4 times higher for those from the country/not a farm as compared to those from towns. Similarly, those from farms and from the country/not a farm both had 1.7 times greater odds of handguns in the home being stored loaded and unlocked vs respondents from towns.

Youth from the South US Census Region had the highest proportions reporting unsafe handgun storage, whereas those

Table 4 Bivariate and multivariable logistic regression analyses regarding the storage of rifles/shotguns in the homes of adolescent survey respondents.[a]

	Rifle storage			Logistic regression analysis[b]	
	Yes[c] n (row %)[d]	No n (row %)[d]	P-value	Odds ratio	Confidence interval
Stored loaded					
Sex					
Male	519 (36)	907 (64)	0.90	0.96	0.81-1.13
Female	439 (37)	759 (63)		1.0 (ref)	
Age					
16-18 years	647 (36)	1129 (64)	0.93	0.97	0.81-1.15
13-15 years	316 (37)	547 (63)		1.0 (ref)	
Residence					
Farm	505 (38)	832 (62)	0.06	1.35	1.06-1.72
Country/not a farm	333 (37)	567 (63)		1.26	0.98-1.63
Town	126 (31)	277 (69)		1.0 (ref)	
Race/ethnicity					
Non-Hispanic White	900 (36)	1581 (64)	0.30	1.0 (ref)	
Other races/ethnicities	63 (40)	93 (60)		1.18	0.83-1.67
US Census Region					
South	286 (52)	268 (48)	<0.001	3.43	1.96-5.99
West	73 (3)	162 (69)		1.49	0.82-2.72
Midwest	580 (33)	1183 (67)		1.59	0.93-2.74
Northeast	19 (24)	59 (76)		1.0 (ref)	
Stored unlocked					
Sex					
Male	807 (56)	641 (44)	<0.001	1.67	1.43-1.95
Female	527 (43)	706 (57)		1.0 (ref)	
Age					
16-18 years	932 (52)	861 (48)	0.002	1.31	1.11-1.55
13-15 years	413 (46)	489 (54)		1.0 (ref)	
Residence					
Farm	733 (54)	618 (46)	<0.001	1.73	1.38-2.17
Country/not a farm	436 (47)	487 (53)		1.31	1.03-1.66
Town	175 (41)	248 (59)		1.0 (ref)	
Race/Ethnicity					
Non-Hispanic White	1262 (50)	1271 (50)	0.91	1.0 (ref)	
Other races/ethnicities	80 (49)	82 (51)		0.94	0.67-1.31
US Census Region					
South	310 (55)	258 (45)	0.009	1.85	1.13-3.04
West	133 (54)	113 (46)		1.77	1.04-3.02
Midwest	861 (48)	931 (52)		1.42	0.88-2.28
Northeast	33 (41)	47 (59)		1.0 (ref)	
Stored loaded and unlocked					
Sex					
Male	348 (25)	1,069 (75)	0.004	1.29	1.07-1.56
Female	239 (20)	966 (80)		1.0 (ref)	

[a]Those who answered "unsure" regarding firearm storage were not included in that analysis.
[b]This analysis controlled for all other variables in the table.
[c]Includes those who answered "Yes, always" and "Yes, sometimes."
[d]The sum of n for a variable may not equal the total Group N due to missing values.

Table 4. Continued.

	Rifle storage			Logistic regression analysis[b]	
	Yes[c] n (row %)[d]	No n (row %)[d]	P-value	Odds ratio	Confidence interval
Age					
16-18 years	415 (24)	1,354 (76)	0.05	1.20	0.98-1.48
13-15 years	175 (20)	695 (80)		1.0 (ref)	
Residence					
Farm	327 (25)	1,000 (75)	0.01	1.45	1.09-1.93
Country/not a farm	187 (21)	714 (79)		1.14	0.85-1.55
Town	76 (19)	336 (82)		1.0 (ref)	
Race/Ethnicity					
Non-Hispanic White	546 (22)	1934 (78)	0.13	1.0 (ref)	
Other races/ethnicities	43 (27)	115 (72)		1.38	0.94-2.02
US Census Region					
South	187 (34)	369 (66)	<0.001	5.90	2.51-13.86
West	51 (21)	187 (79)		3.16	1.30-7.72
Midwest	342 (19)	1415 (81)		2.80	1.20-6.52
Northeast	6 (8)	73 (92)		1.0 (ref)	

[a]Those who answered "unsure" regarding firearm storage were not included in that analysis.
[b]This analysis controlled for all other variables in the table.
[c]Includes those who answered "Yes, always" and "Yes, sometimes."
[d]The sum of n for a variable may not equal the total Group N due to missing values.

from the Northeast had the lowest. Moreover, the odds of youth reporting handguns being stored loaded were 2.6, 2.6 and 5.2 times greater for the Midwest, West and South, respectively, as compared to the Northeast. Similarly, youth from the West and South had 1.9 and 2.3 times higher odds of reporting handguns being stored unlocked, respectively, relative to the Northeast. In addition, the odds of participants reporting handguns being stored loaded and unlocked were 4.3, 5.2 and 8.1 times greater, respectively, for the Midwest, West and South as compared to the Northeast.

Ammunition Storage Practices

Only 43% of respondents with known rifles/shotguns in the home reported that the ammunition was always locked and stored separately from the firearms, and 22% of respondents reported ammunition was not locked at all. Males and respondents aged 16-18 years both had 1.5 times greater odds of reporting ammunition being stored unlocked as compared to females and younger teens (data not shown in a table). There were no observed differences in ammunition storage practices by subject's race/ethnicity, residence, or US Census Region.

The storage practices for handgun ammunition were similar to those of rifles/shotguns in that 41% reported ammunition being locked and stored separately from the handguns, and 22% reporting handgun ammunition as not being locked. Males and those aged 16-18 years had higher proportions with unlocked handgun ammunition in the home with odds 1.4 and 1.7 times greater, respectively, of reporting unlocked ammunition than females or younger teens. The odds of respondents living on a farm reporting unlocked handgun ammunition was 1.5 times higher as compared to those living in town. There were no observed differences by race/ethnicity or across US Census regions.

DISCUSSION

A large majority of survey respondents reported having at least one firearm in their home. Firearm presence in the home was higher in the South, West and Midwest compared to the Northeast for both rifles/shotguns and handguns. Over one-fifth reported that rifles/shotguns were stored both loaded and unlocked at least some of the time, and nearly one-third reported having handguns stored loaded and unlocked at least some of the time. More than three-fifths of those with firearms in the home reported having unsafe storage at least some of the time.

The population of this study is best described as rural adolescents. Several studies have shown that rural settings have higher rates of unintentional and suicide firearm deaths including among youth.[13,14,23,24] Unsafe storage has been associated with an increased risk of youth firearm suicide.[25-27] It is estimated that ~34% of all children in the US live in homes with firearms, and 13% of these homes have firearms that are stored unsafely.[28] Our study respondents had higher proportions of firearm ownership and unsafe storage as compared to the general population. This may contribute to the higher rates of firearm-related injury and suicide seen in rural areas of the US.[29]

Table 5. Bivariate and multivariable logistic regression analyses regarding the storage of handguns in the homes of adolescent survey respondents.[a]

	Handgun storage			Logistic regression analysis[b]	
	Yes[c] n (row %)[d]	No n (row %)[d]	P-value	Odds ratio	Confidence interval
Stored loaded					
Sex					
Male	602 (51)	588 (49)	0.01	1.22	1.03-1.46
Female	438 (45)	533 (55)		1.0 (ref)	
Age					
16-18 years	702 (49)	747 (52)	0.62	1.04	0.87-1.25
13-15 years	343 (47)	382 (53)		1.0 (ref)	
Residence					
Farm	496 (47)	556 (53)	0.15	1.07	0.83-1.37
Country/not a farm	392 (51)	379 (49)		1.24	0.95-1.60
Town	159 (45)	192 (55)		1.0 (ref)	
Race/ethnicity					
Non-Hispanic White	978 (48)	1048 (52)	0.63	1.0 (ref)	
Other races/ethnicities	67 (46)	78 (54)		0.90	0.63-1.28
US Census Region					
South	327 (62)	201 (38)	<0.001	5.15	2.75-9.63
West	94 (44)	119 (56)		2.61	1.35-5.05
Midwest	603 (44)	761 (56)		2.58	1.40-4.75
Northeast	15 (25)	46 (75)		1.0 (ref)	
Stored unlocked					
Sex					
Male	637 (53)	558 (47)	<0.001	1.45	1.22-1.73
Female	429 (43)	560 (57)		1.0 (ref)	
Age					
16-18 years	754 (52)	703 (48)	<0.001	1.46	1.21-1.75
13-15 years	318 (43)	421 (57)		1.0 (ref)	
Residence					
Farm	571 (53)	501 (47)	<0.001	1.79	1.40-2.30
Country/not a farm	362 (47)	400 (53)		1.40	1.08-1.82
Town	142 (39)	221 (61)		1.0 (ref)	
Race/ethnicity					
Non-Hispanic White	1000 (49)	1042 (51)	0.82	1.0 (ref)	
Other races/ethnicities	73 (48)	79 (52)		0.93	0.66-1.32
US Census Region					
South	305 (58)	223 (42)	<0.001	2.28	1.31-3.96
West	119 (54)	102 (46)		1.88	1.04-3.39
Midwest	620 (45)	757 (55)		1.35	0.79-2.31
Northeast	24 (38)	39 (62)		1.0 (ref)	
Stored loaded and unlocked					
Sex					
Male	445 (37)	741 (63)	<0.001	1.69	1.40-2.05
Female	251 (26)	711 (74)		1.0 (ref)	

[a]Those who answered "unsure" regarding firearm storage were not included in that analysis.
[b]This analysis controlled for all other variables in the table.
[c]Includes those who answered "Yes, always" and "Yes, sometimes."
[d]The sum of n for a variable may not equal the total Group N due to missing values.

Table 5. Continued.

	Handgun storage			Logistic regression analysis[b]	
	Yes[c] n (row %)[d]	No n (row %)[d]	P-value	Odds ratio	Confidence interval
Age					
16-18 years	489 (34)	945 (66)	0.01	1.35	1.11-1.65
13-15 years	208 (29)	517 (71)		1.0 (ref)	
Residence					
Farm	358 (34)	692 (66)	<0.001	1.65	1.25-2.19
Country/not a farm	256 (34)	496 (66)		1.68	1.25-2.25
Town	84 (23)	274 (77)		1.0 (ref)	
Race/Ethnicity					
Non-Hispanic White	649 (32)	1364 (68)	0.70	1.0 (ref)	
Other races/ethnicities	49 (34)	96 (66)		1.07	0.73-1.56
US Census Region					
South	227 (43)	299 (57)	<0.001	8.05	3.15-20.56
West	71 (33)	145 (67)		5.23	1.99-13.73
Midwest	388 (29)	962 (71)		4.32	1.71-10.95
Northeast	5 (8)	55 (92)		1.0 (ref)	

[a]Those who answered "unsure" regarding firearm storage were not included in that analysis.
[b]This analysis controlled for all other variables in the table.
[c]Includes those who answered "Yes, always" and "Yes, sometimes."
[d]The sum of n for a variable may not equal the total Group N due to missing values.

Respondents from the South had higher proportions and greater odds of both rifles/shotguns and handguns being stored loaded and unlocked relative to other regions. This was also observed in the 2019 National Firearm Survey where US adults in the South had twice the odds for storing firearms loaded and unlocked as compared to the Northeast, an odds ratio comparatively higher than that of the Midwest and West as well.[30] Conversely, rural youth from the Northeast had lower proportions whose families owned firearms and stored them unsafely. This difference in firearm ownership is consistent with a 2017 Pew Research Center survey that found 16% of adults living in the Northeast reported owning a gun, half the ownership rate of adults in the South (36%), Midwest (32%) and West (31%).[11] Six of the 10 states with the highest youth firearm death rates are in the South US Census Region, and the four states with the lowest rates are in the Northeast.[17] This regional pattern correlates with our study's firearm ownership and storage results. The overlap of higher firearm deaths and unsafe storage practices raises concern for a possible causal relationship; unsafe storage increases access to firearms and risk of possible injury.

Our study shows a high prevalence of firearms that are unsafely stored in homes of rural adolescents. A proven strategy for reducing the risk of firearm-related death is the passage of state child access prevention (CAP) laws that impose criminal liability on adults who fail to prevent children from unauthorized access to firearms. State CAP laws are associated with reductions in firearm mortality including suicide rates among youth.[31,32] Moreover, states with strong CAP laws have lower rates of firearm-related suicide and unintentional injuries in adolescents as compared to states without CAP laws.[18,33-35] Approximately 75% of adults and youth support such measures.[12,36,37] None of the 10 states with the highest youth firearm death rate have implemented CAP laws whereas 9 of the 10 states with the lowest youth firearm death rate have some form of CAP law in place.[38]

Anticipatory guidance has been shown to be effective in increasing parents' awareness of risks to their child's health and to promote safer practices.[39-41] Clinicians counseling patients can effectively promote safe storage practices, especially when offering a free, safe firearm storage device (ie, trigger lock).[42] The AAP recommends that pediatricians routinely discuss firearm safety with patients and their families in the context of injury prevention, including encouraging parents to ask about firearms and their storage in homes their children visit.[43]

Future studies should include focus group discussions to better understand rural families' attitudes regarding firearm storage, what practices households would be willing to change to increase safety, and what messaging they believe would be effective in educating rural families to improve storage practices and help decrease rural firearm-related injuries. Ultimately, a multifaceted approach that includes continued safety education, clinician counseling, and policy will be essential to reduce firearm-related injury and death among our rural youth.

LIMITATIONS

The study used a convenience sampling of US adolescents at the National FFA Leadership Conference who were primarily from rural areas. Thus, the study does not represent urban areas of the country. In 2021, according to the US Department of Agriculture, the percentage of farms by US Census Region was as follows: Midwest 36%; South 42%; West 16%; and Northeast 6%.[44] Nearly two-thirds of our respondents were from the Midwest suggesting an oversampling from this region, likely explained by the conference being held within this region. In addition, over 90% of respondents were NH White, which is a higher proportion than that determined by the 2020 US Census for rural residents (76%).[45] Thus, our findings may not be generalizable to all states and to non-White populations. Responses to the survey were self-reported and could be affected by recall bias and social desirability. However, surveys were completed independently and collected anonymously, which should have helped decrease the social desirability bias.

CONCLUSION

A significant majority of rural youth in our study lived in households with firearms. Most reported some form of unsafe storage. There were differences regarding the presence and storage of firearms by demographics, especially the US Census Region and home setting. Unsafe storage practices could be contributing to the higher unintentional and suicide death rates seen in rural areas. Widespread efforts are needed to educate and counsel rural families about the importance of proper firearm storage and must consider the unique cultural and social aspects of rural communities.

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Incidence and Characteristics of Alcohol-Based Hand Sanitizer Ingestion in Florida before and during the Coronavirus Pandemic

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Introduction: Hand sanitizer use and media coverage increased throughout the coronavirus-2019 pandemic. In this study our goal was to examine and compare the incidence, demographics, and clinical outcomes of exposures to alcohol-based hand sanitizers (ABHS) before and during the COVID-19 pandemic in the state of Florida.

Methods: We analyzed statewide data on all ABHS exposures in adults collected by the Florida Poison Information Network from March 1, 2015–February 28, 2020 ("pre-COVID-19" cohort) and during the COVID-19 pandemic from March 1, 2020–May 5, 2023 ("COVID-19" cohort). We performed descriptive, univariable, and multivariable analyses to assess changes in sex, age, medical outcome, and intentionality of the exposure in the pre-COVID-19 vs COVID-19 study periods, and we examined the factors associated with medical outcomes.

Results: We identified 876 single-substance ingestions of ABHS, 414 in the pre-COVID-19 cohort and 462 in the COVID-19 cohort. The proportions of ABHS ingestions increased significantly during the COVID-19 pandemic in all age groups except the 25-50 age group, where it decreased. Individuals 18-24 of age and those ≥51 years showed a relative increase in both intentional and unintentional ingestions during the COVID-19 period compared to the 25-50 age group. The significant risk factors associated with more severe outcomes in exposed individuals were intentional exposures and younger age.

Conclusion: Unintentional ingestions of alcohol-based hand sanitizers showed a relative increase during the COVID-19 pandemic, particularly in individuals 18-25 years of age and those ≥51. Both intentional ingestions and younger age increased the likelihood of moderate or severe outcomes. Harm reduction strategies targeted toward younger individuals and those with intentional ingestions should be considered during future pandemics. [West J Emerg Med. 2025;26(3)643–649.]

INTRODUCTION

Hand sanitizer use and media coverage increased throughout the coronavirus-2019 pandemic. Both the US Centers for Disease Control and Prevention (CDC) and the World Health Organization strongly advocated for alcohol-based hand sanitizer (ABHS) use to help limit the spread of COVID-19.[1] The CDC had recommended ABHS products with at least 60% ethanol or 70% isopropanol as an antiseptic to limit the spread of COVID-19 infection.[2] The ABHS products most commonly contain ethanol, but less commonly may also contain isopropyl alcohol or quaternary ammonium compounds.[3]

There is growing evidence within the peer-reviewed literature suggesting an increase in reported ABHS ingestion throughout the COVID-19 pandemic. The US Food and Drug Administration found a 79% increase in the number of unintentional ingestions of ABHS reported to poison control centers when comparing March 2020 to March 2019.[4] Additionally, McCulley et al found a 36% increase in ABHS exposures in children ≤5 years of age from January–April 2020.[5] Before the current COVID-19 pandemic, Gormley et al (2012) found that the number of new cases of ABHS ingestion increased by approximately 2,000 cases each year from 2005 to 2009, according to the National Poison Data System (NPDS), suggesting an overall increasing rate of exposure in the US population.[6] Prior to the COVID-19 pandemic, the majority of ABHS exposures were accidental and occurred mostly in pediatric populations.[4,5] Peer-reviewed case studies regarding ABHS exposures, specifically within adult populations, are largely associated with alcohol and substance use disorders.[7-10] The consequences of ABHS ingestion include nausea, emesis, apnea, acidosis, confusion, ataxia, sedation, coma, and death.[11,12]

Given that most previously reported case series have focused on unintentional and accidental exposures to ABHS,[1,10,13] we conducted a retrospective cohort study using statewide data collected by the Florida Poison Information Center Network (FPICN) to elucidate further the trends in intentional vs unintentional ingestions of ABHS among adult populations during a global pandemic. We assessed possible associations between increased incidence of ABHS ingestions, age and sex, intentionality, and clinical outcomes.

Population Health Research Capsule

What do we already know about this issue?
Alcohol-based hand sanitizer (ABHS) use increased during the COVID-19 pandemic.

What was the research question?
How did the characteristics and outcomes of ABHS poisonings change during COVID-19?

What was the major finding of the study?
ABHS ingestions proportionally increased in all age groups (except those 25-50 years of age) from 83 to 142 cases per year (71%) pre-COVID-19 compared to during the pandemic (P <0.001).

How does this improve population health?
Understanding the characteristics, intentionality, and outcomes of ABHS ingestion during COVID-19 can lead to targeted public health messaging and interventions in future events.

METHODS

As part of America's Poison Centers, which represents the 54 accredited poison control centers in the US, the FPICN collects data from throughout the state of Florida and automatically uploads it every 9.50 minutes in real time to the NPDS, a nationwide poison surveillance tool. The FPICN data accurately represents toxic ingestions within Florida.[14] Our COVID-19 group included all consecutive patients ≥18 of age with ingestion of ABHS reported to the FPICN during the pandemic from March 1, 2020–May 5, 2023. (May 5 was the end date of the COVID-19 pandemic per a federal Public Health Emergency declaration.) The control population (pre-COVID-19 group) included all patients ≥18 years of age with ingestion of ABHS reported in the preceding five years from March 1, 2015–February 28, 2020. We excluded exposures with multiple substances or those with incomplete data. All records were abstracted from the FPICN database by the lead author. The University of South Florid Institutional Review Board approved the study.

We conducted a descriptive analysis to describe cases of reported ABHS ingestion and assessed cases based on age, sex, intentionality, and outcome. The yearly incidence of reported ABHS ingestion was calculated as cases per one million people from 2015–2020 and 2020–2023 using the Florida population during these periods. We used the independent means *t*-test to compare the differences in data distribution of continuous attributes (eg, age) across pre-COVID vs COVID-19 cohorts. We used the chi-square test of independence to examine whether there was a statistically significant association between categorical variables. Univariable and multivariable cumulative logistic regression assessed the relationship between risk factors and the degree of medical outcome severity.

The medical outcome severity (no effect; minor; moderate; major; and death) is standardized and was defined a priori for all poisonings by the NPDS data collection tool. Minor symptoms are defined as "minimally bothersome to the patient … and usually resolve rapidly." Moderate symptoms are defined as follows:

> [M]ore pronounced, more prolonged, or more of a systemic nature … and usually some form or treatment is or would have been indicated. Symptoms were not life-threatening[,] and the patient has returned to a pre-exposure state of well-being with no residual disability or disfigurement.

Major symptoms are defined as "life-threatening or resulted in significant residual disability or disfigurement."

Since there were only two cases of medical outcome severity of death, we excluded those two cases from the multivariable analysis. We used SAS statistical software v9.4 (SAS Institute Inc, Cary, NC) to perform all data cleaning and analyses.

RESULTS

We identified 876 single-substance ingestions of ABHS, with 414 in the pre-COVID-19 cohort and 462 in the COVID-19 cohort. The average annual incidence of ABHS ingestions increased considerably during COVID -19 as a whole and among all age groups (mean 83 total cases/year pre-COVID-19 increasing to a mean 142 cases/year during COVID-19). Adjusted for Florida's population, the mean attack rate was four cases per million population in the pre-COVID-19 cohort and 6.2 cases per million population in the COVID-19 cohort. There was some variability in the number of ingestions reported to the FPICN during the COVID-19 study period with a disproportionately large increase in monthly calls during July 2020. Unintentional exposures, starting in 2019, increased significantly and exceeded intentional exposures (Table 1). The annual incidence based on age, sex, intention, and outcome are shown in Figure 1.

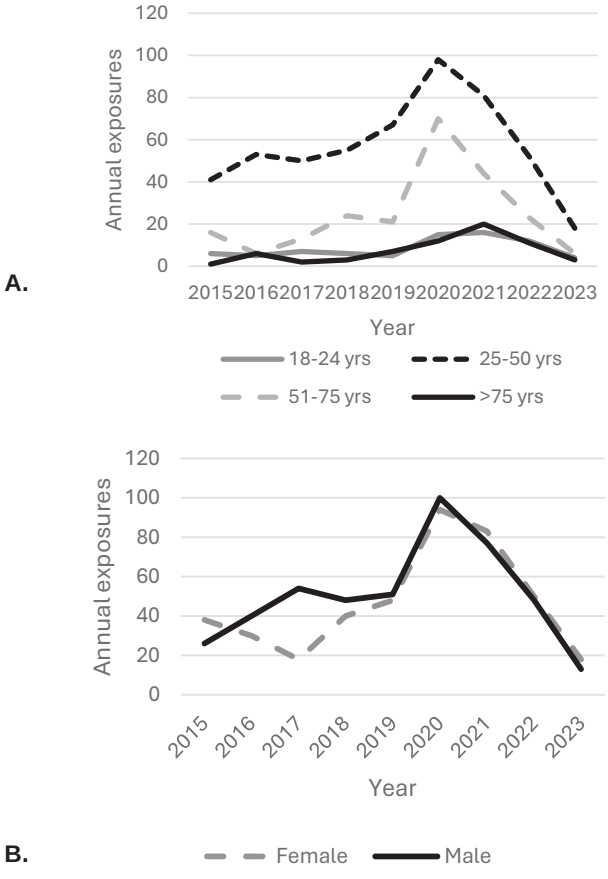

Figure 1. The yearly incidence of ingestion of alcohol-based hand sanitizers reported in Florida as stratified by age, sex, intention, and outcome (March 1, 2015–May 5, 2023).

Age

When assessing all individuals based on age, it appears that individuals in the COVID19 cohort were relatively older (mean age 47 years) than people in the pre-COVID cohort (mean age 42 years) (*P*-value < 0.001, Table 1). While young adults 18-24 years of age, and those 51-75 and >75 represented a larger proportion of the exposures during COVID-19, individuals 25-50 years of age showed a relative decrease in exposures to ABHS compared to other age groups (*P*<0.001, Table 1).

Sex

There were no statistical differences in patient characteristics between the pre-COVID and COVID-19 cohorts related to sex (Table 1). Although males showed no significant changes in their use patterns, the proportion of females demonstrating no effect or minor effects increased from 74.6% during the pre-COVID-19 timeframe to 88.4% during COVID-19 (*P*<0.001, Table 3A). Additionally, females with no effect were statistically older (51.1+/-2.2 years) when compared to those with minor effects (42.4 +/-1.1 years), moderate effects (40.8+/-1.8 years), or major effects (41.4+/-4.3 years) (*P*=0.01, Table 3B). There were no deaths in any females and two deaths in males (both in the COVID-19 group).

Intention

When assessing the effect of intentionality (unintentional vs intentional exposures vs other), the proportion of unintentional ingestions of ABHS in the COVID-19 group was higher than in the pre-COVID group, increasing from 23% of all exposures pre-COVID to 43.3% of all exposures during the COVID-19 pandemic. Still, the intentional ingestions and other ingestions groups had higher proportions during COVID-19 than before COVID-19 (*P* -value <0.001, Table 1). Intentional exposures due to "other" reasons (including adverse reactions, malicious use or tampering, withdrawal, or unknown reasons) relatively increased from 4.8% in the pre-COVID period to 8% during the COVID-19 period (Table 1). Both pre-COVID and COVID-19 cohorts demonstrated an association with unintentional ingestions and a higher mean age (51.8+/-2.4) compared to 39.9+/-0.6 years pre-COVID, 41.1+/-1.9 vs 40.8 +/-1.3 years during COVID-19, *P*<0.001).

Intentional exposures can be broadly divided into three categories: intentional suicide attempt (self-harm attempt); intentional misuse (knowingly using a product other than as directed on the label excluding psychotropic effects); and intentional abuse (using a product for recreational effects, psychotropic effects, or to achieve a high). Although intentional abuse and misuse saw a proportional decrease in exposures during the COVID-19 cohort, intentional suicide increased significantly from 29.4% in the pre-COVID cohort to 42.2% in the COVID-19 cohort (Table 2).

Table 1. Patient characteristics prior to coronavirus 2019 (pre-COVID group: March 1, 2015–February 28, 2020) and during the pandemic (COVID-19 group: March 1, 2020–May 5, 2023) in Florida.

Patient characteristics	Pre-COVID-19 group	COVID-19 group	P-value
Sex			0.078[a]
Male n (%)	229 (55.3)	228 (49.4)	
Female n (%)	185 (44.7)	234 (50.6)	
Age years: n (mean ± SEM)	414 (42.7 ± 0.8)	462 (47.2 ± 0.9)	<.001[b]*
Age group			<.001[a]*
18-24: n (%)	30 (7.3)	45 (9.7)	
25-50: n (%)	279 (67.4)	235 (50.9)	
51-75: n (%)	83 (20)	139 (30.1)	
>75: n (%)	22 (5.3)	43 (9.3)	
Medical outcome			0.083[a]
No effect: n (%)	120 (29)	157 (34)	
Minor effect: n (%)	187 (45.2)	215 (46.6)	
Moderate effect: n (%)	88 (21.2)	74 (16)	
Major effect: n (%)	19 (4.6)	14 (3)	
Death: n (%)	0 (0)	2 (0.4)	
Intentionality			<.001[a]*
Intentional: n (%)	299 (72.2)	223 (48.3)	
Unintentional: n (%)	95 (23)	202 (43.7)	
Other: n (%)	20 (4.8)	37 (8)	

Notes: *indicates statistically significant with *P*-value <0.05. [a]Chi-square test; [b]independent means *t*-test.
SEM, standard error of the mean.

Medical Outcome

During COVID-19, 34% of patients had no effect, 46.6% had minor effects, 16% had moderate effects, 3% had major effects, and there were two deaths (Table 1). There were no notable outcome differences ($P = 0.08$) in the pre-COVID vs COVID-19 groups (Table 1). However, univariable analysis showed that sex, age, being in the either the pre-COVID or COVID-19 groups, and intentional use of ABHS were all significantly related to medical outcome (Table 4). When these four variables were placed into the multivariable model with medical outcome as the dependent variable, only age and those with intentional exposures were noted to be significant predictors of medical outcomes (Table 4).

Table 2. Trends in specific intentional exposure types before COVID-19 (pre-COVID group: March 1, 2015–February 28, 2020) and during the pandemic (COVID-19 group: March 1, 2020–May 5, 2023) in Florida.

	Pre-COVID-19 group	COVID-19 group	P-value
Intentional abuse	193 (64.3%)	118 (52.9%)	
Intentional misuse	19 (6.3%)	11 (4.9%)	
Intentional suicide	88 (29.4%)	94 (42.2%)	
Total	300 (100%)	223 (100%)	0.01[a]*

Note: *indicates statistically significant with *P*-value <0.05. [a]Chi-square test of independence.

DISCUSSION

Overall, the incidence of intentional ABHS ingestion in our study population increased statistically significantly in most age groups during COVID-19 when compared to pre-COVID-19. While we could not determine causation, the data suggests a strong correlation between the observed increase in the ingestion of ABHS and the onset of the COVID-19 pandemic. Factors likely contributing to this observed rise in ABHS ingestion include increased accessibility and visibility of ABHS; increased media attention; education on the daily recommended use of ABHS; and perhaps the absence of clear guidance regarding safe storage and use of ABHS.[4] Online and social media trends recommending the use of ABHS in groceries and the direct ingestion of ABHS started in April 2020.

During the COVID-19 period two notable events in Florida may have impacted exposures to ABHS. The first was a statewide ban on ethanol sold in bars in June 2020 that lasted one week. While this may have limited ethanol access in bars, ethanol and all ABHS products remained available at grocery stores, gas stations, and liquor stores, and it likely did not have

Table 3. Medical outcomes of ingestion of alcohol-based hand sanitizers in Florida before the COVID-19 pandemic (pre-COVID group March 1, 2015–February 28, 2020) and during the pandemic (COVID-19 group March 1, 2020– May 5, 2023) in Florida as stratified by sex and age.

A. Sex.

	Pre-COVID-19 group	COVID-19 group	P-value
Female outcomes	185 (44.2%)	234 (55.8%)	0.001*
No effect	57 (30.8)	86 (36.7)	
Minor effect	81 (43.8)	121 (51.7)	
Moderate effect	39 (21.1)	18 (7.7)	
Major effect	8 (4.3)	9 (3.9)	
Death	0 (0)	0 (0)	
Male outcomes	229 (50.1%)	228 (49.9%)	0.21
No effect	63 (27.5)	71 (31.1)	
Minor effect	106 (46.3)	94 (41.2)	
Moderate effect	49 (21.4)	56 (24.6)	
Major effect	11 (4.8)	5 (2.2)	
Death	0 (0)	2 (0.9)	

Note: *indicates statistically significant with *P*-value <0.05, SEM, standard error of the mean.

B. Sex and age .

	N	Age: mean ± SEM	P-value
Female outcomes			< 0.001*
No effect	143	52.9 ± 1.9	
Minor effect	202	44.2 ± 1.2	
Moderate effect	57	41.1 ± 1.6	
Major effect	17	41.9 ± 3.8	
Death	0	n/a	
Male outcomes			0.02*
No effect	134	47.3 ± 1.7	
Minor effect	200	42.3 ± 1	
Moderate effect	105	42.4 ± 1.1	
Major effect	16	37.9 ± 2	
Death	2	± 18.5	

Note: *indicates statistically significant with *P*-value <0.05, *SEM*, standard error of the mean.

a significant impact on ABHS exposures. The second event was the methanol contamination of certain brands of ABHS in July 2020. This event was widely publicized, and exposed individuals were encouraged to contact poison centers for advice. Poison centers in Florida saw a fourfold increase in mean cases for the year during the three weeks July 13–August 2, 2020 (Figure 2), which was largely attributed to these products.

Table 4. Predictors of severity of medical outcomes of ABHS ingestion. of alcohol-base hand sanitizers in Florida from March 1, 2015–May 5, 2023

Predictors	Univariable analysis OR (95% CI)	Multivariable analysis OR (95% CI)	Multivariable analysis P-value
Sex (Female vs male**)	1.38 (1.08 – 1.77)	0.93 (0.72- 1.21)	0.59
Age	1.02 (1.01- 1.03)	1.01 (1 – 1.02)	0.027*
Group (COVID-19 vs pre-COVID**)	0.74 (0.58- 0.95)	0.92 (0.71- 1.2)	0.56
Ingestion reason (Intentional vs. other**)	0.55 (0.33 – 0.91)	0.56 (0.33 – 0.93)	0.03*
(Unintentional vs other**)	3.29 (1.93 – 5.59)	3.15 (1.85 – 5.36)	<0.001*

Note: *Indicates statistically significant with *P*-value <0.05; **indicates reference category.
OR, odds ratio, *CI*, confidence interval.

Holzman et al reported significant increases of 124% in their total reports of ABHS exposure in Arizona (intentional + unintentional) during COVID-19.[16] Phillips et al reported a 72.5% increase in total ABHS exposures reported to Texas poison control centers during COVID-19.[17] In Texas, the mean age of both unintentional and intentional exposures to ABHS significantly increased from 10.9 to 23.9 years of age during COVID-19. Although a similar increase in mean age was noted by Shulte et al in Texas, our subset of patients demonstrated an older baseline but a similarly significant increase in mean age during COVID-19. The mean age in the COVID-19 cohort likely increased due to a higher proportion of older adults in the 51-75 and >75-year-old categories during COVID-19 compared to the pre-COVID-19 period, as

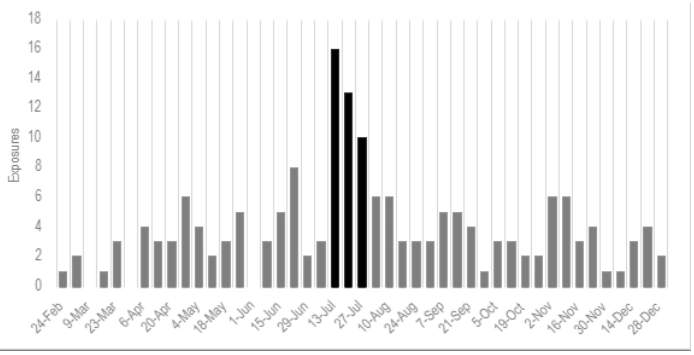

Figure 2. Exposures to alcohol-based hand sanitizers by week in 2020.

well as a baseline older population in Florida. Florida is the third most populus state in the US, with an estimated population in 2022 of 22,244,823, with 21.1% ≥65 years of age. Like Florida, Arizona has an older population (18.3% of the population ≥65 years) compared to the US overall (16.8% of the population ≥65). Our data specifically addresses patients from Florida and showed a 127% increase in the incidence of ABHS exposures from the pre-COVID-19 study period through the COVID-19 study period. It demonstrated relative increases in ABHS exposures in the younger 18–24 years of age group and individuals >51. The largest age group, 25-50, saw a proportionally decreased incidence from 67.4% in the pre-COVID cohort to 50.9% in the COVID-19 cohort.

Interestingly, although there was a decrease in minor and no effects and an increase in moderate and major effects in outcomes after exposure during the COVID-19 period in comparison with pre-COVID, while adjusting for age, sex, and intentionality, there was no statistically significant change in outcomes after exposure when comparing the pre-COVID and COVID-19 cohorts. Females were noted more likely to have either no effect or a minor effect (compared to moderate or major effects) after ABHS exposure than males during the COVID-19 pandemic ($P<.001$), but this was not the case for the pre-COVID-19 period ($P=0.90$). Although not specifically addressed in this study, this was likely due to a lower exposure dose associated with unintentional exposures. Younger adults tend to have more severe medical outcomes in univariable and multivariable analyses.

Furthermore, significant changes in the intentionality were reported to poison centers during COVID-19. As mentioned above, unintentional exposures relatively increased during COVID-19 from 23% to 43.3% of exposures, while intentional exposures relatively decreased from 72.2% to 48.3%. Traditionally, the majority (97%) of all ABHS exposures reported to US-based poison centers are unintentional exposures that occurred in children.[13] Of those with unintentional exposures, Kweon et al reported no notable differences in the distribution of unintentional exposures, adverse reactions, or concomitant exposures in the pre-COVID vs COVID-19 study periods. Similar increased incidences of unintentional ABHS during COVID-19 were seen in children in France, Canada, and Australia.[10]

In our study, however, we focused on adults in which intentional exposures (abuse, misuse, and suicide attempts) vs unintentional exposures were more commonly reported to poison centers. When assessing the type of intentional exposure, a significant increase in the suicide attempt subset (29.4% to 42.2%) was noted, which may not be surprising due to the high level of stress and anxiety that was present during COVID-19. Intentional ingestion of ABHS was found to portend a higher risk of worse medical outcomes as compared to unintentional ingestion, likely suggesting that those with intentional ingestion (suicide attempts are often associated with larger doses) consumed a higher quantity of ABHS. However, the quantity was not analyzed in this assessment. Furthermore, those with intentional ABHS ingestions were more likely to be male and slightly younger, which may be reflective of alcohol use disorder in the general population.

Predictors of moderate or major outcomes included those with intentional ingestions and those with younger age. Intentional ingestions often involve large quantities of ABHS, which often produce more significant clinical effects, including hematemesis, central nervous system and respiratory depression, and the need for invasive monitoring or aggressive supportive care. There were two deaths reported; both were males with intentional ingestions as suicide attempts during COVID-19.

LIMITATIONS

The limitations of this study are largely based on the limitations of poison center reporting. The FPICN records are based on voluntary, self-reported exposures by patients and physicians. Because reporting is not mandated there is potential for selection bias in reported cases. Additionally, the National Poison Database System likely under-represents our population's total incidence of ABHS. Furthermore, given self-reported information, callers may inaccurately report the specific product or substance, dose, clinical features, and outcome. Given the variability in reporting the quantity of ABHS ingested (mostly reported as an estimated amount ingested), we did not include the quantity ingested in our analysis. Certainly, those with a higher dose are anticipated to have more severe outcomes. However, this was not specifically studied. Finally, a broad yet specific population (the State of Florida) may not apply to other populations.

CONCLUSION

Although the ingestion of alcohol-based hand sanitizers increased broadly during COVID-19, proportional use patterns showed only slight variations compared to pre-pandemic exposures. Individuals aged 18-25 of age and ≥51 showed relatively increased rates of exposure to ABHS during COVID-19, and those with increased age demonstrated more moderate and severe outcomes. There was a significant relative increase in unintentional exposures and a relative decrease in intentional exposures, with a dramatic increase in suicide attempts among those with intentional exposures. Despite these changes, most exposed individuals demonstrated no or only minor symptoms after ingestion. The only significant risk factors associated with poor outcomes were intentional ingestion and young age. Although these findings are specific to Florida and based on Florida Poison Information Center Network data, clinicians may be able to use these findings in a similar pandemic or disaster response. Patients should be advised in future pandemics to avoid intentional ingestion of ABHS; access to resources such as counseling, suicide hotlines, poison centers, and safety campaigns should be considered. Additionally, public health

messaging and education targeting younger adults may be worthwhile in mitigating these exposures.

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Comparing Prehospital Time Among Pediatric Poisoning Patients in Rural and Urban Settings

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Objectives: Barriers to healthcare in rural areas can delay treatment in pediatric patients who have experienced poisoning. We compared emergency medical services (EMS) response times and EMS-reported delays in responding to pediatric poisoning incidents between rural and urban settings using the 2021 National Emergency Medical Services Information System (NEMSIS).

Methods: The NEMESIS defines rural areas as locations with a population of <50,000, not part of metropolitan areas, while all other locations are classified as urban (metropolitan) areas. In this study we included 11,911 patients (12% rural) <18 years of age who were transported by EMS with a first-responder primary impression of poisoning. We compared study variables using rank-sum tests and chi-square tests. Multivariable analysis of outcomes included quantile regression and logistic regression for continuous data and categorical data, respectively.

Results: The median total prehospital time by EMS was 40 minutes (interquartile range 29-57), and the most common type of delay was scene delay (6%). On multivariable quantile regression, patients transported by rural EMS agencies experienced 6.6 minutes (95% confidence interval 5-8, P<0.001) longer prehospital time than those transported by urban agencies. There were no differences between rural and urban EMS agencies in the occurrence of dispatch, response, scene, and transportation delays.

Conclusion: These results elucidate the need for equitable allocation of resources and training to enhance rural EMS responders. The additional nearly seven minutes translates into greater risk for the human body to remain physiologically unstable and not be optimally treated. Therefore, by integrating targeted interventions to rural pediatric populations, better care can be achieved across all geographic regions. Further research must be conducted to ascertain the specific factors, aside from delays, that result in the disparity between rural and urban prehospital response time. [West J Emerg Med. 2025;26(3)650–656.]

INTRODUCTION

Pediatric poisoning can occur from a variety of toxic substances. Children in rural settings have a higher incidence of exposure to poisoning events.[1,2] Additionally, youth in rural populations are more likely to attempt suicide, including intentionally using poisoning as a method.[1] Some chemicals, such as organophosphate and carbamate pesticides, are commonly used by farm workers, introducing the risk of unintentional poisoning events and especially posing a threat among children in rural areas.[3]

Barriers to healthcare in rural areas may negatively influence the time to treatment of pediatric poisoning events

before patients reach a facility with the proper resources to manage these emergencies. Barriers may include limited resources within the community, especially when taking into consideration the shortage of emergency medical services (EMS) personnel in rural areas, further exacerbated by the lasting effects of the COVID-19 pandemic and financial inadequacies of rural programs, which limit care.[4,5] As well as increased transportation barriers, including distance to medical centers, additional barriers include inadequate training of medical personnel to treat the disparities present in rural communities; and professional-to-patient language barriers.[6] Additionally, there is a potential health outcome disparity produced by longer pediatric patients transport to urban pediatric specialty care emergency departments (ED) compared to rural EDs.

Epidemiological studies have compared the incidence of pediatric poisoning events in rural to urban areas in countries other than the US,[8,9] while US studies to date have focused on poisoning prevention education and the use of EDs rather than contacting poison control centers in cases of pediatric poisoning.[10,11] However, no recent study has compared prehospital responses to pediatric poisoning events in rural and urban populations within the US. Due to the scarcity of current literature and the widespread occurrence of pediatric poisonings, there is a need to investigate the impacts and disparities associated with EMS care for this patient population. Our primary aim was to compare the EMS response time (time from the call being received by dispatch until the responding unit's arrival at the destination hospital or ED) between pediatric poisoning events transported by rural as compared to urban EMS agencies. Secondary aims included comparing the incidence of dispatch delays, response delays, scene delays, and transport delays between rural and urban settings, as well as analyzing demographic disparities between these two settings.

Population Health Research Capsule

What do we already know about this issue?
Rural pediatric poisoning cases face delayed EMS care due to limited resources, longer transport distances, and workforce shortages.

What was the research question?
Is there a disparity in EMS prehospital care between rural and urban pediatric poisoning cases?

What was the major finding of the study?
On multivariable quantile regression, patients transported by rural EMS agencies experienced 6.6 minutes (95% confidence interval 5-8, P<0.001) longer prehospital time than those transported by urban agencies.

How does this improve population health?
Elucidating disparities in rural EMS services highlights the need for targeted interventions to improve rural care access and outcomes in pediatric poisoning cases.

METHODS

We used the 2021 National Emergency Medical Services Information System (NEMSIS), a multiagency database of EMS activations in the US that included an entire calendar year of data, January 1, 2021–December 31, 2021. All 50 states participate in voluntary submission of datasets to NEMSIS. Due to the use of deidentified data, this analysis was not considered human subjects research by our institutional review board. We identified pediatric patients 0-18 years of age who had a primary impression of poisoning (*International Classification of Diseases*, 10th Rev, ICD-10) code ranges: T43.641A-T54.0X4A, T55.0X1A-T62.94XA, T64.01XA-T65.814A, and T65.831A-T65.94XA). These ICD-10 codes relate to toxic effects caused by various substances: T43.641A-T54.0X4A covers toxic effects of non-medicinal substances such as organic solvents and corrosive acids and alkalis; T55.0X1A-T62.94XA covers toxic effects of soaps, detergents, pesticides, and poisonous ingested foods; T64.01XA-T65.814A covers toxins produced by mold such as aflatoxins in contaminated food as well as other chemicals like nitroglycerin and benzene derivatives; T65.831A-T65.94XA refers to toxic effects of other substances such as nicotine, carbon disulfide, and any unspecified chemical. We excluded patients >18 years of age, patients not transported by the responding EMS unit, patients not transported by land or air EMS, and patients who died prior to arrival at a hospital or ED. We excluded patients not transported by the responding EMS unit due to their transportation occurring via a different EMS agency or individuals, or they were not transported at all. Additionally, we excluded any patients offered treatment by individuals other than EMS professionals, since bystander intervention may have confounded the measurement of prehospital times. Lastly, we excluded cases with missing data on study variables.

The primary outcome was total EMS response time, or time from the call being received by dispatch until the unit's arrival at the destination hospital or ED. The secondary outcomes were incidence of any delays during dispatch, response, time on scene, or transport, as reported by the EMS agency. Delays are identified in the NEMSIS registry through self-reporting by EMS agencies. The exposure is defined as the EMS location, whether urban or rural. Rural areas were defined as any location with a <50,000 population that is not part of a metropolitan area, and all other locations were classified as urban (metropolitan) areas. (Secondary exposures by EMS were not observed in this study).[12,13] County lines are

often the borders used to define these areas. The NEMSIS database also classifies based on the US Department of Agriculture Economic Research Service definition. Covariates included patient age, sex, race and ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic or Latino, or none of the above),=; initial patient acuity (critical, emergent, or lower acuity); and EMS transportation method (ground or air).

Per the NEMSIS data dictionary, dispatch delay is defined as "any time delay that occurs from the time of Personal Safety Answering Point (PSAP) call to the time the unit is notified by dispatch." Response delays encompass "any time delay that occurs from the time the unit is notified by dispatch to the time the unit arrived on scene." A scene delay is "any time delay that occurs from the time the unit arrived on scene to the time the unit left the scene." In terms of transport, delay is defined as "any time delay that occurs from the time the unit left the scene to the time the patient arrived at the destination."

We summarized continuous data using medians with interquartile ranges (IQR), and categorical data using counts and percentages. Study variables were compared between rural and urban settings using rank-sum tests or chi-square tests, as appropriate. Multivariable analysis of study outcomes included quantile regression for continuous data, and logistic regression for categorical data. We reported confidence intervals to characterize the accuracy of the regression coefficients. Each regression coefficient for categorical variables in the model represents an estimated change in the outcome when comparing that category to the reference group. Data analysis was completed in Stata/SE 18.0 (StataCorp, LP, College Station, TX), and $P<0.05$ was considered statistically significant We did not complete a power analysis. STROBE guidelines were followed in the presentation of the data.[14]

RESULTS

The NEMSIS dataset included 31,179 patients 0-18 years of age who had a "provider primary impression" of poisoning. We excluded 6,902 patients who were not transported by the responding EMS unit (either by land or air), or who were not taken to an ED or hospital; we also excluded 2,157 patients who received medication or procedures prior to the responding EMS unit's care. After excluding 10,209 patients who had missing data on study variables, we retained 11,911 patients for analysis. The most common responder primary impression was poisoning by unspecified drugs, medicaments, and biological substances (T50.90, 59%), poisoning by other drugs, medicaments, and biological substances (T50.99, 28%), and poisoning by unspecified substances (T65.9, 7%). All other ICD-10 codes for poisoning accounted for <1% of cases each. In the entire sample, the median total EMS response time was 40 minutes (IQR 29-57), and the most common type of delay was scene delay (6%), followed by response delay (5%), transportation delay (3%), and dispatch delay (1%).

The sample included 10,498 (88%) cases reported by an EMS agency in an urban location and 1,413 (12%) cases reported by an EMS agency in a rural location.

Table 1 presents the bivariate analysis of poisoning patient characteristics by urban or rural EMS agency location. The EMS agencies in rural locations were more likely to transport female patients than EMS agencies in urban locations, which were more likely to transport male patients, although they had the same median age. Non-Hispanic Whites comprised the majority of patients transported by both rural and urban agencies. However, there were higher proportions of Non-Hispanic Black and Hispanic patients transported by the urban agencies. The acuity of patients also differed between the agency types, with a higher proportion of critical (red) and emergent (yellow) cases transported by rural agencies, whereas a greater portion of lower acuity (green) was transported by urban agencies.

Moreover, the proportion of patients transported by air was higher in rural areas compared to urban areas. Total time prior to hospital arrival was greater for cases treated by rural EMS, but a greater proportion of cases treated by urban EMS experienced on-scene delays. With large samples and a non-parametric test, it is possible to attain high levels of statistical significance even if the medians happen to be identical, since the non-parametric test used here is not a test of the medians alone but of the entire distribution in each group.

Table 2 presents the results of the multivariate analysis of EMS time prior to arriving at the hospital by patient characteristics. Each variable category has an individually separate reference (ie, male is the reference for sex, and critical red is the reference for acuity). Patients transported by rural EMS agencies experienced a longer time prior to hospital arrival compared to those transported by urban agencies (6.6minutes (5.2-8.0), <0.001). The 6.6-minute difference is a coefficient from a multivariable quantile regression, as seen in the first row of Table 2. As with all multivariable regression coefficients, it is not based on a difference between one pair of values, but represents the estimated difference associated with a unit change in the independent variable, after adjusting for other variables shown in Table 2. Prehospital times were longer among patients who were female, non-Hispanic White, patients with emergent and low-acuity levels, and patients transported by air. Prehospital times were shorter for those who were older, non-Hispanic Black, Hispanic, or critical (red) acuity.

Table 3 presents the multivariate analysis of different EMS delays by patient characteristics. We used logistic regression for dichotomous secondary outcomes (occurrence of each type of delay). Because the statistical method was the same for all secondary outcomes, we combined them to reflect within this table. Rural agencies experienced no difference in odds of experiencing dispatch, response, on-scene, and transport delays compared to urban agencies. Non-Hispanic Black patients showed higher odds of dispatch delay compared to non-Hispanic White patients, while both non-Hispanic Black and Hispanic patients experienced elevated odds of response and on-scene delays. Additionally, individuals categorized as

Table 1. Bivariate analysis of poisoned patient characteristics by urban or rural EMS agency location (N=11,911).

	Rural n=1,413 patients		Urban n=10,498 patients		
Variable	n (%)	Median (IQR)	n (%)	Median (IQR)	P-value
Age (years)	15	(11, 16)	15	(12, 17)	<0.001
Sex					0.004
Male	465 (33%)		3,869 (37%)		
Female	948 (67%)		6,629 (63%)		
Race and ethnicity					<0.001
Non-Hispanic White	996 (70%)		6,111 (58%)		
Non-Hispanic Black	148 (10%)		2,331 (22%)		
Hispanic	82 (6%)		1,427 (14%)		
Other	187 (13%)		629 (6%)		
Acuity					<0.001
Critical – red	128 (9%)		620 (6%)		
Emergent – yellow	703 (50%)		3,886 (37%)		
Lower acuity – green	582 (41%)		5,992 (57%)		
Transported by air	71 (5%)		135 (1%)		<0.001
Time prior to hospital (minutes)		48 (30, 81)		39 (29, 55)	<0.001
Dispatch delay	9 (0.6%)		106 (1%)		0.17
Response delay	68 (5%)		547 (5%)		0.52
On-scene delay	63 (4%)		617 (6%)		0.03
Transportation delay	33 (2%)		283 (3%)		0.42

IQR, interquartile range.

"other" ethnicities faced higher odds of both dispatch and response delays, with patients of lower acuity (green) more likely to experience dispatch delay but less likely to encounter on-scene delay compared to critical (red) cases, and female patients exhibiting higher odds of transportation delay than male patients, along with older patients having increased odds of transportation delay compared to younger patients.

DISCUSSION

Our study clarifies the disparities in response times and delays of EMS between rural and urban settings for pediatric poisoning events. Pediatric poisoning events are more prevalent in rural communities and have both short- and long-term impacts on pediatric health outcomes.[3,15,16] Our study's findings highlight the challenges rural communities face in accessing timely emergency care for pediatric poisoning patients. Rural communities often face challenges such as longer transportation distances and limited healthcare resources, exacerbating health outcomes. In our study we found that pediatric poisoning patients transported by rural EMS agencies experienced a longer time prior to hospital arrival compared to those transported by urban agencies, with no difference in the incidence of delays.

Pediatric patients transported by rural EMS agencies experienced longer intervals before reaching a hospital than those transported by urban agencies. These delays could lead to worsened patient outcomes, both short and long term.[16] The findings are consistent with a previous study, which noted rural EMS agencies required longer response times compared to urban agencies, often performed less advanced cardiopulmonary resuscitative efforts, and the patients were presumably alive or having a return of circulation after a cardiac arrest.[17] Moreover, rural communities face socioeconomic disadvantages due to a focus on agriculture work and decreased population. The decreased socioeconomic status of a county increases delays in EMS response, primarily due to the lack of nearby hospitals caused by financial instability within these communities, thus increasing transportation delays.[18] In addition, these time disparities may exacerbate the potential health outcome disparity experienced by pediatric poisoning patients' transport to urban pediatric specialty care EDs compared to rural EDs. The limited in-hospital expertise combined with added prehospital time are two additional barriers to optimal care. As supported by previous studies, our findings are applicable internationally.[19]

Furthermore, in our secondary analysis we investigated demographic variations related to EMS delays. Non-Hispanic Black and Hispanic patients had increased occurrences of on-scene and response delays yet experienced shorter time prior to the hospital arrival. An article by Young articulates

Table 2. Multivariate analysis of time prior to arriving at the hospital by patient characteristics (n=11,911).

	Total time prior to hospital (Minutes)	
Variable	Coefficient (95% CI)	*P*-value
EMS agency location		
Urban	Ref.	
Rural	6.6 (5.2, 8.0)	<0.001
Age (years)	-0.4 (-0.5, -0.3)	<0.001
Sex		
Male	Ref.	
Female	1.8 (0.9, 2.8)	<0.001
Race and ethnicity		
Non-Hispanic White	Ref.	
Non-Hispanic Black	-3.2 (-4.3, -2.0)	<0.001
Hispanic	-2.6 (-4.0, -1.2)	<0.001
Other	-0.4 (-2.2, 1.4)	0.67
Acuity		
Critical – red	Ref.	
Emergent – yellow	6.2 (4.3, 8.2)	<0.001
Lower acuity – green	5.6 (3.6, 7.5)	<0.001
Transported by air	68.5 (65.0, 72.1)	<0.001

CI, confidence interval; *EMS*, emergency medical services; *Ref*, reference.

shorter EMS response times but longer ED lengths of stay for Hispanic farmers.[20] Black patients were shown to have shorter response times among EMS, specifically for cardiac arrest yet were more likely to be deceased upon EMS arrival compared to non-Hispanic Whites.[21] Pediatric poisoning patients with lower acuity levels were disproportionately affected by dispatch delays and increased EMS time-to-hospital arrival compared to critical acuity patients. The EMS dispatchers require increased time to determine the acuity with lower acuity patients or higher acuity patients.[22]

Efforts to mitigate EMS delays should incorporate multifaceted strategies, including recruitment of EMS personnel and addressing financial deficiencies in rural programs. This would allow for better compensation of prehospital professionals such as EMS personnel, thus attracting more people to the position, and for contributions to better training and education for trainees hoping to practice in rural areas. Other methods of improvement of response times include focused training including route optimization in rural areas, improvement of coordination with dispatch centers, cultural competence and community relations, and better prehospital assessment and stabilization training. This improvement will better suit EMS personnel in their efforts to benefit response time and reduce delays. Improving community systems and streamlining dispatch processes can reduce response times and optimize rescue utilization.

Table 3. Multivariate analysis of different emergency medical services delays by patient characteristics (n=11,911).

	Dispatch delay	Response delay	On-scene delay	Transportation delay
Variable	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
EMS agency location				
Urban	Ref.	Ref.	Ref.	Ref.
Rural	0.8 (0.4, 1.7)	0.9 (0.7, 1.2)	0.8 (0.6, 1.0)	0.9 (0.6, 1.3)
Age (years)	0.98 (0.95, 1.01)	1.01 (0.99, 1.02)	0.99 (0.84, 1.16)	0.97 (0.95, 0.99)**
Sex				
Male	Ref.	Ref.	Ref.	Ref.
Female	1.0 (0.7, 1.5)	1.1 (0.9, 1.3)	1.0 (0.8, 1.2)	1.6 (1.2, 2.1) ***
Race and ethnicity				
Non-Hispanic White	Ref.	Ref.	Ref.	Ref.
Non-Hispanic Black	4.6 (3.0, 7.1) ***	1.5 (1.2, 1.8)***	1.2 (1.0, 1.5)*	1.1 (0.8, 1.4)
Hispanic	1.5 (0.8, 3.0)	1.4 (1.1, 1.8)**	1.4 (1.2, 1.8)***	1.3 (1.0, 1.8)
Other	2.6 (1.3, 5.3)**	1.7 (1.2, 2.2)***	1.2 (0.9, 1.7)	0.8 (0.5, 1.3)
Acuity				
Critical – red	Ref.	Ref.	Ref.	Ref.
Emergent – yellow	1.6 (0.5, 5.3)	1.0 (0.7, 1.4)	0.6 (0.5, 0.9)**	0.8 (0.5, 1.2)
Lower acuity – green	3.4 (1.0, 11.0) *	1.0 (0.7, 1.4)	0.7 (0.5, 0.9)**	0.8 (0.5, 1.3)
Transported by air	1.9 (0.5, 8.4)	1.3 (0.7, 2.3)	1.1 (0.6, 2.0)	0.5 (0.2, 1.6)

Significance levels (*, *P*=<0.05; **, *P*=<0.01; ***, *P*=<0.001)
CI, confidence interval; *OR*, odds ratio; *Ref*, reference.

The Joint Committee on Rural Emergency Care proposes expanding transportation methods, integrating EMS with community healthcare, and enhancing workforce training.[23] The National Advisory on Rural Health and Human Services aims to increase timely access to care by reducing response times, improving training and recruitment, and expanding telehealth services.[24] Recent studies suggest policy changes to extend transport cutoff times for pediatric trauma patients to Level I pediatric trauma centers.[25] These initiatives promise timely emergency care access, particularly benefiting pediatric patients, and provide opportunities for quality improvement with rural healthcare delivery to enhance outcomes.

Additionally, this article lays the foundation for future research endeavors. As our study broadly includes any substance that can incite a poisoning event, specific toxidromes and their effects on the body are not explored. Further research must be conducted to determine outcomes of delayed treatments in specific poisoning events and means to address these disparities in rural areas so that treatment may become more equitable. Moreover, additional research investigating the nuance between increased delays yet shorter total times for non-Hispanic Black and Hispanic pediatric patients is warranted.

LIMITATIONS

Limitations of our study include the inability to verify the accuracy of the information included in the NEMSIS by the reporting EMS agencies. The NEMSIS receives information via voluntary submission by EMS agencies. The exclusion of pediatric patients who suffered a poisoning event but were not transported by EMS or who died prior to arrival at a hospital or ED presents a selection bias and may affect the generalizability of the information provided. This may cause an underestimation of the severity and true incidence of pediatric poisoning events and skew the data toward less severe cases. The data also does not capture patient outcomes, such as length of stay or specific resuscitation efforts.

The lack of granular data input into the NEMSIS database results in a small, unreliable sample. Due to this, we were unable to determine whether the initial poisoning event was intentional or unintentional. Although various forms of poisoning events were evaluated, there was no inclusion of specific poisons. Finally, the data did not include any follow-up information after patients were admitted to a hospital, preventing the analysis of hospital outcomes. The practice of EMS is expected to progress and introduce advancements in care that may produce additional confounding variables and alter the interpretation of the information presented in this article.

CONCLUSION

Our study underscores a disparity in prehospital response times between rural and urban communities for pediatric poisoning events, highlighting an area of inequality to address within rural settings. This study provides insight into further research areas to investigate the clinical significance and potential outcome disparities associated with the added prehospital time. Efforts to mitigate EMS delays should encompass various strategies, including equitable resource allocation and enhanced training programs. Collaborating with stakeholders can help overcome systemic barriers. Advancing our understanding of prehospital care can ensure equitable access to emergency medical services for all pediatric patients. Future research should explore additional factors influencing EMS response times, including socioeconomic factors and healthcare infrastructures, through longitudinal studies. This ongoing research can inform evidence-based practices and policies, with the goal of equitable access to timely emergency services and safeguarding the health of youth in rural and urban communities.

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Predictive Factors and Nomogram for 30-Day Mortality in Heatstroke Patients: A Retrospective Cohort Study

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Objective: Heatstroke (HS) is a severe condition associated with significant morbidity and mortality. In this study we aimed to identify early risk factors that impacted the 30-day mortality of HS patients and establish a predictive model to assist clinicians in identifying the risk of death.

Methods: We conducted a retrospective cohort study, analyzing the clinical data of 203 HS patients between May 2016–September 2024. The patients were divided into two groups: those who had died within 30 days of symptom onset; and those who had survived. We analyzed the risk factors affecting 30-day mortality. A nomogram was drawn to visualize the clinical model. We used the receiver operating characteristic (ROC) curve and calibration curve to verify the accuracy of the nomogram. A decision curve analysis was also performed to evaluate the clinical usefulness of the nomogram.

Results: Within a 30-day period, 57 patients (28.08%) died. The APACHE II score, the ratio of lactate-to-albumin (LAR), and the core temperature at 30 minutes after admission were independent risk factors for death of HS patients at 30 days. The area under the ROC curve (AUC) for predicting mortality based on the APACHE II score was 0.867, with a sensitivity of 96.5% and a specificity of 61.6%. Moreover, the AUC for predicting mortality based on the LAR was 0.874, with a sensitivity of 93.0% and a specificity of 77.4%. The AUC based on the core temperature at 30 minutes after admission was 0.774, with a sensitivity of 70.2% and a specificity of 78.8%. Finally, the AUC for predicting death due to HS using the combination of these three factors was 0.928, with a sensitivity of 82.5% and a specificity of 91.8%. The calibration curve and the decision-curve analysis showed that the new nomogram had better accuracy and potential application value in predicting the prognosis of HS patients.

Conclusion: A nomogram with these three indicators in combination—APACHE II score, lactate-to-albumin ratio, and core temperature at 30 minutes after admission—can be used to predict 30-day mortality of heatstroke patients. [West J Emerg Med. 2025;26(3)657–666.]

INTRODUCTION

Heatstroke (HS) is a severe condition associated with significant morbidity and mortality. The clinical syndrome characteristics of HS include the body's inability to regulate temperature due to exposure to high temperatures and/or intense physical activity, resulting in an elevation of core temperature and potentially leading to a life-threatening systemic disorder.[1,2] Misset et al reported that the incidence rate of classic HS during summer heat waves in France is 17.6-26.5/100,000.[3] There is no large-scale HS epidemiology

data in the People's Republic of China to date, since China's territory is vast and the climate varies significantly across different regions. In some areas such as the city mentioned in this study, the highest temperature in summer can maintain above 39°C (102.2°F).

The treatment for HS patients involves controlling body temperature and improving heated-induced organ injuries.[4] It has been found that aggressive treatment can improve the prognosis of patients with mild HS. The in-hospital mortality rate of HS patients was 5% in the United States (US), and patients' race/ethnicity makes no difference in mortality.[2] The mortality rate of exertional HS (EHS) among youth in the US was <5%.[5,6] The crude mortality rate from HS in

Saudi Arabia is 50%. while the mortality rate of HS in other desert climate countries was lower at 5.6%.[8] Severe HS still carries a significant mortality rate, with rates exceeding 40%.[9] This risk is even higher in elderly individuals, where mortality rates can reach up to 50%.[10] Therefore, it is crucial for clinicians to identify HS patients at high risk of death based on early indicators.

There has been some research on the independent risk factors and predictive model for prognosis of HS.[11-14] Zhong et al[11] and Wu et al[12] focused on the risk factors and prediction of mortality from HS. However, their studies concentrated only on male patients. Shao et al[13] and Wei et al[14] also constructed nomograms for predicting survival in HS patients. Nevertheless, their studies were focused solely on the elderly. Hence, it is plausible to suggest that their studies exhibit a potential selection bias. There is no consensus on assessing mortality risk in HS patients during the early stages.

In this study, we looked at HS patients who were admitted to Chongqing Emergency Medical Centre and the Second Affiliated Hospital of Chongqing Medical University. After strictly enforcing the inclusion and exclusion criteria, adult patients 19-89 years of age were enrolled, among whom males accounted for 63.1%. We conducted this retrospective cohort research to analyze data from an eight-year period. Our analyses focused on the clinical characteristics, risk factors, and establishment of a predictive model to facilitate the prediction of mortality in HS patients. The Acute Physiology and Chronic Health Evaluation II (APACHE II) has been extensively validated in intensive care unit (ICU) patients, as a highly reliable prognostic scoring system. Its simplicity, clinical utility, accuracy, and validity make it even more reliable. APACHE-IV was first implemented in 2006, based on data collected from ICU patients in the US,[15] but there have been no reports on its application to HS patients in other countries. We used APACHE II to evaluate the severity and prognosis of HS patients in this study.

Population Health Research Capsule

What do we already know about this issue?
Heatstroke (HS) is associated with significant morbidity and mortality. It is crucial for clinicians to identify HS patients at high risk of death based on early indicators.

What was the research question?
The nomogram in this study improved the accuracy of the 30-day death-risk assessment for HS.

What was the major finding of the study?
The area under receiver operating characteristic curve for predicting death due to HS was 0.928 (95% CI 0.889-0.968, P <0.001) with a sensitivity of 82.5% and a specificity of 91.8%.

How does this improve population health?
Considering that HS can cause multiorgan functional disturbance, this nomogram can be used to identify the patient's risk of death and improve the prognosis.

METHODS

Subjects' Inclusion and Exclusion Criteria

This study included adult patients who were admitted to the hospitals between May 2016–September 2024 and met the diagnostic criteria for HS as defined by the Chinese Expert Consensus on the Diagnosis and Treatment of HS,[16] considering that HS can cause damage to multiple organs and systems. The inclusion criteria were as follows: 1) medical history information: exposure to high temperature or high humidity environments or engaging in high-intensity exercise; and 2) clinical presentations (at least one of the following four): central nervous system dysfunction (such as coma, convulsions, delirium, abnormal behavior); core body temperature exceeding 40 °C; functional impairment of multiple organs (at least two) (such as liver, kidney, striated muscle and gastrointestinal tract); severe coagulopathy; or disseminated intravascular coagulation (DIC). The exclusion criteria were as follows: 1) congenital coagulopathy; 2) severe chronic liver or kidney disease; 3) malignant tumors; 4) septic shock; 5) acute severe viral myocarditis; and 6) thyroid storm. The combination of these diseases increases the patient's risk of death. All patients received Basic Life Support based on their condition, and targeted cooling and organ function support were provided when necessary.

This study was conducted at Chongqing Emergency Medical Centre and the Second Affiliated Hospital of Chongqing Medical University. The former was the primary research unit, the Ethics Committee of which approved the research protocol. Since this study did not involve patient intervention measures, informed consent was waived by the hospital's ethics committee (RS202416).

Data Collection

We collected baseline data from electronic health records, including age, sex, basic diseases, and the condition of the basic diseases prior to the onset of HS through their past medical history. Other recorded baseline data included core temperature (rectal temperature), heart rate (HR), mean arterial pressure (MAP), respiratory rate (RR), Glasgow Coma Scale (GCS) scores,[17] and APACHE II scores[18] at the time of admission. The cooling time, which refers to the time taken to cool the body to a core temperature below 38.5°C, was also recorded.[19] The core temperature measurements were recorded at 30 minutes, two hours, and three hours after admission.

We collected clinical and laboratory data related to organ function, including white blood cells (WBC) and platelets, hemoglobin levels, levels of high-sensitivity C-reactive, alanine transaminase (ALT), aspartate amino transferase, albumin, creatine kinase (CK), myohemoglobin, troponin I, urea nitrogen, creatinine (Cr), blood glucose (BG), and lactic acid. Routine coagulation indicators were recorded, including prothrombin time, activated partial thrombin time, fibrinogen, and D-dimer. and the lactate-to albumin ratio (LAR), calculated with the values of lactate and albumin. The hospital length of stay (LOS) and hospitalization fees were also documented.

Patient records and other information were anonymized and de-identified before analysis.

Statistical Analysis

We used SPSS Statistics 27.0 package (IBM Corp, Armonk, NY) for data analysis. Continuous variables are presented as mean values with their respective minimum and maximum ranges, or as mean ± standard deviation. Count and rank data were standardized and reported as medians and interquartile ranges. To compare count data among multiple independent samples we used the Kruskal-Wallis H test and the nonparametric Mann-Whitney U test to compare count data among multiple independent samples and two sets of measurement data, respectively. Statistical significance was determined by a *P*-value <0.05. A Cox regression model was established with the occurrence of 30-day death caused by HS as the dependent variables, with 17 indicators as the independent variables. Indicators already included in the APACHE II were not analyzed separately. We used a stepwise method to screen independent variables to identify which indicators had an impact on the 30-day prognosis of HS patients.

Risk factors were subsequently included in the multifactor Cox regression model. We developed a nomogram based on logistic regression to assess the impact of independent risk factors on clinical prognosis significance. The logistic regression model was established with the "lrm" function in the rms package R 4.2.1 language (R Foundation for Statistical Computing, Vienna, Austria), and we used the "plot" function to draw the nomogram. The ROC curve, calibration curve, and decision curve were used to evaluate the accuracy and clinical prediction efficiency of the nomogram.

RESULTS

General Information of Enrolled Patients

Among of the initial group of 257 patients with HS, some were excluded during the enrollment process. Specifically, 21 patients were screened out due to the absence of clinical data or insufficient quantifiable results. We also excluded seven patients who were <18 years of age. Furthermore, seven patients who were transferred to another facility before the completion of initial evaluation were lost to follow-up. It is worth noting that three patients experienced a hyperthyroidism crisis, while seven patients developed septic shock. Moreover, four patients were diagnosed with malignant tumors, and five others had severe viral myocarditis (Figure 1). Among 203 patients, there were 57 non-survivors (28.08%). We found no significant differences between the non-survivor and the survivor groups in terms of sex distribution, age, the time from onset to treatment, and underlying diseases. Among enrolled patients, 102 patients had classic heat stroke (CHS), while 101 patients had exertional HS; the non-survivor group had a higher proportion of CHS compared to the survivor group. The average time from onset to treatment was 8.29 hours, with a range of 0.5-73 hours (Table 1).

The average core temperature at admission was 39.09±1.77°C, with the highest core temperature recorded at 42.0°C. The non-survivor group had higher core temperatures within three hours of admission compared to the survivor group. The average cooling time was 3.13 hours. There were no significant differences in cooling time between the two groups, which was inconsistent with a previous study,[7] perhaps due to the death of some patients before their core temperature reached 38.5°C in our study. The mean HR was 118.5±31.51 beats per minute (min), the mean RR was 25.04±6.60 breaths/

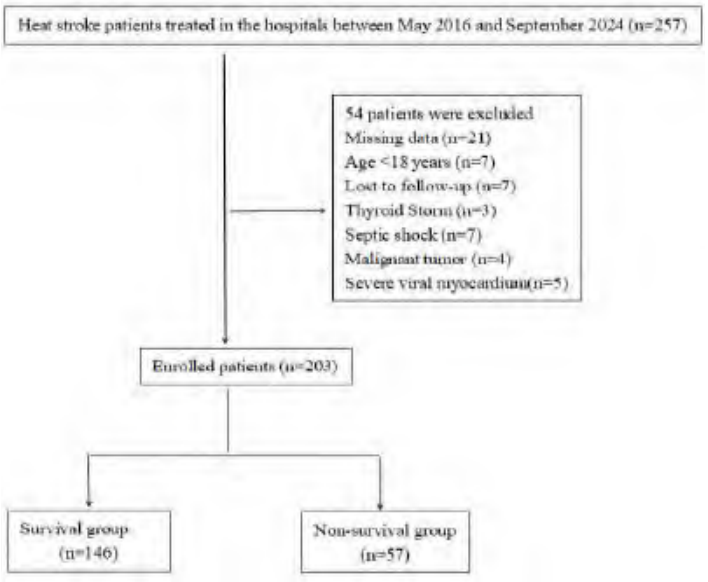

Figure 1. Flow chart of patient enrollment.

Table 1. Characteristics between survivor and non-survivor groups of patients with heatstroke at admission.

	Total	Survivors	Non-survivors	P-value
	(N=203)	(n=146)	(n=57)	
Male	128(63.1%)	95(65.1%)	33(57.9%)	0.34
Female	75(36.9%)	51(34.9%)	24(42.1%)	
Age (years)	56.31±16.45	55.36±16.55	58.75±16.08	0.19
Classic Heat Stroke	102(50.25%)	66(45.21%)	36(63.16%)	0.02
Exertional Heat Stroke	101(49.75%)	80(54.79%)	21(36.84%)	
Time from onset to treatment (hours)	8.29(0.5,73)	9.11 (0.5,73)	6.19(1,24)	0.45
Underlying disease	131(64.53%)	92(63.01%)	39(68.42%)	0.47
Temperature at admission (°C)	39.09±1.77	38.61±1.55	40.32±1.69	<0.001
Heart rate (per minute)	118.47±31.51	111.92±28.95	135.25±31.81	<0.001
Mean arterial pressure (mmHg)	82.87±21.62	89.00±16.94	67.18±24.38	<0.001
Respiratory rate (per minute)	25.04±6.6	22.96±5.16	30.37±6.92	<0.001
Temperature at the 30 mintess after admission (°C)	38.77±1.73	38.28±1.45	40.02±1.77	<0.001
Temperature at 2 hours after admission (°C)	38.37±1.53	37.96±1.26	39.43±1.66	<0.001
Temperature at 3 hours after admission (°C)	37.97±1.36	37.57±1.07	38.99±1.50	<0.001
Cooling time (hours)	3.13(0,48)	3.17(0,48)	3.01(0,10)	0.15
White blood cell count (10^9/)	14.01(1.23,40.23)	13.56(3.49,36.57)	15.16(1.23,40.23)	0.06
Hemoglobin (g/L)	119.05(23,450)	119.79(66,181)	117.14(23,450)	0.12
Platelets (10^9/L)	91.74(9,461)	88.68(9,461)	99.58(9,342)	0.61
Hs-CRP (mg/L)	38.57(0.1,200)	33.42(0.1,200)	51.76(0.5,200)	0.06
APTT (s)	49.55(18.4,183)	47.02(18.4,183)	56(29.2,106.1)	0.13
PT (s)	19.73(12,120)	18.02(12.5,90.2)	24.09(12,120)	0.21
Fibrinogen (g/L)	2.96(0.3,10.32)	2.69(0.3,6.14)	3.65(1.02,10.32)	0.05
D-dimer (ug/ml)	7.89(0.1,33)	7.17(0.1,33)	9.75(0.2,30)	0.98
Serum creatinine (umol/L)	158.39(1.36,1204.7)	128.96(12.78,1204.7)	233.76(1.36,894.5)	<0.001
Lactate (umol/L)	6.8(0.25,25)	4.72(0.25,25)	12.15(2.56,25)	<0.001
Blood glucose (mmol/L)	12.04(3.6,167)	10.54(3.6,36.7)	15.88(5.1,167)	0.09
AST (U/L)	249.04(13,3800)	230.95(13,3738)	295.39(19,3800)	0.70
ALT (U/L)	168.3(7,3628)	173.35(7,3628)	155.35(8,1561)	0.71
Albumin (g/L)	33.74(16.1,49.7)	34.01(16.1,44.2)	33.04(20.2,49.7)	0.13
CK (U/L)	737.99(12,15360)	803.06(12,15000)	571.34(12,15360)	0.78
Myoglobin (ng/mL)	1132.75(2.6,36125)	1115.06(2.6,36125)	1178.08(66,36024)	0.65
Troponin I (ng/L)	43.01(0.01,1001)	47(0.01,1000.1)	32.8(0.01,1001)	0.63
Lactate/albumin ratio (umol/g)	0.2(0.01,0.85)	0.13(0.01,0.73)	0.38(0.07,0.85)	<0.001
GCS score	8.07(3,15)	8.73(3,15)	6.37(3,15)	<0.001
APACHE II score	20.17(5,48)	16.46(5,37)	29.67(16,48)	<0.001
Hospital length of stay (days)	6.2(0.04,29)	6.82(0.29,27)	4.64(0.04,29)	0.06
Hospitalization fee (US dollars)	2,354(155,2,1706)	2,109(155,11,579)	3,116(305,21,706)	0.00

Hs-CRP, hypersensitive C-reactive protein; *APTT*, activated partial thromboplastin time; *PT*, prothrombin time; nine; *AST*, aspartate aminotransferase; *ALT*, alanine aminotransferase; *CK*, creatine kinase; *GCS*, Glasgow Coma Scale; *APACHE-II*, Acute Physiology and Chronic Health Evaluation.

min, and the MAP was 82.87±21.62 millimeters of mercury mmHg. The patients who died had higher HR, RR, and lower MAP than those of survivors (Table 1).

The non-survivor group also showed more severe damage to renal function at admission, with higher levels of Cr compared to the survivor group. There were no significant differences between the two groups in terms of liver function, coagulation, cardiovascular system damage, and respiratory function. The non-survivors did not have increased levels of WBC, platelets, MB, Hs-CRP, and BG, and had increased levels of lactate, Cr, the LAR, and higher APACHE II score. The APACHE II scores including the GCS scores in the non-survivor group were higher than those in the survivor group. The GCS scores in the survivor group were higher than the non-survivor group in this xstudy, which was consistent with a previous study.[20] The GCS score alone is insufficient for assessing the condition because it is an assessment of the level of consciousness and does not reflect other neurological manifestations such as transient convulsions, which occurred in some patients prior to admission.[21]

The average LOS was 6.20 days, and there was no significant difference between the two groups. The mean hospitalization fee was $2,354.32 USD, and the hospitalization cost was higher in the non-survivor group compared to the survivor group.

Predictive Factors and Nomogram for 30-Day Mortality in Heatstroke Patients

Predictive Factors in HS Patients' Mortality

The results showed that the independent risk factors affecting the mortality of HS patients were the core temperature at 30 minutes after admission, the APACHE II score, and the LAR. Each unit of increase in core temperature at 30 minutes after admission, APACHE II score, and LAR was associated with a 1.639-fold, 1.102-fold, 12.772-fold increased risk of death in patients of HS, respectively (Table 2). To verify the association between independent risk factors and the risk of death caused by HS, the patients were divided into two groups based on APACHE II scores, LARs, and core temperatures at 30 minutes after admission. The difference in the 30-day mortality based on different APACHE II scores also showed a statistically significant difference (chi square 53.85, $P < 0.001$) (Figure 2). There was a significant difference in 30-day mortality between patients with a LAR ≥0.160 and those with a LAR <0.160 (chi square 91.32, $P < 0.001$) (Figure 2). The difference in the 30-day mortality based on different core temperatures at 30 minutes after admission was statistically significant (chi square 39.09, $P < 0.001$).

Nomogram for 30-Day Mortality in Heatstroke Patients

Since these three indicators were identified as independent prognostic factors, they were combined to develop a predictive model for 30-day mortality. The formula for the predictive model was:

Y=-27.681 + 0.155×APACHE II score + 5.143×the LAR (micromoles per gram) + 0.559×T at 30 minutes after admission (core temperature℃)

Each variable in the nomogram has a corresponding score for a line segment. By calculating the total score of each variable for each patient, the probability of predicting the patient's death at 30 days can be obtained (Figure 3). If a patient had an APACHE II score of 15, a core temperature of 39°C at 30 minutes after admission, and a LAR of 0.5, according to the nomogram, the values would be 22 points, 24 points, and 34 points, respectively. So, 80 points in total would be obtained, which corresponds to a mortality risk of 96%. In this way, clinicians could quickly assess that this patient has a 96% risk of dying within 30 days and to plan treatment and monitoring accordingly. The nomogram provides an important foundation for clinical decision-making, enabling clinicians to make more precise judgments in complex situations.

The AUC for predicting mortality due to HS based on the core temperature at 30 minutes after admission was 0.774 (95% confidence interval [CI] 0.694-0.854, $P<0.001$). The optimal cut-off value for this indicator was 39.5℃, with a

Table 2. Risk factors for mortality of heatstroke patients in multivariable Cox regression model.

	HR	HR 95% CI	P-value
APACHE II score	1.102	1.067 ~ 1.139	<0.001
Lac/Alb ratio(umol/g)	12.772	3.934 ~ 41.466	<0.001
T at the 30mins after admission (°C)	1.639	1.338 ~ 2.007	<0.001

APACHE-II, Acute Physiology and Chronic Health Evaluation; *Lac/Alb*, lactate to albumin; *T*, core temperature.

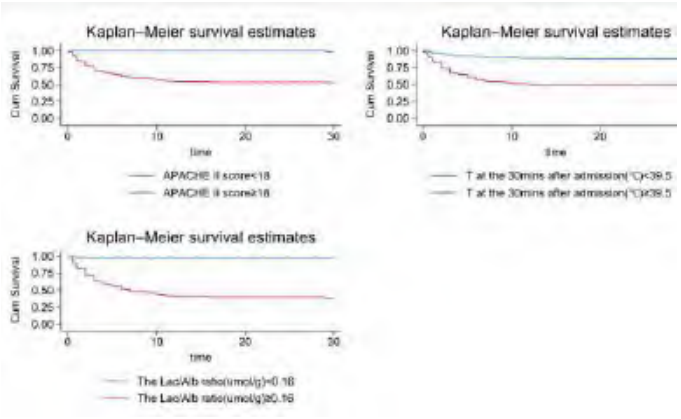

Figure 2. Kaplan-Meier analysis to examine the association of independent risk factors with the risk of death from heatstroke. *APACHE-II*, Acute Physiology and Chronic Health Evaluation; *Lac/Alb*, lactate to albumin; *T*, core temperature.

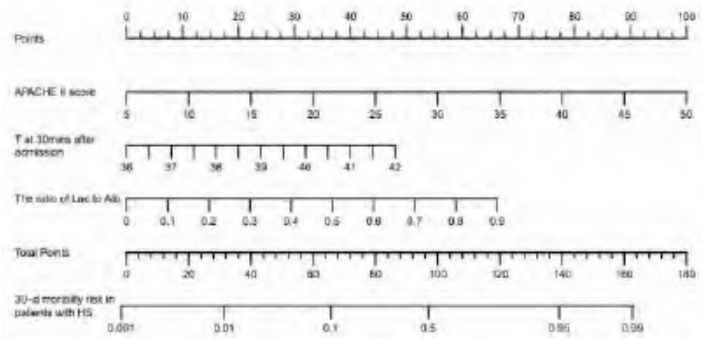

Figure 3. Nomogram model for predicting 30-day mortality risk in patients with heatstroke.
APACHE-II, Acute Physiology and Chronic Health Evaluation**;** *HS*, heatstroke; *Lac/Alb*, lactate to albumin**;** *T*, core temperature.

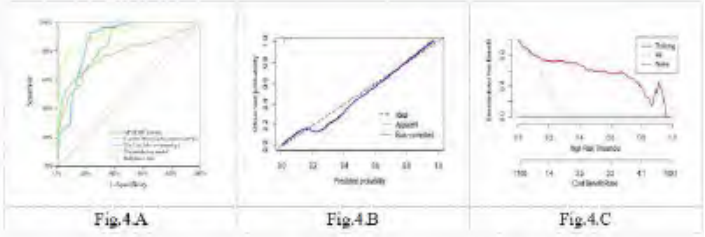

Figure 4. ROC curve, calibration curve, and decision curve of the nomogram.
APACHE-II, Acute Physiology and Chronic Health Evaluation**;** *Lac/Alb*, lactate to albumin**;** *T*, core temperature.

sensitivity of 70.2% and a specificity of 78.8% (Table 3). The AUC for predicting mortality based on the APACHE II was 0.867 (95% CI 0.817-0.916, *P*<0.001), indicating a good predictive accuracy. The optimal cut-off value for this indicator was 18, with a sensitivity of 96.5% and a specificity of 61.6% (Table 3). The AUC for predicting mortality based on the LAR was 0.874 (95% CI 0.827-0.921, *P*<0.001), indicating a high predictive accuracy. The optimal cut-off value for this indicator was 0.160, with a sensitivity of 93.0% and a specificity of 77.4% (Table 3).

The AUC for predicting mortality based on the predictive model combining all three indicators was 0.928 (95% CI 0.889-0.968, *P* < 0.001), indicating a high predictive accuracy. The sensitivity of the model was 82.5% and the specificity was 91.8% (Table 3, Figure 4A). The results of calibration curve analysis showed that the probability of death of HS patients at 30 days predicted by the nomogram was very close to the actual probability (Figure 4B), indicating high accuracy of the nomogram. Decision curve analysis showed that the model had a high net benefit value over the entire threshold probability (Figure 4C). Furthermore, the ROC curve analysis demonstrated that the nomogram had a wide range of cut-off probabilities and showed excellent net benefits for threshold probabilities, indicating the potential clinical utility of the predictive model.

DISCUSSION

The APACHE II scoring system has been widely used to measure severity of disease.[20] It includes 12 points based on physiological parameters, age, and chronic health conditions, and has been applied to assess the severity and prognosis of critically ill patients with various diseases including heart, respiratory, and kidney disease.[22-24] We choose the APACHE II score to evaluate the severity and prognosis of HS, which often involves damage to multiple systems.[14] Previous research has shown that non-survivor HS patients had significantly higher APACHE II scores compared to survivors[25-27] (10 points higher per Wei et al[14]). In our study, we observed that the median APACHE II scores of non-survivors were 13 points higher (*P*<0.001) than those of survivors, indicating a significant difference in disease severity between the two groups. However, when used alone, APACHE II scores may not be able to accurately predict the prognosis for patients with severe HS due to the complex nature of the syndrome involving multiple systems.[28]

Blood lactate levels serve as an indicator of reduced tissue perfusion and cellular hypoxia sensitivity.[29] Elevated lactate levels are often seen in conditions with low perfusion, such as sepsis, shock, and trauma,[30-33] as well as in HS patients,[34-36] potentially due to hypoxia, ischemia, and hypermetabolism.[34,37] In this study, the non-survival group had significantly higher lactate levels compared to the survival group. Many scholars have suggested that hypoalbuminemia can serve as an indicator of the severity of HS, but it is not directly associated with mortality.[38] This study also found that there was no

Table 3. Logistic regression of APACHE II score, lactate-to-albumin ratio, and core temperature at 30 minutes after admission and the predictive model.

	AUC	Sensitivity	Specificity	Cut-off	P	95% CI
APACHE II score	0.867	0.965	0.616	18	0.000	0.817 - 0.916
Lac/Alb ratio (umol/g)	0.874	0.93	0.774	0.16	0.000	0.827 - 0.921
T at the 30 minutes after admission (°C)	0.774	0.702	0.788	39.5	0.000	0.694 - 0.854
The predictive model	0.928	0.825	0.918	-0.534	0.000	0.889 - 0.968

APACHE-II, Acute Physiology and Chronic Health Evaluation**;** *Lac/Alb*, lactate to albumin**;** *T*, core temperature.

statistically significant difference in baseline albumin levels between the two groups of HS patients (P=0.126), which supports the previous findings. Additionally, the LAR has gained attention as a prognostic indicator in critically ill patients reflecting contrasting changes attributed to different mechanisms, with higher ratios indicating a more unfavorable prognosis.[39-42] A higher LAR has been associated with a worsened prognosis in conditions such as sepsis, heart failure, acute pancreatitis, and cirrhosis.[43-46]

A study on pediatric patients with severe sepsis found that the predictive accuracy of the LAR was superior to that of the Lac clearance rate in determining the likelihood of developing multiple organ dysfunction syndrome (MODS) and mortality.[47] The LAR demonstrated superior predictive ability compared to APACHE II in determining the occurrence of MODS and mortality during the early stages of ICU hospitalization of the septic patients.[48] The LARs can be used as early prognostic markers for ICU patients with different initial lactate level and the presence of hepatic or renal dysfunction.[42] It has also been used to predict short- and long-term mortality in critically HS patients,[45] and it has been shown to be an excellent predictive value for myocardial injury in the elderly with severe community-acquired pneumonia.[33] Thus, we chose the LAR as an indicator to evaluate the risk of 30-day death in HS patients in this study. And ROC curve analysis showed that it could be used to determine the prognosis of the disease. Overall, blood lactate levels and the LAR serve as important indicators for assessing disease severity and predicting prognosis in HS patients.

Some research has found that the mortality of HS is significantly affected by the degree and duration of high core temperature. The first 30 minutes after HS onset, also known as the "golden window," is crucial for the outcome of HS.[16,49-51] Due to variations in the time from onset to hospital admission and potential inaccuracies in patient reports, we selected the core temperature at 30 minutes after admission as the golden window for HS in this study. This study demonstrated that the core temperature at 30 minutes, two hours, and three hours after admission all showed an association with HS mortality (Figure 5). Furthermore, the core temperature at 30 minutes after admission had the highest correlation with mortality , even after accounting for confounding factors. The higher the body temperature at the golden window correlated with the greater risk of death. Therefore, it was feasible to use the core temperature at 30 minutes after admission as an indicator to assess the risk of death. Armstrong and Casa have suggested that patients had a higher chance of survival if their core temperature was reduced to below 40.0°C within 30 minutes,[50,51] while Heled indicated that it should be reduced to below 40.5°C.[49] In China, expert consensus recommends reducing it to below 39.0°C within 30 minutes.[16] In this study we found a lower risk of death when the core temperature at 30 minutes after admission was below 39.5°C.

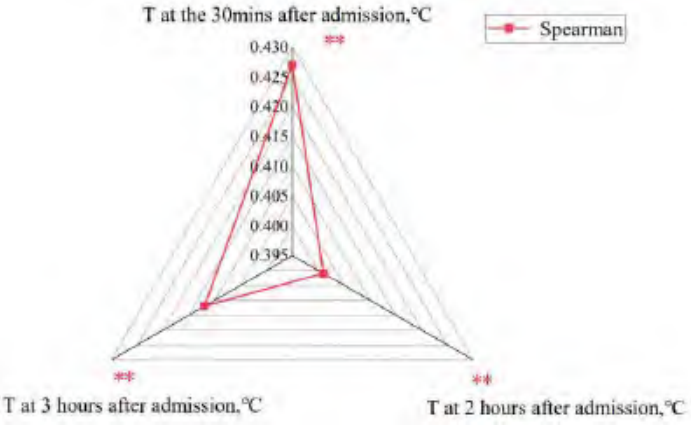

Figure 5. Correlation analysis of core temperature at different times after admission and heatstroke mortality.
T, core temperature.

In this study, the mortality rate of HS patients was 28.08%. The APACHE II score, the LAR, and the core temperature at 30 minutes after admission were found to be significant independent risk factors for mortality of HS patients. The higher the APACHE II score, LAR, and core temperature at 30 minutes after admission the higher the 30-day mortality rate will be in HS patients. These factors were used in a combined model for predicting 30-day mortality in HS patients. We conducted the ROC curve analysis to evaluate the predictive accuracy of the combined model and the three indicators used independently. The results showed that the predictive nomogram had a significantly higher AUC compared to the three indicators used independently, indicating better sensitivity and specificity of the predictive nomogram. We used the ROC curve and the calibration curve to verify the accuracy of the nomogram, and we also performed the decision curve analysis to evaluate the clinical usefulness of the nomogram.

The APACHE II score and LAR can be used in combination to evaluate the prognosis of other diseases such as septic shock, acute severe pancreatitis, heart failure, etc. We used core temperature at 30 minutes after admission as a quick preliminary indicator of HS for evaluating the treatment's effectiveness within the initial 30 minutes, deliberately ignoring the comprehensive treatment. Overall, APACHE II score, LAR, and core temperature at 30 minutes after admission served as important independent risk factors for predicting 30-day mortality in HS patients. The combination of these factors in a predictive model can provide clinicians with valuable information in assessing the criticality of patients' conditions and predicting mortality risk. Compared with the traditional scoring system, the new nomogram in this study improved the accuracy of the death risk assessment for HS. In clinical practice, the HS patient's risk of mortality could be rapidly evaluated by this nomogram during early admission stages, which could help provide guidance for their subsequent clinical care.

As we mentioned previously, our study was not the first to use a nomogram in an attempt to predict the mortality of HS patients. Zhong et al[11] indicated that the duration of cooling, HR at admission, and Sequential Organ Failure Assessment score are independent risk factors for death. However, it was important to note that the subjects of that study consisted solely of young adult males (19-27 years of age, mean 21).Wu et al[12] confirmed that DIC, temperature, and GCS score were independent risk factors for death from exertional HS. The main subjects of the study were predominantly males (95.2%), and the possibility of selective bias also existed. Shao et al[13] and Wei et al[14] also constructed impressive nomograms for predicting survival in HS patients. Shao's nomogram was based on WBC, Cr, ALT, maximum HR, invasive ventilation, and initial MAP and GCS score. Wei's nomogram was based on neutrophil/lymphocyte ratio, platelet, troponin I, CK myocardial band, lactate dehydrogenase, human serum albumin, D-dimer, and APACHE-II scores. Both focused on elderly patients and paid no attention to the importance of early cooling treatment for the prognosis of HS.

Our nomogram has its own advantages. First, our study was conducted at two large, tertiary teaching hospitals, which made it possible for us to enroll more patients than in the previous studies. The gender and age distribution of our patients were more evenly distributed, and efforts were made to minimize the occurrence of selective bias. Then in addition to the APACHE II score, which is a classical mortality risk assessment system, we included two other indicators in the nomogram. The LAR is easily obtainable and can provide valuable information in evaluating the risk of HS-related mortality credited with different mechanisms. The core temperature at 30 minutes after admission considers both the severity of the patient's condition at admission and the effect of cooling treatment on the prognosis. Thus, compared with previous research, this study provides a more objective and in-depth nomogram.

LIMITATIONS

This study has several limitations that should be acknowledged. Firstly, the study was conducted in China, and HS was diagnosed according to the Chinese Expert Consensus on the Diagnosis and Treatment of HS. The following conditions were included in the diagnosis: the functional impairment of at least two of four organs (liver, kidney, striated muscle, and gastrointestinal tract); and severe coagulopathy or DIC, which are not included in the Bouchama HS criteria[52] widely used in western countries. Secondly, due to sample loss and data loss, this study might not be sufficient to provide robust and reliable conclusions. Further research is needed to validate and refine the predictive model, including external validation in diverse healthcare settings in other countries.

CONCLUSION

In this study we identified the APACHE II score, core temperature at 30 minutes after admission, and the lactate-to-albumin ratio as significant independent predictors of 30-day mortality in heatstroke patients. The combination of these three indicators demonstrated the best sensitivity and specificity in predicting mortality. Further research is required, specifically studies of different countries with larger sample sizes, to validate these results and enhance the accuracy of the predictive model. Considering that HS itself can cause multiorgan functional disturbance, we inferred that this conclusion might be applicable globally.

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Association of Heat Index and Patient Presentation Rate at a Stadium

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Introduction: A mass gathering is defined as an event that has the potential to strain the resources of the local health system. An onsite physician for mass gatherings can mitigate the strain on the local health infrastructure. One factor affecting onsite medical usage and patient presentation rates is the heat index, which is a calculated value of perceived heat exposure that combines air temperature and relative humidity. In this study we asked whether there was a positive association between heat index and patient presentation rates for onsite medical care at a bounded (large event in an enclosed location) professional stadium sporting event. We hypothesized that a positive correlation exists between these two variables and assess whether it might surpass current onsite resources.

Methods: We performed a prospective observational study with patients seeking medical care at a baseball stadium in a large northeastern city in the United States. The onsite physician collected information on patients who presented during games held at the stadium. Data on game attendance, temperature in degrees Fahrenheit (F), humidity, and heat index were collected using government and professional organization websites. We assessed the correlation between heat index and patient presentation rate with the Pearson product-moment correlation (PPMC) per 100,000 attendees at the game.

Results: A total of 81 baseball games occurred at the studied stadium from April–September 2023, with eight games excluded due to incomplete data. The heat index ranged from 46°F to 91°F, with a mean (± SD) of 70.8°F (± 10.4°F). The number of patients varied from 0-5 per game, with a mean of 1.92 (± 1.13), and stadium attendance ranged from 25,007 to 47,295, with a mean of 40,824. The patient presentation rate per 100,000 in attendance was 5.04 (± 2.13). The PPMC was calculated to be 0.37 ($P < .01$), indicating a positive correlation between heat index and patient presentation rates. The most common reasons for seeking medical care were lightheadedness and musculoskeletal complaints.

Conclusion: In this study we found that the heat index was moderately associated with higher patient presentation rates at bounded mass gathering baseball events. No additional resources were needed, but this correlation could aid future event medical planning efforts as the climate continues to evolve. [West J Emerg Med. 2025;26(3)667–673.]

INTRODUCTION

A mass gathering is defined as an event that has the potential to strain the resources of the local health system or community.[1-4] Understanding patient presentation rates and etiologies at mass gatherings is essential for maximizing the efficient use of resources and onsite health services, and for activating ambulance services. Effective preparedness for mass gatherings can minimize delays to definitive care and alleviate the burden on local hospitals' resources that would otherwise result from the mass gathering by staffing and planning for predictable health risks, such as heat-related illness.[5-8] Furthermore, data collected from onsite medical care can inform public health surveillance efforts, enabling local emergency departments and 9-1-1 systems to anticipate resource needs and coordinate mutual aid staffing, especially in similarly sized events that may not have onsite medical staffing. Some states have legislated certain regulatory criteria for providing healthcare services at such events to ensure sufficient mass-gathering medical care. In New York State, for example, any event with greater than 5,000 attendees requires a physician to be available within 15 minutes, while events with greater than 30,000 attendees require a physician onsite.[9]

Event physicians can enhance the medical care given by prehospital personnel by providing on-scene medical direction and offering independent and complex medical decision-making, including the ability to return participants safely to the event without unnecessary transport.[10] For those who may require medical evaluation, the onsite physician can determine the most optimal transport mode or even consent for an "against medical advice" decision, if appropriate.[11] This allows for optimizing transport resources and minimizing the impact on local ambulance services and emergency departments.[10] Event physicians may also have prehospital training, encompassing mass casualty triage and familiarity with the incident command system, to effectively manage a sudden surge of patients.[11] The exact role also varies based on the event and distance to definitive care. Events located hours from the closest hospital require more extensive onsite medical care to return participants to the event and conserve medical transport resources due to long turn-around times.

Most mass gathering literature defines three domains impacting healthcare at events.[12] These include biomedical (spectator demographics and health status), psychosocial (crowd behavior, culture, reason for attendance), and environmental (characteristics of venue, weather, presence of drugs or alcohol). The biomedical domain includes the principles of patient presentation rates (PPR) and transfer to hospital rates (TTHR).[13-14] The PPR provides insight into the utilization of onsite health services and refers to the number of attendees who present requesting onsite medical care, while TTHR provides information on prehospital ambulance transports out of the venue. On occasion, patients may refuse ambulance services and elect to self-transfer. This is known as the self-transfer to hospital rate (STHR), which is defined as the number of patients who present for medical attention and elect to go to a hospital by private means. The total number of patients who present to local hospitals for medical care by any means is known as the referred to hospital rate (RTHR).[14]

Population Health Research Capsule

What do we already know about this issue?
Heat increases medical needs at mass gatherings, but data on heat index and its impact on patient presentation rates (PPR) is limited.

What was the research question?
Is there a positive association between heat index and PPR at a bounded professional baseball stadium event?

What was the major finding of the study?
For every 10°F rise in heat index, PPR rates increased by 1.46 per 100,000 attendees ($r = 0.37$, $P < .01$).

How does this improve population health?
These findings help optimize medical staffing at bounded mass gatherings, ensuring sufficient resources as climate change increases heat-related health risks.

Prior research on PPR has produced a wide range of values depending on the nature of the event. For example, an annual, large outdoor music festival in Austria recorded a median PPR of 12.01 per 1,000 attendees.[15] In contrast, the 2019 Rugby World Cup in Japan reported a considerably lower rate with a PPR of 2.63 per 10,000.[16] The New York State Fair demonstrated an annual PPR of 4.8 per 10,000 attendees.[17] Another study exploring various event types found PPRs per 10,000 to be 4.85 at baseball games, 6.75 at football games, and 30 per 10,000 at rock concerts.[18] At the South Africa FIFA World Cup, the PPR was 6.6 per 100,000.[19]

Heat is one important environmental factor affecting PPR and TTHR, leading to various heat-related illnesses; it is on the rise worldwide.[20-21] This is most accurately captured by the heat index, which is a calculated value of perceived heat exposure, combining air temperature and relative humidity. The heat index can help better stratify the risk of heat-related illnesses.[22] This ranges from mild heat cramps to more severe, life-threatening conditions such as heat exhaustion and heat stroke.[23] Several studies have explored the relationship between PPR and temperature; however, few studies look at PPR in the context of the heat index, which provides a more accurate representation

of heat's effect on the human body.[24-25] Perron et al demonstrated that PPR was tied to the heat index at college football games in the southeastern United States during the fall and winter months.[25] This study examined whether the correlation persists during summer months by analyzing the impact of heat on patient presentation rates and its potential to strain onsite medical resources and local healthcare systems. We hypothesized that a positive correlation exists between PPR and heat index at large baseball events in a bounded stadium in the northeastern US but that this increase in patients would remain within the capacity of onsite resources.

METHODS

This prospective, observational study examined the cases of attendees seeking medical attention during baseball games in a large northeastern city in the US. These games took place outdoors in a bounded stadium with ticketed seats. The stadium has open-air seating and limited natural shade with much of the seating areas exposed. The region's climate is characterized as humid subtropical with summer temperatures reaching as high as 100° Fahrenheit (F).[26] The stadium in this study can accommodate 47,309 spectators.

We collected data during regular season games at the stadium between April–September 2023. Patrons could self-present or be brought by emergency medical technicians (EMT) via mobility assist devices and were met by the paramedic supervisor at the front of the medical office. We excluded patrons who self-presented to the medical office solely asking for over-the-counter items such as bandages, acetaminophen, or non-steroidal anti-inflammatory drugs. We included only individuals with acute medical complaints who were then directed for evaluation by a physician. To prevent bias and capture cases of occult heat illness, exacerbations of chronic illness due to heat, and potential sequelae from heat-related crowd behavior, we included all medical complaints.

At these events, the responsibility of the onsite physician was to assess the patient, provide initial stabilization, and determine the need for ambulance transport to a nearby hospital. The onsite physician was an emergency physician with medical command training from the surrounding area. The onsite physician gathered data during home games, using Research Electronic Data Capture (REDCap) tools hosted at the Maimonides Medical Center to record patient information such as age, sex, chief complaint, treatments administered, physician diagnosis, and disposition. Non-physician staffing included one EMS supervisor, two paramedics, five EMTs, and one dedicated transport unit. The EMTs were dispersed throughout the crowd to help facilitate patients in reaching the medical office and then returned to continue crowd surveillance after patient handoff.

We obtained the total number of attendees at each game from Baseball-Reference.com. Temperature and humidity data was obtained from Time and Date AS (Stavanger, Norway), with the game start time as the reference point. We then used this data to calculate the heat index using the US National Oceanic and Administration Weather Prediction Center (College Park, MD). Results are reported with descriptive and quantitative statistics. The correlation between heat index and patient presentation rate was assessed with the Pearson product-moment correlation (PPMC). The PPMC is a statistical tool that we used to control stadium attendance as a contributing factor to the overall number of patients seen; we assessed for a positive correlation between the heat index and the ratio of the number of patients cared for per 100,000 attendees at the game. In addition, we performed chi-squared testing to assess for any statistical difference between sexes and final disposition among the chief complaints and treatments rendered.

RESULTS

A total of 81 home baseball games occurred from April–September 2023, with eight games excluded due to incomplete data from lack of documentation. There were 92 patient encounters among the 2,926,363 total attendees. The heat index ranged from 46°F-91°F, with a mean (±SD) of 70.8°F (± 10.42°F). The number of patients per game varied from 0-5, with a mean of 1.92 (±1.13), and stadium attendance ranged from 25,007 to 47,295. The PPR in our study is defined as the number of patient presentations per 100,000 attendees. The PPR across all games was 5.04 ± 2.13, with the highest PPR in July (6.09 ± 1.66) and the lowest in April (3.19 ± 1.13) (Figure 1).

The average patient age for those seeking medical care was 39.9 years. We calculated the PPMC to be 0.37 ($P < .01$), indicating a moderately positive correlation between heat index and PPR. Our linear equation demonstrated that for every 10-degree increase in heat index, there was a 1.46 increase in the number of patients requiring emergency care per 100,000 attendees (Figure 2).

The mean TTHR was .37 per 100,000 attendees with a peak in June of .60 and a trough in August of .12. The STHR per 100,000 attendees across all games was 0.3 ± 0.6, and our

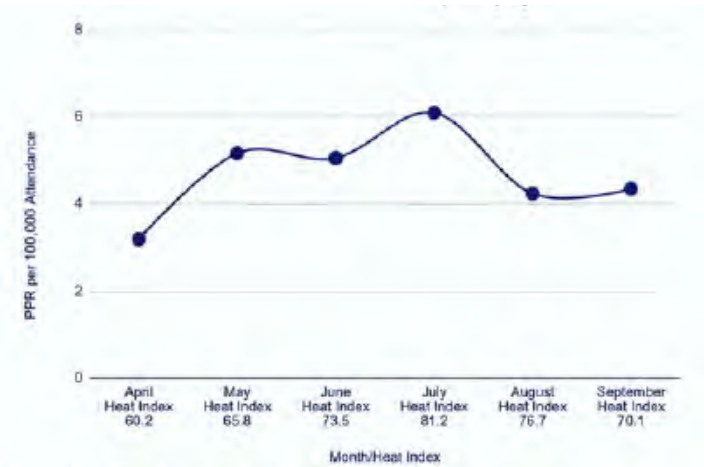

Figure 1, Mean patient presentation rate by month. *PPR,* patient presentation rate.

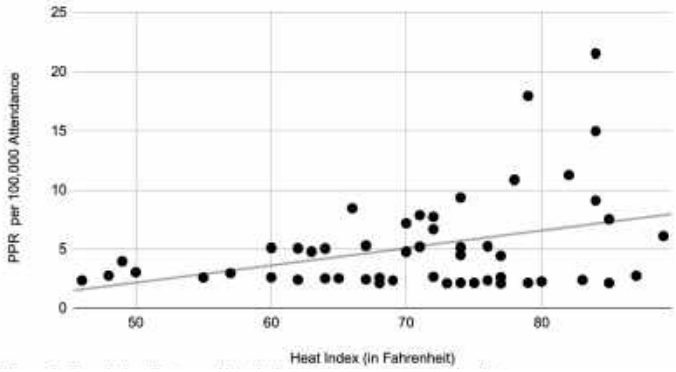

Figure 2. Correlation between heat index and patient presentation rate by degrees in Fahrenheit.
PPR, patient presentation rate.

mean RTHR across all games was .67 ± 0.7 (Table 1).

Chief complaints were broken down by category. Among patients seeking medical attention, the most frequent complaint was musculoskeletal, affecting 31 patients (34%). This was followed by lightheadedness in 24 patients (26%) and nine patients (10%) who were intoxicated. There were no cardiac arrests in this cohort. These chief complaints were comparable in frequency between male and female patients, as well as between patients transported to the hospital vs those who returned to the event (Table 2). A total of 108 treatments were documented across all games because some patients received multiple treatments. The most common treatments included 33 ice packs (31%), 21 (19%) administered NSAIDs or acetaminophen, 12 (11%) miscellaneous, and 11 patients (10%) who received oral fluids. Two patients received an electrocardiogram (2%), and five received intravenous fluids (5%).

Treatments rendered similarly had comparable distributions between sex and final dispositions, and no statistical difference was observed (Table 3). Of all patients who presented, 32 (35%) were referred to the hospital., an average of fewer than one patient per game. Fourteen patients elected to refuse transport by EMS and chose to transport themselves by private vehicle, and 18 (19.2%) who presented for physician evaluation were consequently transported via onsite ambulance. There were zero instances where ambulances from the local 9-1-1 system were needed to transport patients from the event.

DISCUSSION

In this study we examined the correlation between PPR and the heat index at a mass-gathering baseball event. We found a moderate positive correlation between the heat index and PPR. The PPMC was 0.37 ($P < .01$) with a linear equation demonstrating that there was a 1.46 increase in the number of patients presenting for emergency care per 100,000 attendees for every 10-degree increase in the heat index. This could help inform future planning efforts, especially as the host city is projected to have a tripling of days above 90°F by the year 2050.[27] During the study period, there were no instances of outside resources used to render medical aid at the event.

Comparing our event to other mass gatherings is challenging because so many studies depict specific events with unique characteristics. It would be potentially inaccurate to make comparisons to non-sporting events due to different crowd behavior and milieu characteristics. In a study involving spectators at a bounded football game, Perron et al found that for every 10-degree increase in heat index, three more patrons per 10,000 attendees would present for care.[25] Our findings were most similar to the 2010 South Africa World Cup, which shared key characteristics with our event. Both stadium events had ticketed entry, offered alcohol for

Table 1. Medical usage rates by month.

Month	Mean number of patients per game	Mean STHR	Mean TTHR via ambulance	Mean RTHR	Stadium attendance	Mean stadium capacity filled	Mean heat index in degrees Fahrenheit	Mean total patients per 100,000 attendees (PPR)	Mean EMS transports per 100,000 attendees
April	1.27 ± 0.46	0.08 ± 0.44	0.36 ± 0.50	0.44 ± 0.50	39,765 ± 7,106	0.85 ± 0.15	60.2 ± 8.44	3.19 ± 1.13	0.88 ± 1.25
May	2.00 ± 0.69	0.10 ± 0.67	0.21 ± 0.69	0.31 ± 0.82	38,694 ± 2,132	0.83 ± 0.04	65.8 ± 10.31	5.16 ± 1.95	0.55 ± 0.94
June	2.20 ± 1.68	0.11 ± 0.53	0.60 ±0.69	0.71 ± 0.59	43,511 ± 3,311	0.93 ± 0.07	73.5 ± 4.50	5.05 ± 1.27	1.32 ± 1.52
July	2.66 ± 1.50	0.66 ± 0.81	0.50 ± 0.54	1.16 ± 0.98	43,612 ± 3,433	0.93 ± 0.07	81.2 ± 4.73	6.09 ± 1.66	1.17 ± 1.29
August	1.75 ± 1.03	0.75 ± 0.70	0.12 ± 0.35	0.87 ± 0.64	41,316 ± 3,130	0.88 ± 0.06	76.7 ± 4.68	4.23 ± 2.45	0.29 ± 0.83
September	1.67 ± 0.81	0.50 ± 0.83	0.16 ± 0.40	0.66 ± 0.81	38,472 ± 3,209	0.82 ± 0.06	70.1 ± 9.62	4.34 ± 2.10	0.44 ± 1.08
Mean ± SD	1.92 ± 1.13	0.30 ± 0.61	0.37 ± 0.56	0.67 ± 0.73	40,824 ± 4,550	0.87 ± 0.09	70.8 ± 10.42	5.04 ± 2.13	0.90 ± 1.39

Medical usage rates by month include mean number of patient presentations per game, transport rate to hospital via ambulance, and referred-to-hospital rate.
STHR, self-transport to hospital rate; *TTHR,* transport to hospital rate; *RTHR,* referred to hospital rate; *PPR,* patient presentation rate; *EMS*, emergency medical services.

Table 2. Overview of chief complaints.

	Total (N = 92)		Male (n = 54)		Female (n = 38)		Significance	Referred to hospital (n = 39)		Back to event (n = 53)		Significance
Chief complaint	n	%	n	%	n	%	p	n	%	n	%	p
Abdominal pain	6	7	3	6	3	8	0.97	4	10	2	4	0.97
Allergic reaction	6	7	3	6	3	8	0.97	2	5	4	8	0.94
Chest pain	5	5	2	4	3	8	0.93	2	5	3	6	0.93
Intoxication	9	10	6	11	3	8	1	2	5	7	13	0.96
Miscellaneous	7	8	2	4	5	13	0.95	0	0	7	13	0.5
Musculoskeletal	31	34	19	35	12	32	1	13	33	18	34	1
Shortness of breath	4	4	0	0	4	11	0.5	1	3	3	6	0.8
Lightheadedness	24	26	19	35	5	13	1	15	38	9	17	1

sale and free water, and resulted in similar medical needs and PPR (5.04 vs 6.6 per 100,000). However, other well-studied events, such as college football games held in similar settings but with different demographics and environmental traits, revealed significantly higher PPRs.[28] This suggests that factors beyond venue characteristics, such as crowd mood and behavior, may influence the PPR at mass gatherings.

Of all patients who presented for medical care, an average of .67 per 100,000 attendees were referred to nearby hospitals, which likely did not impact operations at local hospitals. Of the 92 patients who presented, 19.2% were transported via ambulance. In months with relatively low heat indexes such as April and May, a single patient was transported via ambulance in one of every three games. However, in months with higher heat index such as June and July, this increased to an ambulance transport every two games. This increase, however, did not meaningfully stress the ability to provide medical aid using our current onsite staffing model.

Overall, the data suggesst a relatively low and predictable PPR at baseball events with a low RTHR and TTHR. However, when compared to similar studies, there is a much higher TTHR in our setting than in others. Patients with the chief complaint of "lightheadedness" were disproportionately more likely to be transported to the hospital, making up 28% of chief complaints but 38% of all transports. In our study, 19.2% of patients were taken to a hospital by ambulance vs 5.7% in Perron et al and 4.1% in Hardcastle et al.[19,25] Perron et al found a significantly higher PPR, while only 5.7% of patrons required ambulance transports. Our study also had a higher average patient age than the other referenced studies. Compared to Hardcastle et al, we recorded a mean patient age that was eight years older. Although patient acuity may explain the difference in TTHR, these events also occurred in different countries. The economic burden of paying for ambulance services, and differences in professional liability, may also account for the difference in TTHR.

Table 3. Overview of treatments rendered to patients who presented for medical care.

	Total (N=108)		Male (n=56)		Female (n = 52)		Significance	Referred to hospital (n=45)		Back to event (n=63)		Significance
Treatment rendered	n	%	n	%	n	%	p	n	%	n	%	p
Bandage	8	7	5	9	3	6	0.99	3	7	5	8	0.98
Diphenhydramine	6	6	3	5	3	6	0.97	3	7	3	5	0.97
Albuterol nebulizer	4	4	3	5	1	2	0.9	1	2	3	5	0.8
ECG	2	2	1	2	1	2	0.75	1	2	1	2	0.75
Ice pack	33	31	17	30	16	31	1	14	31	19	30	1
Intravenous fluids	5	5	3	5	2	4	0.95	3	7	2	3	0.95
NSAIDs/Acetaminophen	21	19	11	19	10	19	1	9	20	12	19	1
Oral Fluids	11	10	5	9	6	12	1	4	9	7	11	1
Ondansetron	6	6	4	7	2	4	0.97	2	4	4	6	0.94
Miscellaneous	12	11	4	7	8	15	1	5	11	7	11	1

ECG, electrocardiogram; *NSAID,* nonsteroidal anti-inflammatory drug .

We found the most common medical complaints were musculoskeletal followed by lightheadedness. There were no differences in chief complaints between sexess or in the final disposition of the patient. This aligns with other studies on mass gatherings where the predominant complaints were musculoskeletal. In the study by Hardcastle et al, of their 316 presentations, 98 (31%) were also musculoskeletal or minor trauma.

There were 108 documented interventions; some patients received multiple interventions while others received none. The physician treated patients with various interventions, with the most common being ice packs (31%), corresponding to 34% of complaints being musculoskeletal. Pain relievers such as NSAIDs and acetaminophen were also frequently used. Oral fluids were the third most common intervention; this is likely under-reported as many patients brought their own water containers.

Interestingly, a limited number of ECGs and IV fluid boluses were administered even though Advanced Life Support was available at all events. This suggests that most patients who presented for medical evaluation did not require advanced prehospital intervention and were likely low-acuity patients. There were zero cases of cardiac arrest during the study period. Removing patients from the heat and providing rest helped most recover. The final disposition of patients was similar for each treatment group.

LIMITATIONS

Our study has several limitations. Because it was an observational study with a 10% missingness rate, we could only establish a correlation between heat index and patient presentation rates and not causation. The data abstractors were not blinded to the premise of the study. Additionally, only one baseball season was studied, which limited the climate and patient data to one specific year. Because our analysis was limited to a single season, we could not further isolate games with higher heat indices without significantly reducing the sample size. Due to the modest sample size, there is a potential for variability, raising concerns about the robustness of the findings. While a moderate correlation was observed for PPR, no such relationship was found for TTHR. For instance, despite having a similar heat index to June, August had a much lower TTHR and PPR.

We chose not to include patients seeking OTC medication who didn't request to see a physician in order to isolate physician staffing needs and the effect of heat index on patient presentation for medical usage. However, the definition of what constituted a patient encounter likely varied between physicians and resulted in a more heterogeneous population despite our efforts to define it. Some treatment interventions may have been undercounted, such as giving oral fluids to patients. We did not capture data on the total supply usage, such as OTC medications dispensed without physician evaluation. Capturing total supply usage may also be of interest to event directors. Lastly, our high TTHR (19.2%) may reflect how we defined a patient. Unlike other studies that classified all individuals who presented as patients, regardless of physician evaluation, we only included those who were formally evaluated by a physician. This measurement difference contributed to our higher TTHR.

While our study shows more patients needing care with a higher heat index, this cannot be extrapolated below 46° F, which was the study's lowest recorded temperature. Studies suggest that extremely cold temperatures also increase PPR given its association with cold-related medical conditions.[28-29] In addition, wedid not us Wet Bulb Globe Temperature (WBGT), which is another modality for temperature measurement that takes into account factors such as humidity, wind, and sunlight.[30-33] While not used before for predicting medical needs at spectator sporting events, WBGT is used in active participation event studies, and future research could explore this further, providing a more comprehensive understanding of variables within the environmental domain.

CONCLUSION

We found that the heat index was moderately associated with higher patient presentation rates at bounded mass-gathering baseball events. Although no additional onsite resources were needed, likely due to low baseline presentation rates and moderate weather during the study period, this correlation could help inform event medical planning efforts as the climate continues to evolve.

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Emergency Department Blood Pressure Management in Type B Aortic Dissection: An Analysis with Machine Learning

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Background: Acute aortic dissections (AAD) have a high morbidity and mortality rate. Treatment for type B aortic dissection includes strict systolic blood pressure (SBP) and heart rate (HR) control per the American Heart Association (AHA) guidelines. However, predictors of successful emergency department (ED) management of SBP have not been well studied.

Methods: We retrospectively analyzed the records of adult patients presenting to any regional ED with type B AAD between 2017–2020 with initial SBP >120 mmHg and HR >60 beats per minute (bpm) and were subsequently transferred to our quaternary center. Primary outcome was SBP <120 mmHg based on both the 2010 and 2022 AHA guidelines and HR <60 bpm (based on the 2010 guideline), or HR <80 (2022 guideline). We used random forest (RF) algorithms, a machine-learning tool that uses clusters of decision trees to predict a categorical outcome, to identify predictors of achieving HR and SBP goals prior to ED departure, defined as the time point at which patients left the referring ED to come to our institution.

Results: The analysis included 134 patients. At the time of ED departure, 26 (19%) had SBP <120 mmHg, 96 (67%) received anti-impulse therapy, and 40 (28%) received beta-blocker or vasodilator infusions specifically. The RF algorithm identified higher triage SBP and treatment with intravenous labetalol as the top predictors for SBP >120 mmHg at ED departure, contrary to AHA guidelines. Pain management with higher total morphine equivalent unit, as well as shorter time to computed tomography as predictors for HR <60 bpm and <80 bpm, were in concert with AHA guidelines.

Conclusion: Many patients with type B AAD did not achieve hemodynamic parameters in line with 2010 or 2022 AHA guidelines while being in the ED prior to transferring to a quaternary care center for further evaluation and management. Patients with higher heart rate and systolic blood pressure on ED arrival were less likely to achieve goals at the time of departure from the referring EDs. Those receiving more pain medications prior to transfer were more likely to meet certain AHA goals. [West J Emerg Med. 2025;26(3)674–684.]

INTRODUCTION

Acute aortic dissection (AAD) occurs when there is a tear in the intima of the aorta resulting in the formation of a false lumen that might cause organ ischemia. An aortic dissection is classified as type A when the dissection flap originates in the ascending aorta proximal to the subclavian artery; type B occurs when the dissection originates in the descending aorta, after the take-off of the subclavian.[1] Up to 35% of people who experience one of these acute aortic syndromes die immediately.[2,3] Overall, the one-year mortality rate is 90%,[3] and approximately 25% of patients die during hospitalization. While type B aortic dissections are relatively uncommon, patients may have severe complications when left untreated, the most serious being rupture of the aorta.[4]

Type A dissection is considered a surgical emergency, while the initial management of a type B dissection is traditionally medical (although when end-organ damage occurs, a type B dissection becomes a surgical emergency).[5] The American Heart Association (AHA) has published and routinely updates guidelines to provide a framework for the management of acute aortic dissections. The most recent iteration of these guidelines was updated in 2022 and suggests the use of medications to acutely lower and maintain patients' systolic blood pressure (SBP) <120 mmHg "or to the lowest BP that allows end-organ perfusion," and heart rate (HR) between 60-80 beats per minute (bpm).[2] (These goals were modifications from the prior guideline's stricter recommendations of HR <60 bpm.[6]) For patients without contraindications, intravenous (IV) beta-blockers (often esmolol, metoprolol, or labetalol) are recommended as first-line therapy, with IV vasodilators (such as nicardipine, clevidipine, or nitroprusside) added on if BP control remains suboptimal after beta-blockers have been started and appropriately titrated. It is recommended that patients with contraindications to beta-blockers be treated first line with non-dihydropyridine calcium channel blockers (CCB) for HR control. Pain management is also recommended, as uncontrolled pain may worsen tachycardia and hypertension. The goal of this "anti-impulse" therapy is to reduce the shearing force on the wall of the aorta while maintaining adequate end-organ perfusion.[7-9]

Emergency physicians (EP) often are the first to triage and diagnose patients who present with AADs and initiate medical management before admitting or transferring them to tertiary care hospitals for continued treatment. With the high morbidity and mortality of this disease, early and effective treatment is necessary to prevent complications.[10] However, data suggests EPs may be falling short of this goal. A prior study showed that among all patients who had "suspected acute aortic dissection" and were transferred to a tertiary care center via air transport, most of these patients' initial vital signs upon leaving the referring EDs were outside the target range recommended by the 2010 AHA at the time.[11] This study showed that only 25% of patients attained a SBP <120 mm Hg and 64% a HR <80 bpm by the time of their departure from the ED.[11] Many of the patients in this group did not receive any antihypertensive (AHT) therapies prior to transfer to a higher level of care. Similarly, another study showed that among 168 patients with acute aortic disease who underwent ED-to-ED transfer to a quaternary care center, 19% and 9% of patients would achieve SBP <120 mmHg or HR <60 bpm, respectively, when they left the referring EDs.[12]

In this study we aimed to investigate the rate at which patients transferred directly from an ED to a quaternary hospital for the management of type B dissection achieve SBP and HR measurements within the parameters recommended by the AHA during patients' ED stay prior to transfer. We also aimed to identify patient characteristics and treatment factors associated with meeting those targets. Having more information regarding any effective modality for treating patients with type B aortic dissection would provide emergency clinicians with further information to improve patient care.

Population Health Research Capsule

What do we already know about this issue?
Type B aortic dissections are hypertensive emergencies managed via rapid control of heart rate (HR) and systolic blood pressure (SBP).

What was the research question?
What percentage of ED patients with type B dissection achieve recommended HR and SBP prior to transfer? What factors predict success?

What was the major finding of the study?
11% of patients met 2022 guidelines for HR and SBP control. Older age and higher triage HR and SBP were predictive of poor BP control in the ED.

How does this improve population health?
By highlighting the low rate of HR and SBP control in EDs, our findings emphasize the importance of early and aggressive medical management to improve outcomes.

METHODS

Study Setting

This was a retrospective study of adult patients transferred from any ED to the critical care resuscitation unit (CCRU) at the University of Maryland Medical Center (UMMC) from January 1, 2017–December 31, 2020. The policy at our institution mandates that all patients from other hospitals who

require urgent surgical evaluation, including patients with any AAD, be transferred to the CCRU first, before going to any other inpatient units of the hospital. Thus, all patients being transferred to UMMC for management of acute aortic diseases are first admitted to the CCRU for initial stabilization and management. Collaborating with the cardiac surgeons or vascular surgeons at our institution, the CCRU clinicians perform acute medical management and resuscitation for patients with a variety of medical and surgical emergencies across specialties. Details regarding the clinicians, nursing staffing, and model of the CCRU have been published elsewhere.[14] The CCRU was designed to have the capabilities of a variety of subspecialty intensive care units (ICU), including cardiac surgery and cardiovascular ICUs.

The UMMC is home to a multidisciplinary Center for Aortic Disease composed of specialists in cardiac and vascular surgery, vascular medicine, and cardiology. Cardiac and vascular surgery specialists are available 24/7 for the initial evaluation and management of patients transferred for acute aortic syndromes. The treatment plans of patients with type B aortic dissections are primarily directed by the vascular surgery team, which evaluates patients immediately upon their arrival at the CCRU. Patients with evidence of end-organ malperfusion or enlarging dissections may be considered candidates for operative or endovascular repair, including physician-modified endovascular grafting.[17]

Following initial stabilization and the identification of an available appropriate bed, patients are transferred to another ICU, often the surgical ICU or cardiac surgery ICU or another appropriate inpatient unit at UMMC. During times characterized by extremely limited bed availability, patients may remain in the CCRU throughout their initial treatment period and be successfully transferred to an intermediate or "step-down" unit following transition from continuous infusions for anti-impulse therapy and onto oral AHTs.

Patient Selection

All patients who were transferred from an ED to the CCRU between 2017-2020 for type B ADDs were eligible for inclusion in this study. We excluded patients with missing records from the referring ED such as vital signs at ED triage and at the time of departure from the referring ED. Patients with SBP <90 mmHg and a heart rate <60 bpm at the time of ED triage were also excluded. The study was approved by the institutional review board at our institution (HP-00084554).

Data Collection and Management

We collected patient data by reviewing our health system's electronic health record system (EHR) (Epic Systems Corporation, Verona, WI). If the referring EDs did not use Epic or the records were not available immediately, the investigator extracted data from the paper version of the documents that accompanied patients when they were transferred to our institution and subsequently scanned into their EHR. Data was extracted into a standardized Excel spreadsheet (Microsoft Corporation, Redmond, WA). Before data extraction, all investigators, who were blinded to the hypothesis, were trained by the primary investigator for data extraction, using sets of 10 patient charts. Training data was compared between investigators and senior investigators until agreement reached 90%. During data collection, up to 5% of data was randomly checked by a senior investigator for accuracy. Our protocol adhered to 7 of 8 of the recommendations outlined by Worster and Bledsoe (except case selection criteria).[13]

We collected information regarding patient demographics, past medical history, social history, and home medications. In addition, we recorded clinical ED data including all SBP and HR measurements recorded throughout their entire ED stay. We extracted data regarding the type, dose, administration route, and administration time (as documented by an ED registered nurse [RN] in the medical record) of beta-blockers, CCBs, vasodilatory medications, and pain medications. If a medication was ordered by the clinician but not documented as given by the RN, that medication was not extracted. We also collected the timing and results of all computed tomography and laboratory values such as serum lactate and creatinine levels, as well as ED triage and departure times.

Outcome Measures

Our primary outcome was SBP <120 mm Hg at the time of departing the referring EDs, as is consistent with the recommendation by both the 2010 and 2022 AHA guidelines. Secondary outcomes included HR <60 bpm (2011 AHA guideline) and HR <80 bpm (2022 AHA guideline).

Data Analysis

We did not perform a sample size calculation for this study due to its exploratory nature and because the outcomes were the prevalence of patients achieving guidelines' recommendation. Histograms of continuous variables were examined for their pattern of distributions and expressed as mean (+/- standard deviation) or median (interquartile range [IQR]) as indicated and analyzed using the Student *t*-test or Mann-Whitney U test as indicated. Categorical variables were expressed as N, and percentages and were analyzed with the chi-square test.

We performed random forest (RF) classification to identify patient and treatment factors predictive of our outcomes. Random forest classification is a machine-learning technique that uses an ensemble of decision trees to predict a categorical outcome. Specifically, we trained three classifiers. We trained the classifiers to predict the achievement of hemodynamic targets, recommended by the 2011 and 2022 guidelines (SBP <120 mmHg or HR <60 bpm), at the time of ED departure. We then trained the classifiers to predict the achievement of hemodynamic targets recommended by the updated 2022 AHA guidelines (HR <80 bpm). We selected 22 predictors a priori for these models including variables related

to age, past medical history and outpatient medications, ED triage vital signs and laboratory values, diagnostic evaluation, and treatment (Appendix 1). While our retrospective analysis could only demonstrate the association, the RF algorithm does not provide measurements of association such as odds ratios or risk ratios as traditional regression models do. The machine-learning algorithms such as RF instead reported "predictors," which referred to clinical factors that would be statistically associated with the outcomes, in this retrospective context.

The results from the RF analyses were depicted as dot plots. The Y-axis represents the order of significant contributions from top (most significant) to bottom (least significant). The X-axis represents the Shapley additive explanations (SHAP) values. The SHAP values use a game-theoretic approach to assign how much a specific feature of a model contributes to its outcome. For our models, positive SHAP values indicated predictors not meeting the AHA guidelines (patients having SBP >120 mmHg or HR >60 bpm, HR >80 bpm at ED departure), while predictors with negative SHAP values indicated patients meeting AHA guidelines (having SBP <120 mmHg, HR <60 bpm). The magnitude of these values corresponds to the extent to which the feature contributes to the model prediction.

We assessed performances of the RF models via the accuracy test, with values approaching 1.0 indicating good discriminatory capability of the models. Sensitivity and specificity were also reported for each RF model. We performed all analyses using Python v3.10.12 (Python Software Foundation, Wilmington, DE). Random forest classifiers and SHAP values were generated using the Python sklearn (v1.4.2) and SHAP (v0.44.1) libraries, respectively. All analyses with a 2-tailed *P*-value < 0.05 were considered statistically significant.

RESULTS

We included 134 patients with type B aortic dissection (Figure 1); all patients were transferred from other hospitals' EDs to our resuscitation unit. The mean SBP (+/- SD) at ED triage was 157 ± 41 mmHg and the mean SBP at referring ED departure was 145 ± 35 mmHg. The mean HR at ED triage and referring ED departure was 78 ± 18 bpm and 76 ± 16 bpm, respectively (Table 1). All patients' blood pressure measurements were from non-invasive cuff blood pressure measurements. Twenty-six (19%) patients achieved SBP <120 mmHg prior to referring ED departure, 16 (12%) HR <60 bpm (Table 2A), and 88 (66%) HR <80 bpm (Table 2B). Three (2%) patients achieved both HR and SBP within the parameters recommended by the 2010 AHA guidelines (SBP <120 mmHg and HR < 60bpm), while 15 (11%) achieved both parameters as recommended by the 2022 guidelines (SBP <120 mmHg and HR <80 bpm).

Ninety-three patients (69%) received impulse control therapy while in the ED: 44 (33%) received IV beta blockers, and 10 (8%) received IV vasodilators in the form of hydralazine or nitroglycerin tablets. A total of 89 (62%) were treated with AHT infusions, 49 (37%) received esmolol, 38 (28%) received either nicardipine or clevidipine, and 2 (1%) patients received nitroprusside. Sixteen (12%) received both esmolol and either nicardipine or clevidipine. A total of 82 patients received opioid medications for pain control. The average morphine equivalent units (MEU) of administered opioids were 10.05 ± 7.69. Fifty-two (36%) patients ultimately underwent surgical intervention for type B aortic dissection during their index hospitalization following transfer to UMMC.

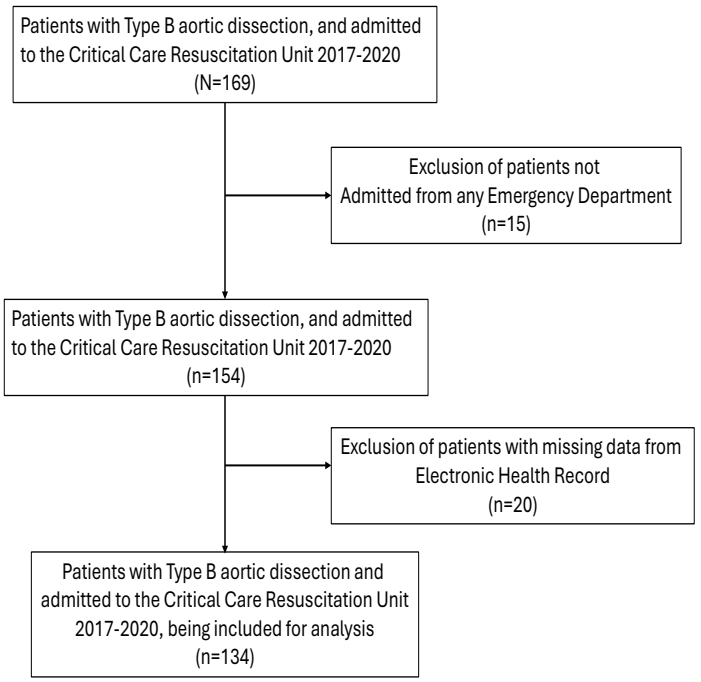

Figure 1. Patient selection flow diagram
CCRU, critical care resuscitation unit; *ED,* emergency department; *EHR,* electronic health record.

Primary Outcome: Systolic Blood Pressure <120 mmHg

Twenty-six (19%) patients had SBP <120 mmHg at departure from the referring EDs (Table 1). The RF algorithm identified older age (SHAP -0.012) as the top predictor for SBP <120 mmHg, as well as higher triage SBP (SHAP 0.018) and higher triage HR (SHAP 0.0009) as top predictors for SBP >120 mmHg at ED departure (Table 3) (Figure 2A). Patients with a shorter ED length of stay were also more likely to have SBP >120 mmHg at ED departure (SHAP -0.0042). This model had good performance (accuracy = 0.89, F1 score = 0.90, specificity = 0.96, sensitivity = 0.89).

Secondary Outcome: Heart Rate <60 bpm at ED Departure (time at leaving the referring EDs)

Sixteen (12%) patients had HR <60 bpm at ED departure (Table 2A). Total MEU, triage HR, triage SBP, and time from triage to first pain medication were among the top predictors for HR <60 bpm at ED departure. Patients receiving pain medications with a higher total MEU (SHAP -0.0015) were more likely to achieve HR <60 bpm at ED departure, while

Table 1. Comparison of characteristics of patients who presented to the emergency department (ED) with type B aortic dissection and left the ED with SBP < 120 mmHg vs those who left the ED with SBP > 120 mmHg.

Variables	All patients N = 134	SBP <120 mmHg n = 26	SBP >120 mmHg n = 108	Difference between groups	95% CI of differences	P-value
Age (mean, SD)	64(14)	65(16)	64(13)	0.9	-5.2,6.9	0.78
Male (N,%)	84(63)	13(50)	71(66)	-0.2	-0.4,0.0	0.14
Female (N,%)	50(37)	13(50)	37(34)	0.2	0.0,0.4	0.14
PMH - DM (N,%)	13(10)	0(0)	13(12)	-0.1	-0.2,0.0	0.06
PMH - HTN (N,%)	102(76)	17(65)	85(79)	-0.1	-0.3,0.0	0.15
PMH - CKD or dialysis (N,%)	11(8)	2(8)	9(8)	0.0	-0.1,0.2	0.91
Cardiac history (N,%)	22(16)	3(12)	19(18)	-0.1	-0.2,0.1	0.45
History of aortic disease (N,%)	30(22)	11(42)	19(18)	0.2	0.1,0.4	0.01
Clinical information						
Triage SBP, (mmHg) (mean, SD)	158(40.9)	133(45.8)	163(37.5)	-30.4	-47.4, -13.5	0.0
Leaving ED SBP, (mmHg) (mean, SD)	145(34.5)	101(16.5)	156(28.7)	-54.9	-66.5, -43.3	0.0
Triage HR (bpm) (mean, SD)	78(17.6)	81(25.3)	77(15.2)	4.1	-3.5,11.8	0.28
Leaving ED HR (bpm) (mean, SD)	75(15.5)	76(13.1)	75(16.1)	1.0	-5.7,7.8	0.76
Triage HR (bpm) (median, IQR)	76[66.5-91]	81[64.3-95]	74[66.5-89.5]	6.5	-6.5,16.0	0.50
Triage pain (median, IQR)	7.0[4-10]	6.5[0-9.5]	8.0[4-10]	-1.5	-8.0,2.0	0.29
Time of treatment while in the emergency department						
Triage to first antihypertensive (hours) (median, IQR)	3.0[1.5-4.7]	1.9[0.9-3.2]	3.0[1.5-4.9]	-1.2	-2.5,0.6	0.10
Triage to start of antihypertensive infusion (hours) (median, IQR)	3.2[1.8-4.7]	3.0[1.8-3.3]	3.3[1.8-4.9]	-0.3	-1.9,0.7	0.33
Triage to first pain medication (hours) (median, IQR)	1.05[0.5-2.]	1.4[0.7-2.1]	1.0[0.5-2]	0.3	-0.6,1.2	0.60
Triage to CT (hours) (median, IQR)	2.3[1.5-4]	1.6[1.3-2.5]	2.5[1.5-4.1]	-0.9	-1.6,0.1	0.06
Treatment in the emergency department						
Any infusions (N,%)	55(41)	8(31)	47(44)	-0.1	-0.3,0.1	0.24
Any esmolol infusion (N,%)	49(37)	8(31)	41(38)	-0.1	-0.2,0.1	0.49
Any CCB infusion (N,%)	38(28)	2(8)	36(33)	-0.3	-0.4,-0.1	0.01
Both esmolol and CCB infusion (N,%)	16(12)	1(4)	15 (11)	-0.1	-0.2, 0.0	0.046
Nitroglycerin (N,%)	5(4)	1(4)	4(4)	0.0	-0.1,0.2	0.97
Nitroprusside (N,%)	2(1)	0(0)	2(0)	0.0	-0.1,0.1	0.48
Any IV push (N,%)	46(34)	3(12)	43(40)	-0.3	-0.4,-0.1	0.01
Any beta-blocker IV push (N,%)	44(33)	3(12)	41(38)	-0.3	-0.4,-0.1	0.01
Hydralazine IV push (N,%)	5(4)	0(0)	5(5)	-0.1	-0.1,0.1	0.26
Any PO antihypertensives (N,%)	5(4)	1(4)	4(4)	0.0	-0.1,0.2	0.97
Any opioids (N,%)	82(61)	12(46)	70(65)	-0.2	-0.4,0.0	0.08
Total MEU (median, IQR)	8.0[4.5-12.8]	9.0[4.8-11.5]	8.0[4.5-12.8]	1.0	-4.0,5.0	0.85
Other pain medications (N,%)	1(1)	1(4)	0(0)	0.0	0.0,0.2	0.04
ED length of stay (hours) (median, IQR)	5.6[3.5-8.3]	3.9[3.1-7.9]	5.7[3.8-7.8]	-1.8	-2.9,1.2	0.14

CCB, calcium channel blocker; *CKD,* chronic kidney disease; *CT,* computed tomography; *DM,* diabetes mellitus; *ED,* emergency department; *HR,* heart rate; *HTN,* hypertension; *IQR,* interquartile range; *IV,* intravenous; *MEU,* morphine equivalent unit; *mmHg,* millimeter of mercury; *PMH,* past medical history; *PO,* per oral (by mouth); *SBP,* systolic blood pressure.

Table 2A. Characteristic of patients who presented to ED with type B aortic dissection and left the ED with HR < 60 bpm.

Variables	All patients N = 134	HR < 60 bpm n = 16	HR >= 60 bpm n = 118	Difference between groups	95% CI of differences	P-value
Age (mean, SD)	64(14.1)	69(9.8)	64(14.5)	4.7	-2.7,12.0	0.22
Male (N,%)	84(63)	12(75)	72(61)	0.1	-0.1,0.3	0.28
Female (N,%)	50(37)	4(25)	46(39)	-0.1	-0.3,0.1	0.28
PMH - DM (N,%)	13(10)	3(19)	10(8)	0.1	0.0,0.4	0.19
PMH - HTN (N,%)	102(76)	14(88)	88(75)	0.1	-0.1,0.3	0.26
PMH - CKD or dialysis (N,%)	11(8)	4(25)	7(6)	0.2	0.0,0.4	0.01
Cardiac history (N,%)	22(16)	0(0)	22(19)	-0.2	-0.3,0.0	0.06
History of aortic disease (N,%)	30(22)	3(19)	27(23)	-0.0	-0.2,0.2	0.71
Clinical information						
Triage SBP, (mmHg) (mean, SD)	158(40.9)	140(36.9)	160(41.0)	-19.5	-40.8,-1.9	0.07
Leaving ED SBP, (mmHg) (mean, SD)	145(34.5)	134 (24.4)	147(35.5)	-12.8	-31.0,5.3	0.16
Triage HR, (bpm) (mean, SD)	78(17.6)	58(10.2)	81(16.6)	-22.9	-31.3,14.4	0.00
Leaving ED HR (bpm) (mean, SD)	75(15.5)	52(12.9)	78(13.1)	-26.1	-33.0,-19.3	0.00
Triage SBP (median, IQR)	151[132-180]	130[116.8-171.8]	152[135-185]	-22.0	-39.0,22.0	0.06
Triage HR (bpm) (median, IQR)	76[66.5-91]	56[51.3-64]	80[69-92]	-24.5	-28.5,-13.5	0.00
Triage pain (median, IQR)	7.0[4-10]	8.0[5-9]	7.0[4-10]	1.0	-4.0,2.5	0.89
Treatment while in the emergency department						
Triage to first antihypertensive (hours) (median, IQR)	3.0[1.5-4.7]	2.1[0.7-3.8]	3.0[1.5-4.7]	-0.9	-2.5,2.5	0.41
Triage to start of antihypertensive infusion (hours) (median, IQR)	3.2[1.8-4.7]	3.1[2.1-5.1]	3.0[1.8-4.5]	0.1	-1.8,3.1	0.91
Triage to first pain medication (hours) (median, IQR)	1.1[0.5-2]	1.7[0.9-2]	0.9[0.5-2]	0.8	-0.2,1.2	0.12
Triage to CT (hours) (median, IQR)	2.3[1.5-4]	2.4[1.6-3.4]	2.3[1.5-4]	0.1	-0.9,1.3	0.96
Treatment in the emergency department						
Any infusions (N,%)	55(41)	5(31)	50(42)	-0.1	-0.3,0.2	0.40
Any esmolol infusion (N,%)	49(37)	3(19)	46(39)	-0.2	-0.4,0.1	0.11
Any CCB infusion (N,%)	38(28)	4(25)	34(29)	0.0	-0.2,-0.2	0.75
Nitroglycerin (N,%)	5(4)	3(19)	2(2)	0.2	0.0,0.4	0.00
Nitroprusside (N,%)	2(1)	0(0)	2(2)	0.0	-0.1,0.2	0.60
Any IV push (N,%)	46(34)	3(19)	43(36)	-0.2	-0.3,0.1	0.16
Any beta-blocker IV push (N,%)	44(33)	3(19)	41(35)	-0.2	-0.3,-0.1	0.20
Hydralazine IV push (N,%)	5(4)	1(6)	4(3)	0.0	0.0,0.3	0.57
Any PO antihypertensives (N,%)	5(4)	0(0)	5(4)	0.0	-0.1,0.2	0.40
Any opioids (N,%)	82(61)	13(0.81)	69(58)	0.2	0.0,0.4	0.08
Total MEU (median, IQR)	8.0[4.5-12.8]	5.0[4-8]	8.0[5-13.5]	-3.0	-6.0,0.0	0.04
Other pain medications (N,%)	1(1)	0(0)	1(1)	0.0	-0.1,0.2	0.71
Any vascular surgeries during hospital stay (N,%)	71(53)	12(75)	59(50)	0.3	0.0,0.4	0.06

CCB, calcium channel blocker; *CKD,* chronic kidney disease; *CT,* computer tomography; *DM,* diabetes mellitus; *ED,* Emergency Department; *HR,* heart rate; *HTN,* hypertension; *IQR,* interquartile range; *IV,* intravenous; *MEU,* morphine equivalent unit; mmHg, millimeter of mercury; *PMHx,* past medical history; *PO,* per oral (by mouth); *SBP,* systolic blood pressure.

Table 2A. Continued.

Variables	All patients N = 134	HR < 60 bpm n = 16	HR >= 60 bpm n = 118	Difference between groups	95% CI of differences	P-value
Hospital length of stay (days), (median, IQR)	7.4[4-12]	6.4[4.9-8.9]	7.7[3.9-12]	-1.3	-3.5,1.2	0.48
Mortality (N,%)	11(8)	2(12)	9(8)	0.0	-0.1,0.3	0.51
ED length of stay (hours) (median, IQR)	5.6[3.5-8.3]	4.8[3.5-9.2]	5.6[3.5-7.8]	-0.8	-2.3,3.4	0.94

HR, heart rate; *bpm,* beats per minute; *CI,* confidence interval; *IRQ,* interquartile range; *ED,* emergency department.

those with higher triage HR (SHAP 0.003) and higher triage SBP (SHAP 0.001) were more likely to have a HR >60 bpm at ED departure (Table 3) (Figure 2B).

Secondary Outcome: Heart Rate <80 bpm at ED Departure (time at leaving the referring EDs)

Eighty-eight (66%) patients had HR <80 bpm at ED departure (Table 2B). Triage HR, triage SBP, ED length of stay, time from triage to CT scanner, and age were among the top predictors for HR <80 bpm at ED departure. Patients with lower triage SBP (SHAP -0.015) and longer ED length of stay (SHAP -0.0008) were more likely to achieve HR <80 bpm at ED departure, while those with higher triage HR (SHAP 0.002), longer time from triage to CT scanner (SHAP 0.011), and younger age (SHAP 0.005) were more likely to have HR >80 bpm at ED departure (Table 3) (Figure 2C).

DISCUSSION

This study identified a number of predictors for patients with type B aortic dissection who met AHA guidelines for SBP and HR at the time of leaving the referring ED prior to transfer to a quaternary center. The majority of patients who presented with type B aortic dissections to EDs did not meet 2010 AHA goals for either SBP (19%) or HR (12%) during their ED stays, and only three patients (2%) met both goals. This appears to be similar to the findings in previous literature.[11,12] The majority of patients (66%) achieved the more liberal HR goal recommended by the updated 2022 AHA guidelines, although these updated guidelines were not yet published at the time when they received their care. There was a higher number of patients (11%) who achieved both HR and SBP parameters as recommended by 2022 guidelines.

Patients who did achieve SBP <120 mmHg at ED discharge presented with lower average triage SBP and had a shorter time from triage to CT, potentially allowing clinicians to more rapidly diagnose the aortic pathology and initiate medical management while awaiting transfer to higher level of care. While these findings did not achieve statistical significance, we observed a trend toward more rapid administration of the first dose of AHT infusion and initiation of continuous infusions among patients who achieved SBP < 120 mmHg at leaving the

Table 2B. Characteristics of patients who presented to emergency department (ED) with type B aortic dissection and left the ED with heart rate <80 bpm.

Variables	All patients N = 134	HR < 80 bpm n=88	HR ≥ 80 bpm n = 46	Difference between groups	95% CI of differences	P-value
Age (mean, SD)	64(14.1)	65(13.5)	63(15.1)	2.1	-3.0,7.2	0.41
Male (N,%)	84(63)	58(66)	26(57)	0.1	-0.1,0.3	0.29
Female (N,%)	50(37)	30(34)	20(43)	-0.1	-0.3,0.1	0.29
PMH - DM (N,%)	13(10)	8(9)	5(11)	0.0	-0.2,0.1	0.74
PMH - HTN (N,%)	102(76)	65(74)	37(80)	-0.1	-0.2,0.1	0.40
PMH - CKD or dialysis (N,%)	11(8)	5(6)	6(13)	-0.1	-0.2,0.0	0.14
Cardiac history (N,%)	22(16)	14(16)	8(17)	0.0	-0.2,0.1	0.83
History of aortic disease (N,%)	30(22)	18(20)	12(26)	-0.1	-0.2,0.1	0.46
Clinical information						
Triage SBP, (mmHg) (mean, SD)	158(40.9)	156(37.3)	160(47.4)	-3.3	-18.1,11.4	0.66
Leaving ED SBP, (mmHg) (mean, SD)	145(34.5)	142(30.0)	152(41.5)	-9.5	-21.9,2.8	0.13

CKD, chronic kidney disease; *DM,* diabetes mellitus; *ED,* emergency department; *HR,* heart rate; *HTN,* hypertension; *IQR,* interquartile range; *mmHg,* millimeter of mercury; *PMH,* past medical history; *SBP,* systolic blood pressure.

Table 2B. Continued.

Variables	All patients N = 134	HR < 80 bpm n=88	HR ≥ 80 bpm n = 46	Difference between groups	95% CI of differences	P-value
Triage HR, (bpm) (mean, SD)	78(17.6)	72(16.0)	90(14.2)	-18.2	-23.7,-12.6	0.00
Leaving ED HR (bpm) (mean, SD)	75(15.5)	67(10.1)	91(10.8)	-24.4	-28.1,20.6	0.00
Triage SBP (median, IQR)	151[132-180]	152[133.5-180]	148[129.8-189.8]	4.5	-21.0,17.0	0.97
Triage HR (bpm) (median, IQR)	76[66.5-91]	70.0[62.5-79.5]	90[80.3-100]	-19.5	-26.5,-13.6	0.00
Triage pain (median, IQR)	7.0[4-10]	8.0[4-10]	6.5[3-8.8]	1.5	-0.5,4.0	0.11
Treatment while in the emergency department						
Triage to first antihypertensive (hours) (median, IQR)	3.0[1.5-4.7]	3.1[1.3-4.8]	2.7[1.8-4.1]	0.4	-0.7,1.5	0.72
Triage to start of antihypertensive infusion (hours) (median, IQR)	3.2[1.8-4.7]	3.0[1.6-4.6]	3.5[1.9-4.5]	-0.5	-1.3,1.2	0.60
Triage to first pain medication (hours) (median, IQR)	1.1[0.5-2]	0.9[0.5-1.9]	1.5[0.7-2.4]	-0.6	-1.4,0.3	0.27
Triage to CT (hours) (median, IQR)	2.3[1.5-4]	2.4[1.6-3.9]	2.1[1.3-4]	0.3	-0.9,1.3	0.59
Treatment in the emergency department						
Any infusions (N,%)	55(41)	36(41)	19(41)	0.0	-0.2,0.2	0.96
Any esmolol infusion (N,%)	49(37)	32(36)	17(37)	0.0	-0.2,0.2	0.95
Any CCB infusion (N,%)	38(28)	24(27)	14(30)	0.0	-0.2,0.1	0.70
Nitroglycerin (N,%)	5(4)	5(6)	0(0)	0.1	0.0,0.1	0.10
Nitroprusside (N,%)	2(1)	2(2)	0(0)	0.0	-0.1,0.1	0.30
Any IV push (N,%)	46(34)	28(32)	18(39)	-0.1	-0.2,0.1	0.40
Any beta-blocker IV push (N,%)	44(33)	28(32)	16(35)	0.0	-0.2,0.1	0.73
Hydralazine IV push (N,%)	5(4)	3(3)	2(4)	0.0	-0.1,0.1	0.79
Any PO antihypertensives (N,%)	5(4)	4(5)	1(2)	0.0	-0.1,0.1	0.49
Any opioids (N,%)	82(61)	58(66)	24(52)	0.1	0.0,0.3	0.12
Total MEU (median, IQR)	8.0[4.5-12.8]	8.0[4.3-13.9]	8.0[5-10]	0.0	-2.5,3.5	0.88
Other pain medications (N,%)	1(1)	1(1)	0(0)	0.0	-0.1,0.1	0.47
Any vascular surgeries during hospital stay (N,%)	71(53)	48(55)	23(50)	0.1	-0.1,0.2	0.62
Hospital length of stay (days), (median, IQR)	7.4[4-12]	7.1[3.9-12]	7.9[4.4-11]	-0.8	-2.9,1.6	0.60
Mortality (N,%)	11(8)	7(8)	4(9)	0.0	-0.1,0.1	0.88
ED length of stay (hours) (median, IQR)	5.6[3.5-8.3]	5.7[3.7-8.3]	4.6[3.3-7.4]	1.1	-1.3,2.3	0.32

CT, computed tomography; *ED,* emergency department; *HR,* heart rate; *IQR,* interquartile range; *IV,* intravenous; *MEU,* morphine equivalent unit; *mmHg,* millimeter of mercury; *PO,* per oral (by mouth); *SBP,* systolic blood pressure.

ED prior to transfer to a quaternary care center. Our analysis also suggested that patients who received a higher number of IV beta-blocker pushes were not likely to achieve SBP <120 mmHg at ED departure (Figure 2A). While we could not exclude the reverse association that patients with higher SBP would receive more doses of IV beta blocker, the combination of early AHT infusion and ineffectiveness of IV push beta blocker may present a potential modifier for clinical change for clinicians. Prior studies have demonstrated a benefit of early initiation of nicardipine infusions and improved efficacy of nicardipine when compared to IV labetalol in patients with acute intracranial hemorrhage or stroke.[14,15] Based on our findings, we suggest clinicians have a low threshold to escalate impulse control therapy to include beta-blocker and AHT infusions in patients with acute type B dissections not meeting the hemodynamic parameters recommended by the AHA.

Our findings further support the recommendation by the AHA that pain management be considered a component

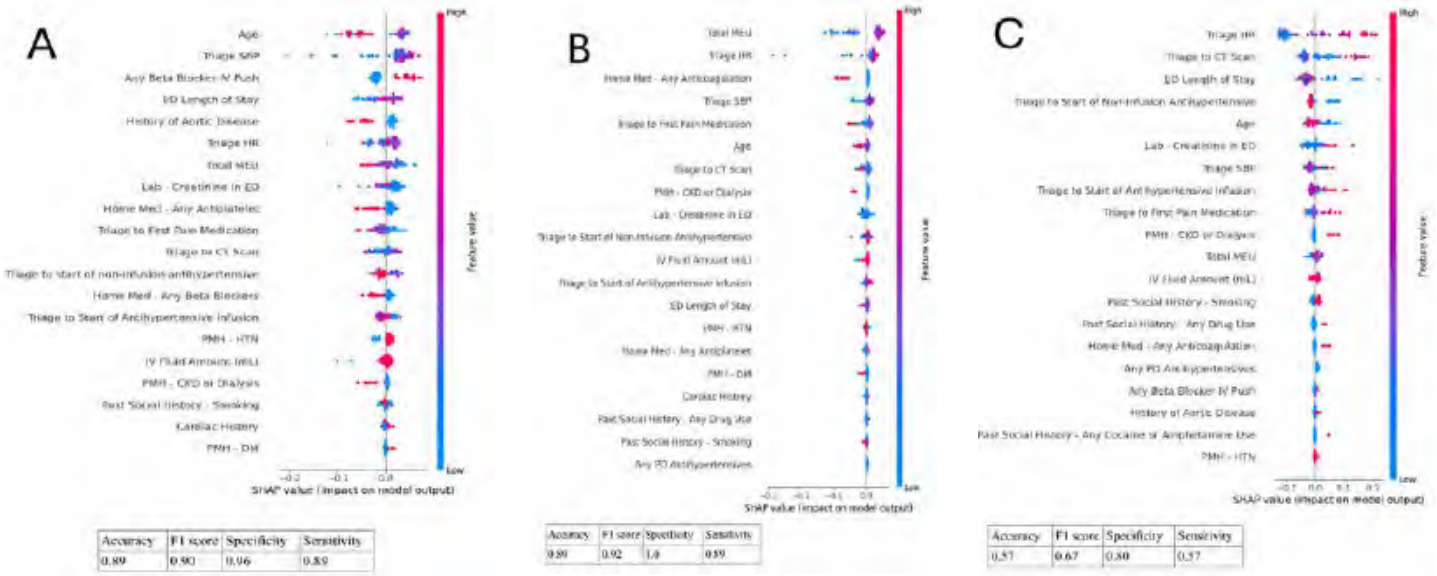

Figure 2. Dot plots generated from random forest analysis for the outcomes of interest (Figure A for SBP < 120 mm Hg; B for HR <60 bpm; C for HR <80 bpm). Blue dots represent lower values of the predictors, while red dots represent higher values of the predictor. Dots to the left of the vertical midline represented negative SHAP values, with prediction for SBP <120 mmHg.
CKD, chronic kidney disease; *CT,* computed tomography; *DM,* diabetes mellitus; *ED,* emergency department; *HR,* heart rate; *HTN,* hypertension; *IV,* intravenous; *PMH,* past medical history; *MEU,* morphine equivalent unit; *mL,* milliliter; *PO,* per oral; *SBP,* systolic blood pressure.

of hemodynamic management in patients with aortic dissection. Our analysis identified a higher total MEU as a predictor for HR <60 bpm at the time of transferring from the ED to a quaternary care center. Aortic dissections cause significant pain, which not only heightens patient suffering but also contributes to hypertension and tachycardia. It has been suggested that opioids specifically can attenuate sympathetic alpha-adrenergic outflow, thereby functioning as an additional component of anti-impulse therapy.[16] In our study, just over half of the population received any form of pain medication.

While there is certainly a subset of patients with type B aortic dissections who require surgical management (and this proportion was relatively high in our population [35%] likely due to our selection of complex patients at high risk of need for repair as priorities for transfer to our quaternary care center), the acute management, and for many patients, the primary treatment of the disease is medical. This anti-impulse therapy can and should be started in the ED immediately following diagnosis, as the appropriate titration of medications requires time, and their impact is not immediate. We found that longer ED length of stay and shorter time from ED triage to CT were key drivers of achieving HR goals as recommended by the AHA, suggesting that with increased time after diagnosis, emergency clinicians were able to make significant progress. In addition to securing a disposition, appropriate, aggressive, and timely management of aortic disease within the ED is only becoming more important as ED boarding, including of critically ill patients, becomes more the norm than an anomaly.

LIMITATIONS

As this was a single-center study, it is difficult to generalize our findings. At UMMC, the vascular surgery team is responsible for management of type B dissection patients who are transferred from any referring hospitals. As a referral center with expertise in open and endovascular repair of complex dissections requiring surgical interventions, a relatively large proportion of our patients are managed surgically, given that the high likelihood of need for surgical intervention is most often considered the indication for transfer. Thus, the successful medical management of these patients may be more challenging than that of patients with a lower rate of ultimate surgical intervention, although conversely, patients with poor hemodynamic control throughout the hospitalization course may have also been at higher risk for requiring surgical management.

During our data collection, we lost a significant number of patients due to lack of access to their ED records from outside facilities directly before transfer, which was consistent with previous observations that documentation for patients with dissections were somewhat inadequate by both emergency clinicians[17] and in transport,[18] likely due to patients' acuity and familiarity with the disease state. We were unable to account for the vitals or management of these patients during transport due to limited documentation from transport clinicians in the EHR. Additionally, when predicting outcomes based on AHA guidelines, the training data for our RF classifiers only had a few patients who met the criteria. Unproportional examples of these outcomes likely led to bias and variance imbalance, which could limit the generalizability of these models.

Table 3. Top five features of the random forest analysis for the three outcomes of interest. Each feature contributes to the predictability of the model. The significance of each feature is calculated by the mean absolute SHAP values across all data points.

	SBP <120	HR <60	HR<80
Accuracy	0.89	0.89	0.57
F1 score	0.90	0.92	0.67
Specificity	0.96	1.00	0.8
Sensitivity	0.89	0.89	0.57
Feature 1	Age (-0.012)	Total MEU (-0.001)	Triage HR (0.002)
Feature 2	Triage SBP (0.018)	Triage HR (0.0002)	Time from triage to CT (0.011)
Feature 3	Any beta-blocker IVP (0.002)	Home medication – Any anticoagulation (-0.004)	ED length of stay (-0.0008)
Feature 4	ED length of stay (-0.004)	Triage SBP (0.001)	Time from triage to start of non-infusion anti-hypertensive medication (0.004)
Feature 5	History of aortic disease (-0.0005)	Time from triage to first pain medication (0.001)	Age (0.005)

CT, computed tomography; *ED,* emergency department; *HR,* heart rate; *IVP,* intravenous push; *MEU,* morphine equivalent unit; *SBP,* systolic blood pressure; *SHAP,* Shapley additive explanations.

CONCLUSION

Many patients transferred from EDs to a quaternary care center for management of type B aortic dissections did not achieve hemodynamic parameters in line with either the 2010 or 2022 American Heart Association guidelines prior to transfer. Patients with higher HR and SBP on ED arrival were less likely to achieve goals at the time of leaving the referring ED, while those who received more pain medications, prior to transfer, were more likely to meet certain AHA goals. Emergency physicians should be cognizant of this patient population given the high morbidity and mortality that type B dissections present with. Antihypertensive therapy and opioid pain medications should be prioritized in these patients as soon as the diagnosis is made and should be continued even through transport to continue to achieve AHA guidelines.

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Ultrasound-guided Emergency Pericardiocentesis Simulation on Human Cadavers: A Scoping Review

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Objectives: Emergency pericardiocentesis is a critical but infrequently performed procedure in emergency medicine, necessitating effective training modalities for emergency physicians. In this scoping review we aimed to identify existing literature on simulation of ultrasound-guided pericardiocentesis in human cadavers.

Methods: We carried out a scoping review based on a search on the use of sonography on human cadavers. The following databases were searched: MEDLINE; EMBASE; CENTRAL; BIOSIS Previews; and Web of Science Core Collection. Additionally, we performed a gray literature search. Title and abstract screening were done by a single reviewer, and full-text review was performed by two independent reviewers. Studies included were limited to those published in English or German, focusing specifically on ultrasound-guided pericardiocentesis training models in human cadavers, with no restrictions on publication year or outcomes.

Results: Our search strategy yielded 9,821 publications and 1,440 reports were assessed for eligibility. Ultimately, four studies met the inclusion criteria. All were conducted in the USA; two used soft-embalmed cadavers, one reported using fresh frozen cadavers, and one did not specify the cadaver type used. All studies accessed the pericardial sac using large-bore catheters or peripheral lines, filling it with (colored) water for simulation.

Conclusions: Evidence on ultrasound-guided emergency pericardiocentesis simulation on human cadavers remains limited, but based on the four studies we reviewed human cadavers could be used for (emergency) pericardiocentesis simulation. [West J Emerg Med. 2025;26(3)685–691.]

INTRODUCTION

Emergency pericardiocentesis is a core emergency medicine (EM) skill covered in EM curricula such as the Emergency Medicine Key Index Procedure Minimums, the European Core Curriculum for Emergency Medicine and the 2022 Curriculum for the Fellowship of the Australasian College for Emergency Medicine.[1-3] It is an infrequent, high-acuity-low-occurrence (HALO) procedure, and emergency physicians are expected to perform this skill in a resuscitative setting.[4] Hence, it is essential that EM residency programs provide realistic training opportunities that facilitate learning and prepare emergency physicians to perform emergency

pericardiocentesis. Currently, training is typically performed by using commercial or self-made pericardiocentesis simulators.[1] However, simulators often lack realism in terms of haptic feedback and possible pericardiocentesis sites.

Previous research has demonstrated the superiority of cadaver training to simulator training for skills acquisition in other EM procedures, such as emergency front of neck access (eFONA) and tube thoracostomy.[5] During the implementation of cadaveric emergency pericardiocentesis simulation at our own institution, we identified several challenges such as rapid leakage of fluid from the pericardial sac into the chest, breakdown of the simulation after a few punctures, and the quality of the pericardial effusion on ultrasound. To learn from the experience of others, we conducted a scoping review to systematically map the current body of literature. Our aim in this scoping review was to identify existing literature on simulation (concept) of ultrasound-guided pericardiocentesis (context) in human cadavers (population). The primary research question was: What is the existing literature regarding the use of human cadavers for simulation of ultrasound-guided (emergency) pericardiocentesis?

Population Health Research Capsule

What do we already know about this issue?
Emergency pericardiocentesis is a core emergency medicine skill, but because it is infrequently performed realistic training opportunities are needed.

What was the research question?
What is the existing literature regarding the use of human cadavers for simulation of ultrasound-guided emergency pericardiocentesis?

What was the major finding of the study?
In four studies, human cadavers were used for ultrasound-guided emergency pericardiocentesis simulation.

How does this improve population health?
Cadaver-based simulation of emergency) pericardiocentesis seems feasible and could improve procedural competency.

METHODS

Study Design

A protocol for this scoping review was registered in Open Science Framework Registries (osf.io/qby92) on September 27, 2024. This scoping review is based on a search on the use of sonography on human cadavers and was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines.[6]

Eligibility Criteria

This scoping review includes literature on ultrasound-guided pericardiocentesis simulation on human cadavers. The following types of publications were considered for inclusion: peer-reviewed articles; conference abstracts; dissertations; and textbook chapters. Only studies published in English or German were included, with no restrictions on publication year or study outcomes. We excluded articles focusing on animal studies, phantoms, or landmark-guided emergency pericardiocentesis. Additionally, we excluded all studies involving organ transplantation, as preliminary searches yielded many unrelated results in this area.

Search Strategy

We developed a search strategy in consultation with a data librarian to generate a database on the use of sonography on human cadavers. (See Table 1 in the online appendix.) The search process for this database was conducted on January 3, 2023. The results were updated by a search performed on June 20, 2024. The following databases were searched: MEDLINE, EMBASE, CENTRAL, BIOSIS Previews, and Web of Science Core Collection. Additionally, gray literature was searched in the National Grey Literature Collection. Furthermore, dissertations and PhD theses were retrieved from the Electronic Theses Online Service (EThOS) and the Open Access Theses and Dissertations (OATD) database. We reviewed the reference lists of all studies meeting the inclusion criteria for this scoping review for additional relevant publications.

Study Selection

Following the search, we collated all identified citations using Endnote X9 (Clarivate, Philadelphia, PA).[7] Duplicates were removed by Endnote following Bramer and Giustini[8] and then manually removed when further duplicates were found later in the review process. In the process of developing a cadaver lab for sonography on human cadavers, we wanted to learn from the experience of others. For this reason, we used a broad search strategy to generate a database on the use of sonography on human cadavers. We performed title and abstract screening in Endnote X9. The initial title and abstract screening were conducted by a single reviewer, who evaluated the search results against the minimum inclusion criteria of the database on the use of sonography on human cadavers. In the event of uncertainty, a second reviewer was consulted. To determine eligibility, two independent reviewers performed full-text review. To make the generated database on sonography on human cadavers more user-friendly, we ordered all citations according to the organ structures that the

identified study was written on. For this purpose, one reviewer generated a list of 12 main categories and 225 sub-categories of anatomical structures (Table 2 in the online appendix) and ordered each study into the corresponding folder. For this scoping review, all studies from the "cardiac" folder were reviewed in full text by two independent reviewers against the inclusion and exclusion criteria. Disagreements were resolved by involvement of a third reviewer at each stage.

Data Extraction and Synthesis

The following data were extracted from each article when available: authors; year of publication; journal in which the article was published; type of publication; country of origin; simulation setting; and evaluation of the simulation. Two extractors independently extracted the above-mentioned items, and their data were synthesized into a single table that summarized key findings. Additionally, a narrative review of the results of each included study was performed. In cases of disagreement, this was resolved through discussion.

RESULTS

Study Selection

The search yielded a total of 9,821 results, of which 4,775 were identified as duplicates and subsequently removed. A total of 1,440 records were subjected to full-text screening for eligibility. Of these, 10 publications were categorized into the "cardiac" folder, of which four publications were deemed eligible for inclusion. (See PRISMA flowchart in Figure 1.)

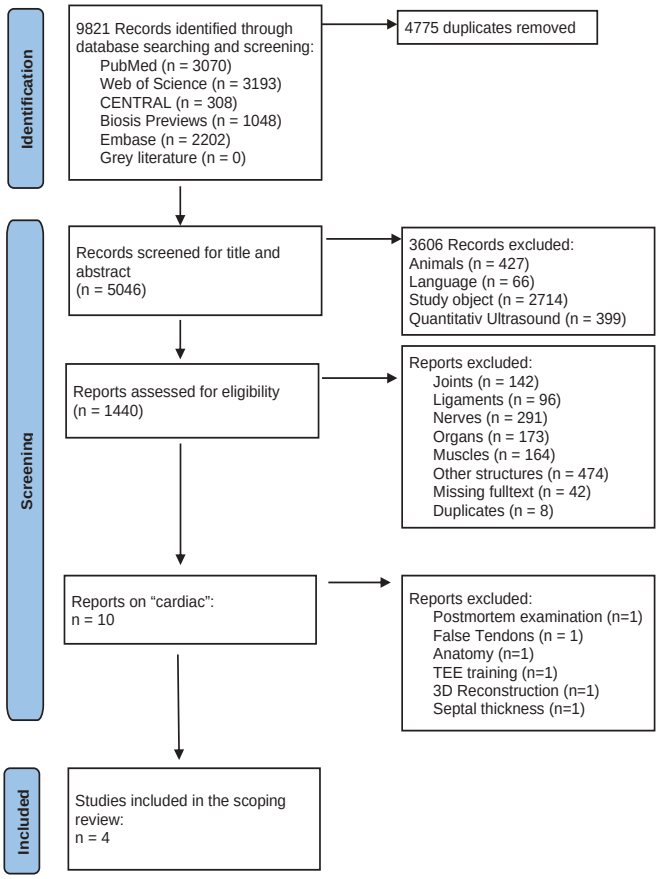

Figure 1. PRISMA flowchart.
PRISMA-ScR, Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews; *CENTRAL,* Cochrane Central Registration of Trials; *TEE,* transesophageal echogardiography.

Study Characteristics of Included Articles

All four included studies were written in English and were conducted in the USA. Two of the studies were published as conference abstracts, while the other two were published as original research articles. All studies were published in peer-reviewed journals, with two published in 2012, one in 2013, and one in 2023. None of the four studies indicated sources of funding. Three of the four studies were conducted by emergency physicians, while the remaining study was conducted by cardiologists. A comprehensive overview of the studies, including methodologies and key findings, is presented in Table 1.

Access to the Pericardial Sac with a Large-bore Catheter

Two studies report on the use of a large-bore catheter such as a sheath or a paracentesis catheter to fill the pericardial sac with fluid to simulate pericardial effusion.[9,10] Fenstad et al used fluoroscopy to insert a guidewire through the left subclavian vein into the right ventricle (RV) where the RV free wall was pierced to access the pericardial space. Subsequently, a sheath was advanced into the pericardial space and water (100-500 milliliters) was injected into the pericardial sac. In another study, a right-sided thoracotomy was performed, and a large-bore paracentesis catheter was inserted into the pericardial sac.[10] For this purpose a number 11 scalpel was used to create a nick in the pericardial sac and the large-bore paracentesis catheter was sutured to the pericardial sac. In this study, a normal saline bag hanging against gravity was used to fill the pericardial sac.

Access to the Pericardial Sac with a Peripheral Venous Cannula

One study reported on the use of a peripheral venous cannula to fill the pericardial sac with fluid.[11] In that study, a left-sided 3-4 centimeter mini thoracotomy was performed in the 5th intercostal space just over the cardiac apex. The left lung was retracted until the pericardial sac and phrenic nerve were identified. Using toothless forceps, an 18-gauge peripheral venous catheter was inserted into the pericardial sac. The peripheral venous catheter was sutured to the intercostal soft tissues and connected to a bag of normal saline, which was infused with a pressure bag.

Filling of the Pericardial Sac

Three of the four studies specified that they used an intravenous (IV) bag to fill the pericardial sac with fluid.[10-12]

Table 1. Characteristics of included studies.

Authors	Year	Journal	Publication type	Country of origin	Simulation Set-up	Evaluation of the simulation
Fenstad E et al[9]	2012	*Critical Care Medicine*	Conference (Abstract)	USA	Cadaver (not further specified), fluoroscopy guided puncture of the RV-free wall trough the left subclavian vein. Insertion of a sheath into the pericardial sac, injection of variable amounts of water (100-500 ml).	Likert-scale ratings, where 5 indicates very satisfied and 1 indicates very dissatisfied, were completed by 28 out of 36 participants (78%). The overall course satisfaction rating was 4.94.
Friedman TA et al[12]	2013	*Annals of Emergency Medicine*	Conference (Abstract)	USA	Fresh frozen cadavers were used, with a catheter placed in the pericardial sac and a hanging bag of saline. Methods were not further specified.	No evaluation of the simulation.
Inboriboon, PC et al[10]	2012	*Journal of Emergency Medicine*	Research Article ("How to")	USA	Soft cadavers were used, with a right-sided thoracotomy performed to introduce a large-bore paracentesis catheter into the pericardial sac. A saline bag was hung to gravity and attached to the catheter.	No evaluation of the simulation.
Oskar K et al[11]	2023	*Journal of Education & Teaching in Emergency Medicine*	Research Article ("How to")	USA	Soft cadavers were used, with a left-sided apical mini-thoracotomy performed. An 18-gauge angiocath was introduced into the pericardium and sutured to the intercostal soft tissue. A saline bag was attached to the catheter and infused using a pressure bag.	All nine participants were able to visualize the needle under dynamic ultrasound guidance. The model demonstrated no evidence of breakdown after approximately 40 to 50 punctures.

USA, United States of America; RV, right ventricle.

Inboriboon et al dyed the IV fluid with methylene blue. This allowed differentiation between a pericardial puncture (blue) and a cardiac puncture (red).[10] One study specified that they used an IV-pressure bag.[11]

Cadaver Type

In two studies soft cadavers were used; these cadavers were preserved by soft embalming rather than through a formalin-based fixation.[10,11] In contrast to traditional formaldehyde embalmment cadavers, soft-embalmed cadavers retain tissue flexibility and texture, which makes them especially suitable for procedural training. Another study used fresh-frozen cadavers.[12] One study did not further specify what cadaver type they used.[9]

Efficacy of Simulation and Quality of Pericardial Effusion on Ultrasound Image

Two manuscripts additionally reported on the efficacy of their simulation. In one study, participants were asked to rate their overall course satisfaction on a 5-point Likert scale (5 is very satisfied, 1 is very dissatisfied). Likert-scale ratings were completed by 28 of 36 participants (78%), and the overall course satisfaction was rated to be 4.94.[9] The second manuscripts noted that all nine participants were able to visualize the pericardiocentesis needle under dynamic ultrasound guidance and that the model did not demonstrate evidence of breakdown after approximately 40-50 punctures. The other manuscripts did not provide information on the quality of the pericardial effusion on ultrasound image. Moreover, the participants were asked to rate their pre- and post-training procedural confidence on a Likert scale from 0-7, where 7 is best. The average pre-training procedural confidence was 2.1 + 0.9, the average post-training procedural confidence 5.3 + 0.6 with an absolute change of +3.2 (95% CI 2.2-4.3, P <0.001). The participants were also asked to provide qualitative feedback. Here, the participants highlighted realism of the training model. However, only one of nine participants had previously performed an (emergency) pericardiocentesis in real life.[11]

DISCUSSION

This scoping review identified four studies that report on the use of a cadaver model for ultrasound- guided emergency pericardiocentesis simulation. Our scoping review indicates that both soft and fresh-frozen cadavers can be used for cadaver-based emergency pericardiocentesis simulation. Access to the pericardium was achieved using either large-bore catheters or peripheral venous catheters, with fluid infusion facilitated by IV bags hung against gravity or by using a pressure bag.

Different types of human cadavers are used in medical education, each offering distinct advantages and disadvantages. Formalin-embalmed cadavers are ideal for long-term preservation, but the stiffness induced by formalin compromises their natural flexibility.[13] In contrast, soft-embalmed cadavers maintain a more natural texture. However, they are susceptible to mold if not stored correctly, and their embalming process is more complex and costly compared to formalin-embalmed cadavers.[14] Soft-embalmed cadavers were rated to provide a higher degree of realism than formalin-embalmed cadavers in a study on cadaver-based thyroid surgery training.[15] Another option is a fresh-frozen cadaver. They are preserved shortly after death without chemical embalming and retain the texture, color, and structural integrity of fresh tissues. However, their handling and storage present challenges, and they must be thawed prior to use.[13] Often, cadavers are from older people, who typically experience sarcopenia, a natural age-related loss of muscle mass. In contrast, patients of many resuscitative procedures such as resuscitative thoracotomy are predominantly young and male.[17] Hence, some resuscitative procedures (such as resuscitative thoracotomy) are less physically demanding in cadaver labs than in real life.[18] However, for emergency pericardiocentesis training on human cadavers, this is usually not an issue, as the haptic feedback during the procedure closely resembles that of living patients. Access to cadavers remains a barrier as most cadaver labs located at universities, compounded by limited supply and the high costs associated with preparation, storage, and eventual burial.[19] Nonetheless, there are numerous commercial and academic, human cadaver-based courses for resuscitative procedures such as resuscitative thoracotomy. However, human cadavers seem not yet to be widely used for emergency pericardiocentesis simulation.[18]

Participants of emergency pericardiocentesis simulations on human cadavers rated themselves to be more confident in the procedure and highlighted the realism of the simulation on human cadavers.[11] While a positive self-evaluation does not necessarily translate to proficiency in performing resuscitative interventions, previous research indicates that physicians are less likely to commence resuscitative procedures when they lack confidence in performing them, highlighting that perceived self-efficacy is a determinant of performance in resuscitative practice.[20] Procedural competency for other life-saving procedures such as rapid sequence intubation (RSI) or tube thoracostomy can be acquired by training in the emergency department, as these are required sufficiently frequently.[21] However, emergency pericardiocentesis is a rare procedure that might even have to be performed without the back-up of a colleague with prior experience in emergency pericardiocentesis.

Learning Points from this Scoping Review for Our Own Cadaver Lab

This scoping review provided valuable insights for developing a soft-embalmed cadaver emergency pericardiocentesis simulation. Previous simulations at our institution faced issues such as fluid leakage from the pericardial sac, simulation breakdown after a few punctures, and poor ultrasound quality of the pericardial effusion.

Building upon this scoping review and prior experience, a new simulation was developed. All consent requirements were met in accordance with Article 36 of the Human Research Act (HRA), and prior determination of death was conducted as per Article 37, paragraph 1 HRA. In this simulation, the pericardial sac is continuously filled with fluid through a pressured infusion via a right-sided mini-thoracotomy (see Figures 2 and 3). As in previous experiments

Figure 2. Right-sided mini-thoracotomy in the 4th intercostal space at the anterior axillary line.
A 14G peripheral venous cannula is sutured into the pericardium, as described in Table 2.

Figure 3. Simulation setup.
The peripheral venous catheter in the pericardial sac and the subclavian central line are both connected to a pressure infusion via IV tubing.

the heart appeared as a single mass on ultrasound, the heart chambers were filled with fluid to enable their identification. Additionally, the left hemithorax was filled with fluid to facilitate pericardiocentesis training from all three approaches (subxiphoidal, apical, and parasternal). The abdomen in soft-embalmed cadavers is usually collapsed, which potentially makes subxiphoid pericardiocentesis easier than in real patients. To mitigate this, fluid was introduced into the abdominal cavity to create a more distended appearance. Detailed setup instructions are provided in Table 2.

The simulation setup yielded ultrasound images consistently rated as highly realistic by all authors with real-world experience in emergency pericardiocentesis. Notably, even after approximately 50 punctures and dilations, no structural breakdown was observed in the cadaver model. Importantly, the modifications to the soft-embalmed cadaver did not compromise the realism of training for other resuscitative procedures. This was crucial, as both ethical and financial considerations must be carefully weighed when using human cadavers. The right-sided mini-thoracotomy used to fill the pericardial sac did not interfere with resuscitative thoracotomy training. In fact, the presence of fluid in the left chest and pericardial sac enhanced the fidelity by simulating pathologies commonly encountered during resuscitative thoracotomy for traumatic cardiac arrest (TCA). Additionally, the cadaver allowed for the identification of TCA-associated pathologies with ultrasound, such as free fluid in the pericardium, left chest, and abdomen.

Further research should evaluate the quality of the effusion as observed on ultrasound, as well as participants´ perceived procedural competency following the simulation. Moreover, authors should focus on providing a well-documented methodology for their human cadaver-simulation setup. By these means, other programs can replicate the setup and benefit from the insights gained.

LIMITATIONS

This scoping review was conducted based on a database of ultrasound-guided procedures on human cadavers. Hence, a very broad search strategy was used to generate this database. (See Table 1 in the online appendix.) During the initial screening process, many irrelevant citations related to transplantation were found, prompting the addition of the Boolean operator "NOT transplantation" to the search string. While this might have excluded studies that involved the transplantation of other tissues into human cadavers for emergency pericardiocentesis training, it seems unlikely that this substantially impacted our results.

Table 2. Materials and instructions for setting up human cadaver emergency pericardiocentesis simulation.

Materials:

1x DeBakey (mini-Finochietto) rib spreader
1x 14G peripheral venous cannula (Vasofix Safety, B. Braun Melsungen SE, Melsungen, Germany)
2x 10G peripheral venous cannula (BD angiocath Becton, Dickinson and Company, Franklin Lakes, NJ, USA)
4x IV-giving set (Intrafix SafeSet, B. Braun Melsungen SE, Melsungen, Germany)
Approx. 9x 1000mL bag of normal saline
1x 3-way-stopcock with 10cm connection tubing (Discofix, B. Braun Melsungen SE, Melsungen, Germany)
4x 1000mL pressure infusion bag
1x red food dye
1x 8Fr two-lumen-central line (with Blue FlexTip, Arrow International, Inc, Reading, PA, USA)
2x 2.0 monofilament sutures (SERALON blau monofil, Serag- Wiessner, GmbH & Co, Naila, Germany)
1x DeBakey 25cm needle holder
1x DeBakey atraumatic dissecting forceps
1x Scalpel No 10

1. **Filling of the Pericardial Sac:** An approximately 6 cm incision is made at approximately the 4th right intercostal space at the anterior axillary line. The intercostal muscles are dissected from the rib until the right lung is exposed. Using a needle holder, the lung is gently pressed downward to expose the pericardium. A 14G peripheral venous cannula is then inserted into the pericardial sac and secured with sutures (Figure 2). A 3-way stopcock is attached so that the IV tubing can be more easily connected to the cannula, and 1–2L of normal saline is infused using a pressure bag. Red food dye may be added to enhance realism. The infusion must remain pressurized throughout the pericardiocentesis simulation.

2. **Filling of the Heart Chambers:** A right-sided subclavian central line is inserted using an open surgical technique. If large blood clots are present in the subclavian vein, they must be removed using forceps to allow central line insertion. A pressure bag is then attached to the central line to fill the heart chambers, allowing proper visualization of the heart and its chambers on ultrasound imaging.

3. **Filling of the Left Hemithorax:** A 10G peripheral venous cannula is placed in the 4th left intercostal space at the mid-axillary line. A pressure bag is used to infuse 2-3L of normal saline until the left hemithorax is completely filled. This step is essential for enabling parasternal and apical ultrasound imaging.

4. **Filling of the Abdominal Cavity:** A 10G peripheral venous cannula is inserted into the abdominal cavity. Approximately 3L of normal saline are infused via a pressure bag until the abdomen becomes distended.

CONCLUSION

Evidence on ultrasound-guided emergency pericardiocentesis simulation on cadavers remains limited. However, four studies show that it is feasible to use human cadavers for simulation of (emergency) pericardiocentesis.

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Diagnostic Delays Are Common, and Classic Presentations Are Rare in Spinal Epidural Abscess

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Introduction: Spinal epidural abscess (SEA) is a rare surgical emergency of the spine that can result in permanent neurological injury if not diagnosed and treated in a timely manner. Because early presentation can appear similar to benign back or neck pain, delays in diagnosis may be relatively common. We sought an improved understanding of the characteristics associated with SEA and frequency of delays in SEA diagnosis.

Methods: We conducted a retrospective cohort study of adult patients with new magnetic resonance imaging-confirmed SEA from January 1, 2016–December 31, 2019 in an integrated healthcare system. We applied electronic data abstraction and focused manual chart review to describe potentially SEA-related ambulatory and emergency visits in the 30 days prior to SEA diagnosis, and patient characteristics including comorbidities, potential risk factors, and presenting signs and symptoms. We described the frequency of potential delays in diagnosis and of previously described clinical characteristics and risk factors for SEA.

Results: Spinal epidural abscess was diagnosed in 457 patients during the study period, 178 (39%) of whom were female, with median age 63 years (interquartile range 45-81 years). More than two-thirds of patients had at least one visit prior to diagnosis (323, 71%), and SEA location was most commonly the lumbar spine (235, 51%). Although over 90% of patients presented with back or neck pain or tenderness, the classic triad of back pain, fever, and neurologic symptoms was present in only 10% of patients. Diabetes mellitus and infection in the prior 90 days were common, while injection drug use, chronic steroid use, HIV infection, and solid organ transplant were rare.

Conclusion: In an integrated healthcare system, 71% of patients with spinal epidural abscess had potentially related ambulatory care or emergency visits in the 30 days prior to diagnosis. Diagnosis of SEA remains challenging, with multiple visits common before the diagnosis is clear. [West J Emerg Med. 2025;26(3)692–699.]

INTRODUCTION

Spinal epidural abscess (SEA) is a rare condition with increasing incidence over the past decade, which if not promptly diagnosed and treated can lead to permanent and devastating neurologic disability.[1,2] It is a condition associated with high morbidity resulting in permanent neurologic deficit

in approximately one-third of SEA patients.[3] Accurate diagnosis requires mobilization of magnetic resonance imaging (MRI), the diagnostic gold standard, but it is a relatively scarce and time-consuming resource in emergent situations. The clinical presentation of SEA can vary, however, and many patients have multiple visits before diagnosis.[4] The most common complaint in SEA malpractice claims is delay in diagnosis, and mean claim payouts are between $4-5 million dollars.[5,6]

Despite our understanding of the diagnostic urgency of SEA, clinical guidance to determine which patients need emergent MRI is sparse. Beyond a high index of clinical suspicion, the classic triad of back pain, fever, and neurologic deficit is present in only a minority of patients with SEA.[1] Obtaining an MRI in all ED patients with neck or back pain, however, is impractical and would lead to low-yield over-testing. This dilemma may give rise to delays in diagnosis, which are costly and associated with worse long-term neurologic outcomes.[4,6-9]

Previous literature on SEA is comprised largely of case series over long periods or single institutions, and published risk factors across varied study populations may include coincident conditions rather than causal risk factors, complicating risk assessment.[2,3,10-15] Small studies and case series postulate characteristics associated with SEA, including advanced age, gender, diabetes, end-stage renal disease, history of spine surgery or dental work, immune compromised state, injection drug use, trauma, and alcohol use disorder.[2,8,16,17] Laboratory and exam findings associated with SEA include elevated serum inflammatory markers (C-reactive protein [CRP], erythrocyte sedimentation rate [ESR], leukocytosis), fever, back pain, and progressive neurologic deficit.[14,18] Given the relatively small case series and variation in described SEA characteristics, a larger dataset over a shorter time period would add to our understanding of the disease.

We sought to describe SEA characteristics and the frequency of potential delay in diagnosis in a large integrated healthcare system. We hypothesized that classic presentations would be rare and that potential delays in diagnosis would be common.

Population Health Research Capsule

What do we already know about this issue?
Spinal epidural abscess (SEA) is a rare surgical emergency with variable clinical presentations that can result in permanent neurological injury if not promptly diagnosed.

What was the research question?
How common is delay in diagnosis, and what are the characteristics of patients with SEA?

What was the major finding of the study?
Most (70.7%) patients had a delay in diagnosis. Only 10.7% of patients had the triad of back or neck pain, fever, and weakness.

How does this improve population health?
This study highlights challenges associated with the timely diagnosis of SEA and the lack of any specific clinical or sociodemographic factors associated with this delay.

METHODS

Study Setting and Participants

We conducted a cross-sectional study of adult (≥18 years of age) patients diagnosed with SEA from January 1, 2016–December 31, 2019 at Kaiser Permanente Northern California (KPNC), an integrated healthcare system. KPNC provides care to over four million individuals who are representative of the surrounding community with respect to demographics, socioeconomics and medical conditions.[19,20] Patients were included in the study if they had a new diagnosis of SEA (spine MRI with epidural fluid collection or phlegmon within three days of diagnosis documentation), and were health plan subscribers in 9 of the 12 months prior to diagnosis (to ensure complete health records for data extraction).

Study Design

The KPNC Institutional Review Board granted permission to publish fully anonymized, aggregate data, with a waiver of individual patient consent. We used electronically extracted and manually reviewed data to confirm SEA diagnosis and ascertain patient and SEA characteristics, as well as history of potentially related ambulatory or emergency department (ED) visits in the 30 days prior to diagnosis. Patient demographics, comorbidities, social history (injection drug use, illicit drug use, and alcohol use disorder), infection 90 days prior or spine instrumentation 30 days prior to diagnosis, and presence of indwelling vascular catheter were all evaluated.

Main Variable of Interest

Our main variable of interest was the prevalence of potential diagnostic delay, defined as a visit in the 30 days prior to SEA diagnosis in ambulatory care (primary care, spine surgery, physical medicine and rehabilitation, neurology, and orthopedics) or the ED with documentation of any of the following: back or neck pain; fever or chills; radicular pain; sensory changes; motor weakness; or cauda equina symptoms or findings.

Covariables

Electronic variables were extracted from the electronic health record (EHR) (Epic Systems Corporation, Verona,

WI) and its associated databases by experienced data analysts (MA, BFF). The following data elements were extracted electronically: age; sex; ethnicity/race; English language preference; and neighborhood deprivation index (NDI, a composite measure of socioeconomic status); body mass index (BMI); solid organ transplant; alcohol use disorder; chronic steroid use; chronic liver disease; chronic kidney disease; diabetes; HIV infection; 90-day prior sepsis, bacteremia, endocarditis, or joint, urinary or skin/soft tissue infection (International Classification of Diseases, Rev 10 [ICD-10] codes).

Structured Electronic Health Record Review

Manual chart review was performed by investigators who were trained prior to data collection. A coding manual containing a priori definitions of positive findings (explicitly documented notation of presence) and negative findings (explicit documentation of negative findings or no documentation) was reviewed with all investigators prior to commencing chart review, and MVK trained reviewers on the data collection tool and process. Inclusion criteria, exclusion criteria, and variables for case selection were defined a priori. Although investigators were not blinded to the outcome, variables and their coding were pre-defined and discrepancies were adjudicated by the two co-principal investigators (SMC and MVK), with a consensus decision based on definitions in the coding manual.

All chart abstractors received standardized training on data collection methods and use of the electronic data collection instrument, which was modified to its final form after pilot testing. SMC and MVK answered and arbitrated all coding questions and monitored data collection activities by reviewing each abstractor's performance at regular intervals throughout the abstraction period. Inter-rater reliability was tested as excellent (kappa = 0.8649, 95% confidence interval 0.7180-1.0000) between the co-principal investigators who performed the majority of chart reviews and supervised chart abstraction.

All matching ICD-10 code diagnoses during the study period were extracted from the KPNC EHR. Chart abstractors then manually validated the presence of a new SEA diagnosis by chart review. Missing values for demographic and clinical variables were not imputed and are enumerated in their respective tables. We limited our analyses to descriptive statistics and univariate regression; so, these missing variables were not critical. All criteria for health record review as outlined by Worster and Bledsoe were followed except for calculating IRR for the non-co-PI chart abstractors, as mentioned previously.[21]

Specific manually abstracted elements were confirmation of new SEA diagnosis and location (MRI findings of epidural fluid collection or phlegmon); social history (unhoused status, current use of tobacco, illicit drugs, injection drugs, and/or alcohol use disorder); previous 30 day spine instrumentation (epidural injection, paravertebral facet joint denervation [radiofrequency neurolysis]; paravertebral facet joint injections or blocks; sacroiliac joint injections; lumbar/pre-sacral spinal fusion surgery; spinal decompression surgery; artificial intervertebral disc replacement; release of spinal cord, excision of joint or disc, spinal cord stimulator); 90 day prior antibiotic prescription; and presence of indwelling vascular catheter (peripherally inserted central catheter, hemodialysis catheter, chemotherapy port). For the index visit (visit during which a spine MRI was ordered) and for visits in the 30 days prior to diagnosis in ambulatory care or the ED, we extracted presenting signs and symptoms consistent with SEA (i.e., fever or chills, documented temperature at or above 38°C or 100.4°F, complaint of back or neck pain, spinal tenderness to palpation, radicular pain, sensory changes, motor weakness, cauda equina constellation [urinary retention >200 milliliters, new urinary or stool incontinence, decreased rectal tone and/or saddle or perineal anesthesia]).

Statistical Analysis

We calculated descriptive statistics (frequencies, proportions, means and medians) for demographic and clinical characteristics of patients diagnosed with SEA. Categorical variables, including risk factors, presence of sensory, motor, or perineal findings on exam at the time of index diagnosis, are presented as proportions. Continuous variables including laboratory tests (CBC, ESR, CRP), are presented as means with standard deviations or median values and interquartile ranges. We conducted a bivariate analysis to identify covariates associated with the potential delay in SEA diagnosis using chi-square or Fisher exact tests for categorical variables, and *t*-test or non-parametric tests for continuous variables. We conducted analyses using SAS 9.4, (SAS Institute In., Cary, NC) with the threshold of significance set at two-sided $P<0.05$.

RESULTS

After applying exclusion criteria, the 457 patients included in the study cohort (Figure 1), had a median age of 63 years (interquartile range 45-81 years), and 178 (39%) were female. Over two-thirds of patients (323, 70.7%) had at least one visit in the 30 days prior to SEA diagnosis for back or neck pain, fever, radicular pain, focal weakness, or numbness. Race/ethnicity and primary English language preference were similar between patients with 30-day prior visits and those without. Chronic steroid use, solid organ transplant, HIV infection, and injection drug use were infrequent, while diabetes mellitus and recent infection were common (Table 1). Of these variables, only chronic steroid use (9.0% vs 2.2%) and unhoused status (0.3% vs 3.7%) showed a statistically significant difference in delay vs no delay in diagnosis, although very few of our patients were chronic steroid users or unhoused (32 and 6, respectively).

At diagnosis, at least one element of the classic triad of back or neck pain, fever, and weakness was commonly

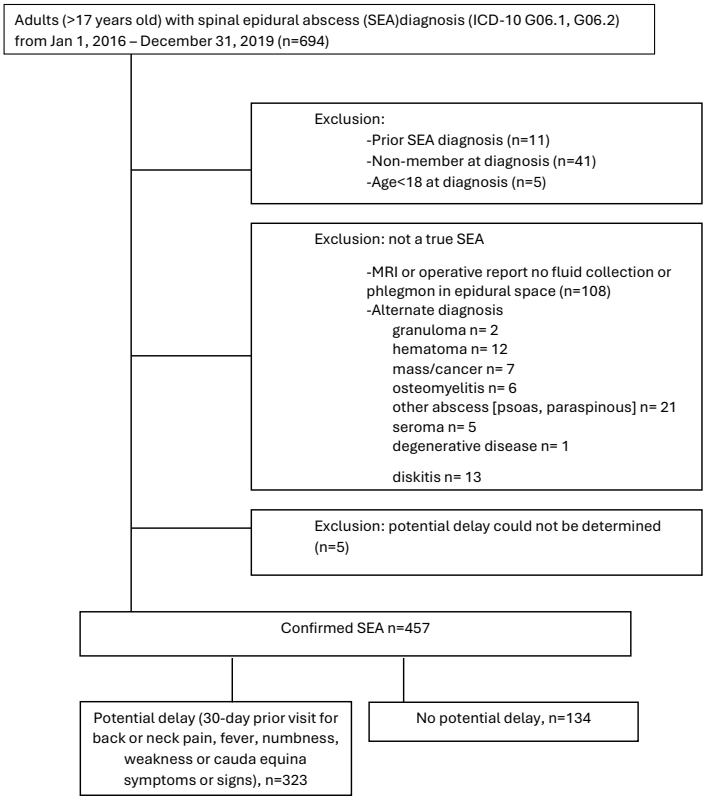

Figure. Cohort assembly of patients with spinal epidural abscess.

present, with 91% of patients presenting with back or neck pain; however, only 10.7% of patients had all three triad elements (Table 2). Elevated temperature was present in 27% of patients with potential delay and 34% without potential delay. Weakness or motor findings were present in 27% and 31% of patients with and without potential delay, respectively. Although the difference in the proportion of weakness or motor findings between patients with and without potential delay did not reach statistical significance (27% vs 31%, *P*=0.09), the trend suggests a possible association (Table 2).

Among patients with a delay in diagnosis, most (69%) had two or fewer potentially related visits prior to diagnosis with a mean of 2.18 visits (95% CI 2.03-2.34). The number of visits prior to diagnosis in this group is tabulated in Table 3. Among this group, the average time between their initial visit and the index visit (diagnosis) was 12.82 days (95% CI 11.79-13.84).

DISCUSSION

In this retrospective study of ED patients with SEA, 70.7% of patients had at least one ambulatory care or ED visit in the 30 days prior to diagnosis (visit documentation of back or neck pain, fever or chills, radicular pain, sensory changes, motor weakness, or cauda equina symptoms). Previously described risk factors of chronic steroid use, HIV infection, injection drug use, and solid organ transplant were infrequently observed, while diabetes mellitus was present in over one-third of the cohort. Fever and neck or back pain were common.

Our study highlights some of the challenges in diagnosing SEA and aligns with other literature on SEA characteristics. Not only was at least one prior potentially related visit common among patients diagnosed with SEA, but the most common presenting symptom—back or neck pain or tenderness—has a broad differential diagnosis with many benign etiologies. Our finding that fever and back or neck pain were common in both groups, those with and those without potential delay in diagnosis, underscores the challenge of finding serious causes of back or neck pain in ambulatory and emergency settings. A systematic review of 40 publications on SEA found the most common characteristics associated with SEA were fever and spinal pain.[22] Proposed clinical risk prediction scores for SEA or pyogenic spinal infection include clinical and historical features such as injection drug use, liver disease, diabetes, spine instrumentation, recent infection, and indwelling catheters as well as progressive neurological deficit, CRP and fever, and may aid in identifying potential SEA among myriad other causes of back pain.[23-25] Several of these characteristics were common in our cohort, including diabetes, fever, back or neck pain, and recent infection.

We did not observe racial or ethnic disparities in association with potential diagnostic delay nor was English language preference or socioeconomic status associated with potential delay in diagnosis in bivariate analyses. Larger studies report that Black and Hispanic non-White patients may be less likely to undergo advanced imaging in the ED, and racial disparities associated with delayed diagnosis of conditions from malignancy to infection are well described.[26-30] The observation that age, race/ethnicity, and sex were not associated with potential diagnostic delay in our cohort may reflect more equitable access to health services among members of an integrated healthcare system; however, absent a large enough sample to perform multivariable analyses, interactions between these characteristics may be present, complicating the interpretation of these results. We may have inadvertently excluded patients with other risk profiles including injection drug use, unhoused status, or alcohol use disorders from our analysis as they may be under-represented within our system.

The timing of diagnosis and intervention remains of paramount importance in SEA. Although robust data on the optimal timing of surgical intervention is sparse, limited data describes more favorable neurologic outcomes with earlier (<24 hours) surgical management.[31] Our observation of a non-statistically significant association (P = 0.09) between weakness or motor findings and delay in diagnosis aligns with the expectation that patients experiencing longer delays may manifest neurological motor weakness over time. Had we identified additional factors associated with delayed diagnosis, these could have served as potential red flags for clinicians to consider in patients presenting to the ED with back pain or fever. Back pain, however, is the eighth most

Table 1. Characteristics of patients diagnosed with spinal epidural abscess.

Characteristics*	All SEA patients (N=457, 100%)	Potential delay in diagnosis (n=323, 70.7%)	No potential delay in diagnosis (n=134, 29.3%)	*P*-value†
Age (Years), median (IQR)	63.0 (54.0-72.0)	63.0 (55.0-72.0)	63.0 (53.0-71.0)	0.90
Sex, n (%)				0.70
Female	178 (39.0)	124 (38.4)	54 (40.3)	
Male	279 (61.0)	199 (61.6)	80 (59.7)	
Race/Ethnicity, n (%)				0.87
White	273 (59.7)	191 (59.1)	82 (61.2)	
Asian/Pacific Islander	47 (10.3)	33 (10.2)	14 (10.4)	
Black	48 (10.5)	36 (11.2)	12 (9.0)	
Hispanic/Latinx	67 (14.7)	49 (15.2)	18 (13.4)	
Other‡	22 (4.8)	14 (4.3)	8 (6.0)	
Preferred language English§, n (%)	432 (94.5)	303 (93.8)	129 (96.3)	0.29
NDI§, n (%)				0.24
<25th percentile (least deprived)	114 (25.0)	79 (24.6)	35 (26.1)	
25th to <50th percentile	115 (25.3)	89 (27.7)	26 (19.4)	
50th to <75th percentile	120 (26.4)	84 (26.2)	36 (26.9)	
75th percentile or higher (most deprived)	106 (23.3)	69 (21.5)	37 (27.6)	
BMI§ (kg/m^2), median (IQR)	28.0 (24.0-32.6)	28.0 (23.9-32.7)	28.2 (24.8-32.0)	0.83
Obese (≥30.0), n (%)	170 (37.5)	123 (38.1)	47 (36.2)	0.70
Unhoused status, n (%)	6 (1.3)	1 (0.3)	5 (3.7)	0.005
Alcohol use disorder, n (%)	39 (8.5)	24 (7.4)	15 (11.2)	0.28
Injection drug use, n (%)	22 (4.8)	13 (4.0)	9 (6.7)	0.21
Chronic steroid use, n (%)	32 (7.0)	29 (9.0)	3 (2.2)	0.01
Solid organ transplant, n (%)	6 (1.3)	6 (1.9)	0 (0.0)	0.19
HIV, n (%)	6 (1.3)	2 (0.6)	4 (3.0)	0.06
Diabetes mellitus, n (%)	158 (34.6)	116 (35.9)	42 (31.3)	0.35
Liver disease, n (%)	26 (5.7)	21 (6.5)	5 (3.7)	0.24
Kidney disease, n (%)	119 (26.0)	84 (26.0)	35 (26.1)	0.98
Recent infection, n (%)	192 (42.0)	144 (44.6)	48 (35.8)	0.14
Spine instrumentation, n (%)	49 (10.7)	34 (10.5)	15 (11.2)	0.70
Indwelling vascular catheter, n (%)	52 (11.4)	42 (13.0)	10 (7.5)	0.15

*Age and NDI were at study index date; body mass index was closest to the index date and within ±30 days of study index date; recent infection and indwelling vascular catheter were within 90 days prior to study index date; spine instrumentation was within 30 days prior to study index date; all other clinical characteristics were within one year prior to study index date.
†Comparisons were made using chi-squared or Fisher exact test for categorical variables and Wilcoxon-Mann-Whitney tests for non-parametric continuous variables.
‡Other race/ethnicity: Multiple race (n=15); Native American (n=4); Unknown (n=3)
§Missing values: Preferred language (n=25); NDI (n=2); BMI (n=4)
SEA, spinal epidural abscess; *IQR,* interquartile range; *NDI,* Neighborhood Deprivation Index; *BMI,* body mass index; *kg/m^2*, kilogram per meter squared.

common reason for ED presentation, and fever is the fifth.[32] Obtaining advanced imaging on every patient with back pain, or even the combination of back pain and fever, is infeasible and unnecessary.

One of the challenges in diagnosing SEA is that presentations might not be classic until SEA has progressed substantially; so delays from the first symptom to definitive SEA diagnosis may be common. In fact, increased time to diagnosis has been noted among patients with errors in SEA diagnosis and frequency of diagnostic delay may be as high as 75%.[4,24] Given the prevalent allegation of delayed diagnosis and high malpractice settlements in successful SEA claims, non-operative clinicians, including emergency physicians, may be at higher risk of litigation.[6] A multitude of proposed

Table 2. Spinal epidural abscess patient characteristics at diagnosis.

Characteristics*	All SEA patients (N=457, 100%)	Potential delay (n=323, 70.7%)	No potential delay (n=134, 29.3%)	P-value†
Vital signs on index visit‡, n (%)				
Temperature, elevated (>100.4°F)	132 (29.3)	87 (27.3)	45 (34.4)	0.13
Respiration, high (>20/min)	169 (37.6)	117 (36.9)	52 (39.7)	0.58
Heart rate, high (>90/bpm)	321 (71.3)	223 (69.9)	98 (74.8)	0.30
Systolic, low (<90 mm Hg)	34 (7.6)	25 (7.8)	9 (6.9)	0.72
History and exam findings, n (%)				
Fever or chills	165 (36.1)	111 (34.4)	54 (40.3)	0.11
Radicular pain	165 (36.1)	125 (38.7)	40 (29.8)	0.19
Neck/back pain/spine tenderness	417 (91.2)	295 (91.3)	122 (91.0)	0.94
Sensory changes or symptoms	86 (18.8)	64 (19.8)	22 (16.4)	0.25
Weakness or motor findings	129 (28.2)	88 (27.2)	41 (30.6)	0.09
Back or neck pain, fever, and weakness	49 (10.7)	31 (9.6)	18 (13.4)	0.23
Cauda equina symptoms / findings (new bowel or bladder incontinence, decreased rectal tone, post void residual >200 mL)	57 (12.5)	44 (13.6)	13 (9.7)	0.15
Abscess location, n (%)				0.16
Cervical	50 (10.9)	40 (12.4)	10 (7.5)	
Thoracic	77 (16.8)	53 (16.4)	24 (17.9)	
Lumbar	235 (51.4)	170 (52.6)	65 (48.5)	
Multiple	95 (20.8)	60 (18.6)	35 (26.1)	
Laboratory data§				
WBC, median (IQR)	13.2 (8.9-16.9)	12.1 (8.9-16.4)	12.3 (9.0-17.7)	0.89
Neutrophil, median (IQR)	10.0 (6.5-12.9)	9.1 (6.5-12.6)	10.0 (6.3-14.1)	0.20
ESR (mm/hr), median (IQR)	77.1 (54.0-101.5)	84.5 (58.0-102.0)	78.0 (48.0-100.0)	0.28
CRP (mg/L), median (IQR)	15.3 (5.8-23.2)	14.0 (5.7-23.0)	12.7 (6.7-23.6)	0.46
Blood or abscess fluid culture, n (%)				0.46
Staphylococcus aureus, methicillin-sensitive	137 (31.0)	99 (31.7)	38 (29.2)	
S. aureus, methicillin-resistant	25 (5.7)	14 (4.5)	11 (8.5)	
S. aureus, coagulase-negative	9 (2.0)	8 (2.6)	1 (0.8)	
Other bacterial	90 (20.4)	64 (20.5)	26 (20.0)	
Other (Cryptosporidium, fungal)	2 (0.0)	1 (0.3)	1 (0.8)	
No growth	179 (42.4)	126 (40.4)	53 (40.8)	

*Vital sign measurements were within ±1 day of study index date; lab results were within ±3 days prior to study index date; all other clinical characteristics were within one year prior to study index date.
†Comparisons were made using chi-squared or Fisher's exact tests for categorical variables and Wilcoxon-Mann-Whitney tests for nonparametric continuous variables.
‡Missing vitals values: temperature (n=7); respiration (n=8); heart rate (n=7); blood pressure (n=7)
§Missing lab values: WBC (n=18); neutrophil (n=73); ESR (n=168); CRP (n=166); blood/abscess cultures (n=15)
SEA, Spinal epidural abscess; *WBC,* white blood cell; *ESR,* erythrocyte sedimentation rate; *CRP,* C-reactive protein; *IQR,* interquartile range.

risk factors and the frequency of back pain-related ED visits make diagnosing SEA akin to finding a needle in a haystack; one multistate study noted a 0.1% rate of intraspinal abscess among 1.3 million patients discharged from the ED with a non-specific back pain diagnosis.[33] In our cohort, the prevalence of many frequently described SEA risk factors was similar among patients with and without prior visits (potential diagnostic delays), underscoring that SEA may persist as a difficult diagnosis to make without the "tincture of time" or repeated evaluation.

Table 3. Number of visits prior to diagnosis in cases of delayed diagnosis.

Number of visits	Frequency	Percent	Cumulative frequency	Cumulative percent
1	138	42.72	138	42.72
2	85	26.32	223	69.04
3	47	14.55	270	83.59
4	30	9.29	300	92.88
5	11	3.41	311	96.28
6	7	2.17	318	98.45
7	3	0.93	321	99.38
8	1	0.31	322	99.69
9	1	0.31	323	100.00

LIMITATIONS

This retrospective study had several limitations. Only patients with health plan membership were included, but SEA risk factors encompass some variables that may be more common in patients without regular care access (eg, homelessness, substance use); thus, our ability to discern significant associations between these less common risk factors and diagnostic delay was limited. However, KPNC members are representative of the surrounding communities with respect to demographics, comorbidities, and health status. Because the study was designed to examine visits prior to diagnosis, there was no feasible way to include patients without health plan membership, who would not have had prior outpatient visits in our system. We relied on chart review for some variables as we could not feasibly extract these datapoints electronically. Chart review followed a priori definitions established by the PIs based on published definitions in the literature, with training of chart reviewers on the most complex chart-review variables. We relied on documentation of key risk factors (social history) that depend on the clinician asking the question and documenting the answer in their note.

Missing data were coded as absence of that variable if not documented or if documented as negative. Although we constructed an extensive list of variables previously studied, it is possible that confounding variables or unknown significant risk factors were not included. We included all SEA cases over a consecutive four-year period, but SEA is rare; so our sample was underpowered to perform adjusted analyses of characteristics associated with potential delay in diagnosis. Nevertheless, it is a larger sample in a shorter period than current studies.

CONCLUSION

Our study highlights some of the challenges associated with the timely diagnosis of spinal epidural abscess. Potential delay in diagnosis appears to be the rule rather than the exception, and we did not find any specific clinical or sociodemographic factors that were associated with this delay. It is unclear whether this reflects the inherent challenge of diagnosing SEA or whether participation in an integrated healthcare system may attenuate some of these effects. Further studies could help uncover some of the reasons for delay, as well as better elucidate risk factors for SEA.

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Practical Status and Social Background of Current Mobile Stroke Units Worldwide: A Survey and Investigation

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Background: We aimed to clarify the current challenges involved in introducing and operating mobile stroke units (MSU) in new regions, considering the social background of regions with MSUs.

Methods: We conducted a questionnaire survey on the operational and financial status of all active MSU programs worldwide as of March 2023, and investigated the demographic, economic, and healthcare backgrounds of areas with and without active MSUs. We compared the data for the two groups at the country, state, or city level. We then correlated data gathered from the survey and the investigation.

Results: Of the 33 MSU programs contacted, 19 (59%) responded. The responding programs treated a range of 52-1,663 (median 781) patients at an MSU per year. The most commonly reported hours of operation were eight hours every weekday (5, 26%). The majority had four staff on board (11, 58%). No physicians were on board in six MSUs (32%). The catchment area radius ranged from 5-250 (median 22) kilometers. The start-up costs and subsequent annual operation costs of an MSU ranged from $0.7-1.8 million (median 1.0) and $0.7 -1.7 (median 1.0) million US dollars, respectively. Reimbursement was obtained by eight (47%), with full reimbursement by two (12%). A negative gross financial balance was reported in eight MSUs (53%, of 15), and a financial challenge was reported in 17 (94%, of 18). Compared to the non-MSU group at the country level, active MSU groups had a significantly higher population, nominal gross domestic product, healthcare access and quality index, and physician density. They also had significantly lower age-standardized stroke incidence rates and age-standardized stroke disability-adjusted life year rate. The MSU operation time was significantly positively correlated with age-standardized stroke incidence rate and negatively with physician density.

Conclusion: Despite facing serious financial problems, mobile stroke units currently operate around the world. However, the social context of MSUs appears relatively advanced. For future implementation of MSUs, cost-saving strategies and reimbursements should be addressed, and national or regional social backgrounds should be considered. [West J Emerg Med. 2025;26(3)700–711.]

INTRODUCTION

A mobile stroke unit (MSU) is a specialized ambulance equipped with a computed tomography (CT) scanner and telemedicine capabilities. The MSUs allow for the diagnosis and treatment of acute stroke patients at emergency scenes and enable prehospital triage to ensure that a patient is sent to the

most appropriate hospital. The clinical usefulness of MSUs for tissue plasminogen activator treatment in ischemic stroke patients has been evidenced in terms of functional outcomes.[1,2] Similarly, studies have shown that MSUs are more cost effective compared to standard ambulances.[3,4] The MSUs can also save time from dispatch to mechanical thrombectomy in ischemic stroke patients, decreasing their odds of suffering disabilities.[5] In patients with intracerebral hemorrhage, MSUs facilitate ultra-early management or prehospital triage.[6]

Since the first MSU was introduced in Homburg, Germany, in 2008,[7] the use of MSUs has gradually spread around the world. According to the updated world map of MSUs created by Fassbender et al,[8] there were 33 active MSU programs worldwide as of 2022 with an additional eight MSU programs in the planning or implementation stage. The distribution of MSUs appears to be concentrated in North America and Western Europe. Because stroke is the second leading cause of both disability and death globally, with the highest burden of the disease in the countries or regions of Africa and Asia,[9] the implementation of MSUs in such regions is expected.[8]

However, despite the cost effectiveness of MSUs, the high cost of their installation and operation and the uncertainty of reimbursements pose a financial barrier.[10,11] These issues create a significant obstacle to implementing MSUs, especially in remote and rural areas or in developing countries.[12,13] For project teams planning to install and continuously operate MSUs in new regions, it is essential to develop a working organization and socio-technical infrastructure.[14] Additionally, it is crucial to update understanding of the current status of active MSUs worldwide and clarify their social background, since this has never been studied.

In this study, we conducted a global survey to update data regarding the current practical status of MSUs and a novel investigation to clarify the social backgrounds of regions with and without MSUs. The survey was conducted independently of the support of the Prehospital Stroke Treatment Organization (PRESTO [https://www.prestomsu.org/]), an international consortium of MSUs, as we sought to obtain information from non-PRESTO MSU programs, presenting ourselves as questioners exploring the implementation of and business plans for MSUs.[11,15]

Population Health Research Capsule

What do we already know about this issue?
Mobile stroke units (MSU) facilitate the diagnosis and treatment of acute stroke patients in the emergency setting, but start-up and operational costs are high.

What was the research question?
What is the updated status of MSU implementation? What is the social background of regions with MSUs vs those without?

What was the major finding of the study?
There are 33 MSU programs, each treating 52-1,663 (median 781) patients per year. Start-up and annual costs were $0.7-1.8 million (median 1.0) and $0.7 -1.7 (median 1.0) million US dollars, respectively. Countries with MSUs had higher GDP (P< 0.0001; 99.99% CI, 2,328- 7,998 billion USD) than those without MSUs.

How does this improve population health?
While MSUs improve health outcomes, cost-saving strategies and reimbursements must be addressed, along with social background, prior to establishing a MSU.

METHODS

Study Design

Survey of Active Mobile Stroke Units

We emailed the survey to the 33 active MSU programs worldwide as of 2022. These program sites were identified through Fassbender et al's 2023 review paper.[8] Contact information for the representative or director of each MSU program was obtained through the programs' official websites.

In the e-mail sent to each MSU program, we provided a status update on our own planned project to implement MSUs in Japan; we requested current information and described our study goals. We then requested updated operational and financial information on the MSU program that was current as of March 2023. The survey comprised nine structured questions referring to a single MSU. Respondents could select answers from multiple choices or write their own responses. The requested information was as follows: 1) model name of onboard CT scanner (multiple choice); 2) time and hours of operation (free-text description); 3) average number of personnel on board (multiple choice); 4) catchment area (free-text description); 5) start-up cost and annual operating costs (free-text description); 6) financial source (multiple choice), 7) status of reimbursement (multiple choice), 8) gross financial balance (multiple choice), and 9) current challenges they face (multiple choice). Finally, respondents were given the option to provide comments in a free-text section. If MSU operations were suspended as of March 2023, we requested information on the most recent date of MSU operations.

The e-mails were delivered beginning March 7, 2023. Deadline for response was April 30, 2023. All responses went to one of the authors (MH). In some cases, a single e-mail reminder was sent. For the responding programs, a post-survey was additionally conducted to ascertain the number of patients treated per a single MSU per year, as referenced in their published papers or official websites.

Investigation of MSU Vs Non-MSU Regions

We collected the most recent data on all regions with an active MSU (33 units in 11 countries, 24 states, and 33 cities) to investigate demographic, economic, and healthcare backgrounds at the country, state, or city levels. Similarly, for non-MSU regions, data were collected from the countries, from other states in the same MSU country, and from other cities in the same MSU state. We gathered the data from comprehensive public sources via the internet. The data consisted of the following from the studied countries,[16] states,[17-19] and cities[18-20]: 1) population; 2) population density; 3) nominal gross domestic product (GDP) of the studied countries[23] and states[18,24]; 4) the age-standardized incidence rate of all strokes in the studied countries;[9] 5) the age-standardized disability-adjusted life years (DALYs) of all strokes in the studied countries[25]; 6) the healthcare access and quality (HAQ) index in the studied countries[26]; and 7) physician density in the studied countries[27] and states.[18] In these citations, only key references were provided due to the limitation of the number of references.

To be included in this study, the countries had to have a population of at least one million. We made this decision due to the uncertainty surrounding the effectiveness of MSUs in countries with very small populations. "States" refer to administrative divisions, such as states, regions, provinces, or counties. The designation "cities" included the smallest administrative districts, in cases where the city data was unavailable. For non-MSU regions, city population, size, and density were collected from the top 20 most populous cities in the same state that contained an MSU site. This ensured validity in comparison of population size or density between the small number of MSU cities and the large number of non-MSU cities, the latter of which are often sparsely populated. If an MSU city was identical to the administrative district, we collected data for the non-MSU cities from the adjacent states.

Statistical Analysis

We performed descriptive analysis on the survey responses to determine the current operational and economic status of the MSUs, and the number of patients treated in a MSU per year. Inferential analysis was also conducted to examine the relationship between the status variables, which included the model of onboard CT scanners, hours of operation, number of onboard personnel and physicians, the catchment radius, the start-up cost, the annual operating cost, the status of reimbursement, and the gross financial balance. We used the Spearman rank-order correlation test or Kruskal-Wallis rank-sum test for these analyses. To investigate the differences between active MSU and non-MSU regions, we compared the two types of locations across all demographic, economic, and healthcare background categories. At the country level, we used the Mann-Whitney U test. At the state and city levels, we performed the Wilcoxon signed-rank test with mean ranks and mean ranks of mean ranks, respectively. Additionally, we investigated a threshold of each category between active MSU and non-MSU regions at the country level. This was estimated as having a maximum F1 score, by using the receiver operating characteristic analysis and binomial logistic regression analysis. The threshold was finally indicated when a predictive probability of overall model quality was ≥0.60 and a predictive accuracy rate was ≥0.80. Finally, for the active MSU sites, all operational and economic status variables were correlated with all background variables of active MSU regions, using the Spearman rank-order correlation test or the Kruskal-Wallis rank-sum test.

A *P*-value <.05 was considered statistically significant. We organized and managed the data using Microsoft Excel (Microsoft Corp, Redmond, WA) and analyzed it using SPSS 29.0.1 (IBM Corporation, Armonk, NY).

Ethics Review

Approval for this international MSU study was obtained from the institutional review board at Tsukuba Medical Center Hospital.

RESULTS

Active Mobile Stroke Unit Programs

Overview

Of the 33 active MSU programs contacted, we received

Table 1. Overview of mobile stroke unit programs.

Location	All active MSU programs,[§] n	Programs that responded to the survey		
		Number, n (% of active programs)	Operating as of March 2023, n (% of respondents)	MSU vehicles per program, median (range)
North America	22	12 (55) *, **, †, ‡	9 (75)	1 (1–3)
Asia/Oceania	5	4 (80) †	4 (100)	1 (1–6)
Europe	4	3 (75) ***	2 (67)	1 (1–3)
South America/Africa	2	0 (0)	N/A	N/A
Total	33	19 (58)	15 (79)	1 (1–6)

Four programs were put on hold in March 2023, In these cases, the data provided were from the period when the MSU had most recently operated.

†Two programs had a whole-body CT scanner onboard.

‡One program did not employ a telemedicine system for MSU.

MSU, mobile stroke unit; *CT,* computed tomography; *N/A,* not assessed.

19 (58%) e-mail replies. Of these, 12 programs were in North America, four in Asia/Oceania, and three in Europe (Table 1). The operation of four programs was on hold due to the COVID-19 pandemic (three in North America, one of which was delayed due to financial difficulties and one in Europe due to a planned program shift. Two programs, one in North America and another in Asia, had a whole-body CT scanner onboard in their MSUs. One program in North America did not use a telemedicine system. One program in North America and another in Europe had three MSUs, while one in Asia had six MSUs. Post-survey investigation found that of the 19 responding programs, 12 reported the number of patients treated per a single MSU per year, ranging from 52 to 1,663 (median 781). (Data of seven programs could not be found in the original articles or on their official websites.)

Status of Active Mobile Stroke Unit Programs

The models of onboard CT scanners were as follows: CereTom (NeuroLogica [https://www.neurologica.com/]) in 14 programs (74%); OmniTom (NeuroLogica) in two (11%); CereTom and OmniTom in one (5%); SOMATOM Scope (SIEMENS Healthineers [https://www.siemens-healthineers.com/]) in one (5%); and Ingenuity (Philips [https://www.philips.com/] in one (5%). The hours of operation varied among programs (Table 2). Nine (47%) operated five weekdays per week, while the remaining 10 (53%) operated seven days per week. The most common time of operation was eight business hours every weekday in five programs (26%). Four programs (21%) reported operating 24 hours/day, seven days/week. The number of MSU staff on board ranged from two to seven, with the mode of four reported by six programs (32%). Six programs (32%) had no physicians on board. The most commonly reported number of physicians was one (58%); the physicians were typically vascular neurologists or stroke physicians, as reported by eight programs (48%). An expert nurse was on board in 12 (63%), a radiology technician in 16 (84%), one or two emergency medical technicians in nine (48%), one or two paramedics in 11 (58%), and one telemedicine technologist in two (11%). The catchment area radius for MSU operation ranged from 5-250 kilometers (km), with a median value of 22 km and a skewness of 3.9 (n = 18; Figure 1).

The costs associated with the MSU programs are presented in histograms in Figure 2. The initial costs of 17 programs ranged from 0.7-1.8 million United States dollars (USD), with a median value of 1.0 million USD and a skewness of 1.3 (Figure 2A). The annual operation costs of 16 MSU programs ranged from 0.7 to 1.7 million USD, with a median value of 1.0 million USD and a skewness of 0.7 (Figure 2B). The detailed financial statuses of 17 MSUs are shown in Table 3. The financial sources for the MSU programs consisted of government funds in eight programs (47%), non-governmental foundation funds in four (24%), hospital organization funds in eight (47%), philanthropic funds in 10 (59%), and reimbursement in eight (47%). Only two programs (12%) received full reimbursement. The most commonly used financial strategy was a philanthropic fund only in three programs (17%). The combination of all five financial sources in two MSU programs (12%) was the next most common strategy, while the remaining programs all used a different type (1 program, 6%, each). The gross financial balance for 15 programs was positive in four programs (27%), negative in eight (53%), and neutral in three (20%).

The reported challenges faced by 18 programs (Table 4) were finances in 17 programs (94%), human resources in 10 (56%), maintenance in three (17%), and follow-ups on patient outcomes in one (6%). The most frequent free-text comments from 15 programs (Table 4) were related to insufficient or absent reimbursement in nine programs (60%). Other comments included MSU replacement, vehicle wear-and-tear, operational troubles due to harsh weather, service suspension due to maintenance, and buy-in or expansion of the catchment area (two programs, 13%, each). No significant differences or correlations were found among the operational and financial variables relevant to MSUs.

Table 5 presents the the difference in demographic, economic, and healthcare backgrounds between active MSU and non-MSU regions. Compared to non-MSU regions, active MSU regions (MSU group) had higher population size at the country, state, and city levels. Similarly, Mthe SU group had higher population density at the state level, and nominal GDP was higher at both the country and state levels. Furthermore, the active MSU group reported higher HAQ index at the country level and physician density at both the country and state levels. Additionally, the active MSU group reported a lower age-standardized stroke incidence rate and age-standardized stroke DALY rate at the country level.

We identified the threshold between active MSU and non-MSU regions at the country level as follows: threshold (predictive probability of overall model quality, predictive accuracy rate); population size (216,927×1,000 [0.72, 0.94]), nominal GDP (670 billion USD [0.91, 0.94]), and the age-standardized stroke DALY rate (562 per 100,000 [0.62, 0.86]) (Figure 3).

Relationship Between Practical Status and Social Background of Mobile Stroke Units

In active MSU programs, a significant positive correlation was found between hours of operation per week and age-standardized stroke DALY rate by country ($\rho = 0.598$, $P < .05$, Figure 4A). In addition, a significant negative correlation was found between hours of operation per week and physician density by country ($\rho = -0.401$, $P < .05$, Figure 4B). Otherwise, no significant differences or correlations were found in active MSU programs between variables of the practical status and social background.

DISCUSSION

The 58% survey response rate (19 programs) was

Table 2. Operation characteristics of mobile stroke units.

Demographics	Frequency	% of total
Operation time (n=19)		
5 days per week (weekdays)	9	47
8 hours, daytime	5	26
10 hours, daytime	4	21
7 days per week	10	53
10 hours, daytime	2	11
12 hours, daytime	3	16
16 hours, daytime to late evening	1	5
24 hours	4	21
Onboard personnel (n=19)		
Total number		
2	5	26
3	3	16
4	6	32
5	4	21
7	1	5
Physician		
0	6	32
1	11	58
Vascular neurologist/stroke physician	8*	48
Neuroradiologist	2	5
Trained medical doctor	1	5
2		
Vascular neurologist, radiologist	1	5
3		
Emergency physician, radiologist, anesthesiologist	1	5
Expert nurse		
0	7	37
1	12**	63
Radiology technician		
0	3	16
1	16†	84
Emergency medical technician		
0	10	52
1	6	32
2	3	16
Paramedic		
0	8	42
1	8	42
2	3	16
Telemedicine technologist		
0	17	89
1	2	11

*One vascular neurologist had the qualifications of an emergency physician.
**One held a doctorate and underwent stroke fellowship training.
†One had received training as an emergency medical technician.

comparable to that of previous surveys, such as the 2018 review paper by Calderon[28] that summarized the operational status of MSUs in 14 global regions, the 2021 survey report by Reichenbach[29] that showed reimbursement limitations and a negative financial status of 19 programs in the United States, and the 2023 global survey report by Kovi[30] that clarified the impact of the COVID-19 pandemic on MSU operations in 20 programs. The number of patients treated with MSUs in our survey exhibited a considerable degree of variability. This result seems to be contingent on the population of the MSU coverage area, although this data is not presented.

Regarding the operational status of MSUs, this survey found that the CereTom (NeuroLogica) was the most common onboard CT scanner. It is the smallest and lightest among all scanners used at active MSU sites, and is expected to save costs[31] and to work well in new regions, particularly rural or low economic areas. The hours of operation varied from program to program, with most MSUs limiting their operations to daytime on weekdays. Just one-fifth of all sites operated 24 hours/day, 7 days/week. These findings are consistent with those of previous reports and likely reflect the importance of maintaining a cost–performance balance.[28] The onboard staff consisted of a combination of various professionals. Notably, no physician was on board in one-third of the programs. This is probably due to the advanced qualifications held by the non-physician staff and the use of telemedicine, as has been previously reported.[31] The catchment areas reported, which ranged from 5–250 km, were consistent with previous reports[31] and indicate that MSU coverage areas are program- or region-specific, ranging from the city to the state level.

Regarding the financial status of MSUs, the initial costs and annual operating costs reported in this study were high, consistent with previous studies.[4,10,31] The annual operating costs consisted primarily of personnel, MSU vehicle or CT scanner maintenance, and telemedicine use.[10] To reduce costs, MSU staff need to have more advanced qualifications.

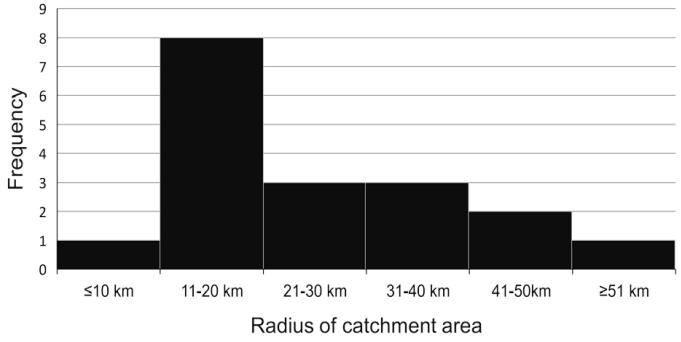

Figure 1. Histogram of catchment area of mobile stroke units (MSU). Data shown are for a single MSU in a program. Data were obtained from 18 programs.
km, kilometer.

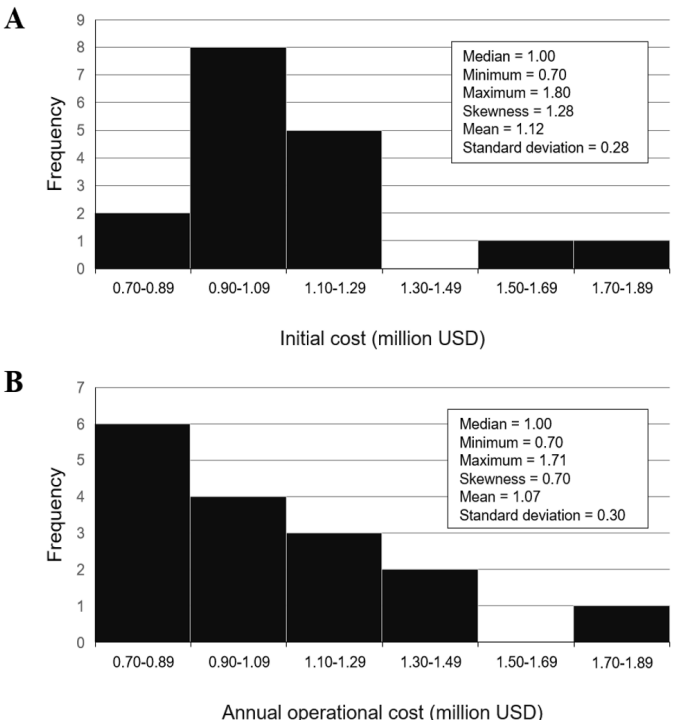

Figure 2. Costs of mobile stroke units (MSU). Data on initial costs (A) and annual operating costs (B) were obtained from 17 and 16 programs, respectively. The cost is estimated for a single MSU. USD, United States dollar.

Moreover, the development of cheaper or more cost-effective MSU hardware is necessary.[31] Most MSU programs relied on philanthropic funds for financial support, with some programs being solely supported by philanthropic funds. Full reimbursement was received in very few programs, meaning that most programs had a negative gross financial balance. Accordingly, financial issues were commonly raised as a challenge confronted by MSU programs. These results are in line with a 2021 report, which showed that the majority of MSU sites in the United States are at financial risk,[29] and with a 2022 report that proposed specific solutions for this issue.[10] The second most frequently encountered challenge was related to human resources. Human resources is a critical issue when operating MSUs, especially in remote or rural areas,[13] and when implementing a telemedicine system.[32]

When comparing regions with and without active MSUs in terms of their demographic and economic contexts, regions with MSUs had a larger population at the country, state, and city levels and had larger nominal country and state GDP. A large population influences the economic development of a society.[33] Nominal GDP is the total market value of all goods and services produced in a country's economy in a given period and is just one way to measure the economic performance of a country.[34] Therefore, our results suggest that most MSUs were implemented under the advanced economic conditions at the three administrative levels. Additionally,

Table 3. Financial status of mobile stroke units.

Category	Subcategory	Financial source/balance	Frequency	% of total
Finance source (n=17)	Included	GF	8	47
		NGFF	4	24
		HOF	8	47
		PF	10	59
		RI	8	47
		Partial	6	35
		Full	2	12
	Individual	GF only	1	6
		GF, HOF	1	6
		GF, RI	1	6
		GF, NGFF, HOF, PF, RI	2	12
		NGFF, HOF	1	6
		NGFF, RI	1	6
		HOF only	1	6
		HOF, RI	1	6
		PF only	3	17
		PF, GF	1	6
		PF, HOF	1	6
		PF, GF, RI	1	6
		PF, NGFF, RI	1	6
		PF, HOF, RI	1	6
Gross financial balance (n=15)		Positive	4	27
		Negative	8	53
		Neutral	3	20

GF, government funds; *NGFF*, non-governmental foundation funds; *HOF*, hospital organization funds; *PF*, philanthropic funds; *RI*, reimbursement.

Table 4. Present challenges confronted and free comments regarding mobile stroke units.

Category	Frequency (%, n = 18)	Free Comment	Frequency (%, n = 15)
Finance	17 (94)	Insufficient or absent reimbursement*	9 (60)
		Cost of MSU replacement	2 (13)
		Others	6 (40)
Human resources	10 (56)		
Maintenance	3 (17)	Vehicle wear-and-tear	2 (13)
		Out of service during maintenance	1 (7)
Patients' outcomes	1 (6)	Follow-up of patients' outcome	1 (7)
Others	6 (33)	Out of service due to harsh weather	2 (13)
		Buy-in or expansion of catchment area	2 (13)
		Extension of operation hours	1 (7)
		Stroke education for community residents	1 (7)

*Data included fragmentation of reimbursement due to the COVID-19 pandemic (n=1).

regions with active MSUs had a higher population density at the state level. This makes sense in light of our finding that the MSU catchment area extends to the state level (Figure 1) and may be explained by the idea that high population density can facilitate the development of infrastructure.[35]

In our investigation of the healthcare background of regions with and without MSUs, we found that at the country level, regions with MSUs exhibited a lower stroke-incidence rate, and a

Table 5. Demographic, economic, and healthcare backgrounds of regions with and without active mobile stroke units.

Categories	Measures	Results		
		With MSU	Without MSU	*P*-value
Population size, number (×1,000)				
	N	11	150	
Countries[16]	Mean (SD)	339,822 (543,541)	28,131 (43,858)	<.001†
	Median (range)	71,697 (5,434–1,425,887)	11,062 (1,120–275,501)	
	N	24	289	
States[17,18,19]	Mean (SD)	17,116 (21,938)	7,048 (16,227)	<.01‡
	Median (range)	6,348 (1,629–83,720)	3,189 (423–39,030)	
	N	33	480*	
Cities[18,19,20]	Mean (SD)	1,337 (1,900)	193 (436)	<.05‡
	Median (range)	677 (16–5,588)	93 (10–540)	
Population density, per km^2				
	N	11	150	
Countries[21]	Mean (SD)	137 (138)	242 (886)	.94†
	Median (range)	136 (3–416)	80 (2–8,286)	
	N	24	276	
States[17,18,19]	Mean (SD)	1,129 (3,211)	330 (1,001)	<.05‡
	Median (range)	175 (7–3,623)	122 (3–310)	
	N	33	480*	
Cities[18,19,22]	Mean (SD)	2,961 (3,459)	1,560 (1,924)	0.17‡
	Median (range)	1,795 (270–15,378)	938 (143–6,338)	
Nominal GDP, billion USD				
	N	11	145	
Countries[23]	Mean (SD)	5,450 (8,308)	287 (578)	<0.001†
	Median (range)	2,140 (477–25,463)	70 (2–4,231)	
	N	24	291	
States[18,24]	Mean (SD)	706 (850)	142 (268)	<.01‡
	Median (range)	174 (19–844)	63 (3–432)	
Age-standardized incidence rate of all strokes, per 100,000 population				
	N	11	149	
Countries[9]	Mean (SD)	116 (39)	137 (34)	<.05†
	Median (range)	106 (83–226)	129 (79–224)	
Age-standardized DALYs rate of all strokes, per 100,000 population				
	N	11	149	
Countries[25]	Mean (SD)	953 (594)	1706 (950)	<.01†
	Median (range)	692 (428–2,342)	1543 (338–5,091)	

Countries were defined as having a population of at least one million. States included regions (administrative districts), provinces, and counties. Cities included the smallest administrative districts in cases where city data was unavailable. Non-MSU region data at the state or city level was selected from the same country or state as the MSU. *The top 20 most populous cities were analyzed. The median is the median of the medians at the state level and the median of the medians of the medians at the city level. Only key references were provided due to the limitation of the number of references.

†Mann-Whitney U test,

‡ Wilcoxon signed rank test using mean-ranks at the state level and mean-ranks of mean-ranks at the city level.

MSU, mobile stroke unit; *SD,* standard deviation; *USD*, United States dollar; *GDP*, gross domestic product; *DALY*, disability-adjusted life year; *N/A*, not assessed.

Table 5. Continued

Categories	Measures	Results		
		With MSU	Without MSU	*P*-value
HAQ index				
Countries[26]	N	11	148	<.01†
	Mean (SD)	71 (21)	54 (20)	
	Median (range)	81 (32–91)	54 (15–93)	
Density of physicians, per 10,000 population				
Countries[27]	N	11	147	<.05†
	Mean (SD)	29 (17)	18 (16)	
	Median (range)	35 (3–52)	13 (1–84)	
States[18]	N	24	282	<.05‡
	Mean (SD)	4.3 (4.7)	2.2 (4.7)	
	Median (range)	1.5 (0.1–20.5)	0.8 (0.1–9.9)	

Countries were defined as having a population of at least one million. States included regions (administrative districts), provinces, and counties. Cities included the smallest administrative districts in cases where city data was unavailable. Non-MSU region data at the state or city level was selected from the same country or state as the MSU. *The top 20 most populous cities were analyzed. The median is the median of the medians at the state level and the median of the medians of the medians at the city level. Only key references were provided due to the limitation of the number of references.
†Mann-Whitney U test,
‡ Wilcoxon signed rank test using mean-ranks at the state level and mean-ranks of mean-ranks at the city level.
MSU, mobile stroke unit; *SD,* standard deviation; *USD*, United States dollar; *GDP*, gross domestic product; *DALY*, disability-adjusted life year; *HAQ*, healthcare access and quality.

lower stroke DALY rate, as well as a higher HAQ index. The disease incidence is a commonly used measure of the disease risk for a specific population during a specified period.[36] The DALY is an indicator of the disease burden and represents the sum of years of life lost and years lived with disability.[37] The HAQ index estimates healthcare access and quality across different locations. This index is based on death rates and mortality-to-incidence ratios of various causes of death, including stroke (cerebrovascular disease).[26] Therefore, our results suggest that current MSUs operate in areas with an advanced healthcare system and a lower disease burden at the country level. Regions with MSUs also exhibited a higher physician density both at the country and state levels. Physician density, which represents the number of physicians per population, is a crucial measure of the health human resources necessary for the healthcare system to function properly.[38] An adequate supply of physicians is necessary to ensure access to affordable and quality healthcare. Our results suggest that the success of MSU operations may rely on the presence of better health human resources in the vicinity of the MSU catchment area.

The country-level thresholds for distinguishing between regions with and without MSUs were dependent on the population, nominal GDP, and age-standardized stroke DALY rate. These thresholds may be useful, approximate indicators to understand the current status of MSU implementation. Since population and nominal GDP data are updated annually and always available, these two thresholds may be particularly practical. With regard to the stroke DALY rates, the range between the threshold and the minimum value appears narrow (Figure 3C). Thus, this threshold may not be a practical approximate indicator.

Furthermore, we found a significant positive correlation between the MSU hours of operation and the country's age-standardized stroke DALY rate. This supports the notion that the DALY metric reflects the degree of unmet medical needs.[39] We also found a significant negative correlation between the MSU hours of operation and the country's physician density. Reports have suggested that a shortage of physicians presents a significant barrier to providing effective and equitable healthcare services.[40] In such regions, physicians may need to be sourced from other areas to participate in the MSU program. Otherwise, it may be necessary to use telemedicine systems to their fullest potential. Taken together, the hours of operation of MSUs may depend on insufficient healthcare delivery systems or environments where stroke is more likely to occur.

LIMITATIONS

This study has several limitations and problems. First, the survey response rate (58%) was relatively low in the field of medicine and healthcare. The majority of non-responding MSU programs (10) were located in the United States (71% of all non-response programs, Table 1). It can be confirmed via official websites that in the United States non-responding

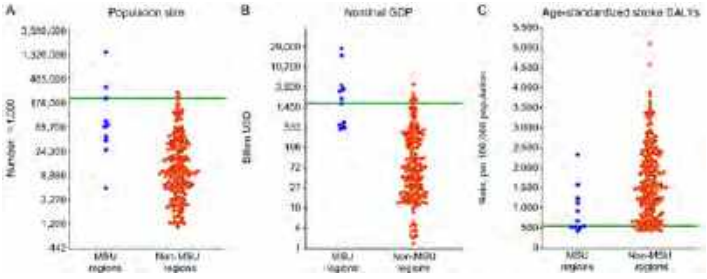

Figure 3. Scattergram showing the data of (A) population size, (B) nominal gross domestic product, and (C) age-standardized stroke disability-adjusted life year rate at the country level.
MSU, mobile stroke unit; *GDP*, gross domestic product; *DALY*, disability-adjusted life year; *USD,* United States dollar.

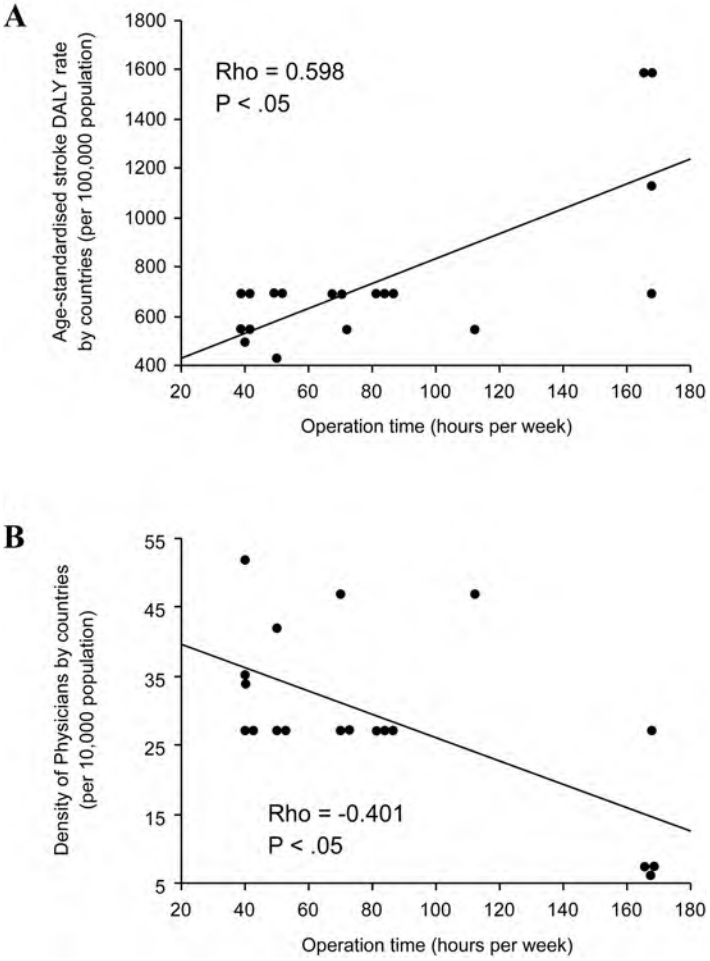

Figure 4. Scattergram showing the correlation between the mobile stroke unit hours of operation per week (MSU) and the age-standardized rate, disability-adjusted life year, of all strokes by country (A) and between the MSU hours of operation per week and physician density by country (B) disability-adjusted life year.
DALY, disability-adjusted life year.

programs and responding programs employ nearly identical models of CT scanners or MSU vehicles. Consequently, non-response bias in our survey is minimal. Second, we did not inquire about the details of MSU costs or finances. Questions were simplified to maximize the number of responses. Our results showed that the total costs and model of CT scanner used were almost the same as those reported by previous studies. This means that the remaining costs including personnel and maintenance have probably not changed significantly from before, but there is no more specific information available regarding costs such as vehicle repair, CT maintenance, or telemedicine usage among MSU programs.

We also found that only a few MSU sites were fully reimbursed or had a positive gross financial balance. However, we were unable to obtain the essential details necessary to offer solutions to the financial issues faced by the majority of MSU sites. Considering these limitations, future studies should focus on the specifics of MSU costs and finances. Third, data on nominal GDP, stroke incident rate, stroke disability-adjusteds life year rate, HAQ index, and physician density were unavailable at the city level or at both state and city levels for all locations. Therefore, we could not form conclusions on the regional specificity of economic and healthcare backgrounds in the states and cities. These factors should be analyzed in individual studies. Fourth, the limited number of active MSU programs prevented us from conducting a proper multivariate analysis or a two- or three-way Mann-Whitney U analysis. Thus, our study did not demonstrate any interactions on the relationships between MSU status variables, or interactions on the relationships between regions with and without MSUs at the country (three-way) and state (two-way) levels.

Finally, we did not inquire about the impact of the COVID-19 pandemic on MSU operations. Kovi[30] reported that MSUs were able to overcome the challenges posed by the early phase of the COVID-19 pandemic. A retrospective study would clarify the impact of the entire phase of COVID-19 pandemic on MSUs. This information is essential for MSUs to prepare for any future pandemics.

CONCLUSION

Mobile stroke units operate globally in program- or region-specific ways. The MSU programs are confronted with significant financial challenges, including high start-up and annual operating cost or uncertain reimbursement. Regions with MSUs tend to have relatively large populations, nominal GDP, HAQ index, and physician density, as well as relatively low stroke-incidence rates and stroke disability-adjusted life year rates. Meanwhile, regions without MSUs appear to have significant barriers to MSU implementation with regard to their demographic, economic, and

healthcare backgrounds. Nevertheless, for the populations in these regions, MSU-based care appears to be a more beneficial option, particularly considering the disease burden. To successfully implement an MSU program in a new region, it is essential that the project team conduct a thorough assessment of the regional social contexts and address any pertinent issues. Finally, strategies for establishing reimbursements and reducing costs should be considered.

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Civil Monetary Penalties from Violations of the Emergency Medical Treatment and Labor Act for Patients Arriving or Leaving with Law Enforcement

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Introduction: The Emergency Medical Treatment and Labor Act (EMTALA), a federal law enacted in 1986, is intended to prevent inadequate, delayed, or denied treatment of emergency medical or emergency psychiatric conditions by Medicare-participating hospitals when individuals present to dedicated emergency departments (EDs). EMTALA requires all patients seeking evaluation for an emergency medical condition (EMC) at a dedicated ED to have an appropriate medical screening exam (MSE), stabilization of identified EMCs, and an appropriate transfer if specialized services are needed for stabilization.

Methods: We obtained summaries of all EMTALA-related civil monetary penalties (CMPs) between 2002–2023 from the Office of the Inspector General (OIG) and reviewed them for instances where patients arrived or departed with law enforcement officers (LEOs). In this article, we describe the characteristics of these CMPs.

Results: Of 260 EMTALA-related CMPs, 15 (5.8%) were identified as having involved patients arriving to or departing from an ED with LEOs. Among these, nine (60%) involved patients arriving to the ED with LEOs, of whom five (55.6%) were transported to alternate facilities by LEOs at the direction of ED staff without receipt of an appropriate MSE. Overall, eight (88.9%) of nine patients arriving with LEOs involved psychiatric concerns. Four cases were identified as having involved patients discharged from but not arriving to the ED with LEOs. Of these, two involved patients brought to the ED for evaluation of psychiatric conditions and discharged to jail without appropriate MSE after becoming disruptive. Two involved patients with psychiatric issues sent to jail without appropriate MSE/stabilization, some due to hospital policies pertaining to alcohol intoxication. Two involved patients without noted psychiatric concerns escorted from the ED with the assistance of LEOs after reported to be "resistant" or "aggressive." One returned to the ED in cardiac arrest, and another was subsequently diagnosed with bacterial meningitis.

Conclusion: Overall, 5.8% of EMTALA-related CMPs involved patients arriving to or departing from the ED with LEOs; most of these involved patients with psychiatric emergencies. In many cases, LEOs were advised to either transport patients to an alternate medical facility without an appropriate MSE, or disruptive or intoxicated patients with noted psychiatric concerns were discharged to jail without adequate MSE or stabilization. Findings indicate a need for education surrounding EMTALA requirements to provide MSEs and, if needed, stabilizing treatment prior to discharge or transfer for all patients presenting to the ED, regardless of LEO involvement. [West J Emerg Med. 2025;26(3)712–719.]

INTRODUCTION

Interactions between patients and law enforcement officers (LEOs) occur frequently in emergency departments (EDs).[1] Individuals in the custody of LEOs requiring emergency medical care are commonly brought to EDs similarly to individuals requiring medical clearance for booking at a correctional facility. LEOs often respond to psychiatric and mental health emergencies in the prehospital setting and transport patients to EDs for evaluation of behavioral or psychiatric emergencies.[2-4] Further, LEOs are also sometimes called by the ED to ensure the safety of staff or other patients when patients are perceived to be aggressive or violent and may be used to assist in removal of patients who are violent, threatening, or refuse to leave the hospital premises.[3-6] Despite frequent interactions between LEOs and hospital staff, each may approach encounters with ED patients with different perspectives and priorities.

Many of a hospital's duties pertaining to the care of patients requiring evaluation or stabilization of emergency conditions are specified in the Emergency Medical Treatment and Labor Act (EMTALA), which is intended to prevent inadequate, delayed, or denied treatment of emergency medical or emergency psychiatric conditions.[7] Regardless of LEO presence or requests, EMTALA requires all hospitals with a Medicare agreement to provide patients for whom evaluation or treatment for an emergency condition is sought with the following: 1) an appropriate medical screening exam (MSE), 2) stabilization of any identified emergency medical condition (EMC), and 3) appropriate transfer to another facility if services required for stabilization are not available at the initial hospital.[7] EMTALA is actively enforced, with nearly half of hospitals in the United States investigated and two-thirds of investigated facilities cited by the Centers for Medicare & Medicaid Services (CMS) for a violation between 2005–2014.[8] A summary of the EMTALA enforcement process is included in Supplementary Exhibit A. Additionally, the Department of Health and Human Services Office of the Inspector General (OIG) can impose civil monetary penalties (CMP) to facilities found to have negligently violated EMTALA.[9] Prior published manuscripts have described general as well as hospital-level characteristics associated with EMTALA-related CMPs, as well as EMTALA-related CMPs involving individual physician fines, pediatric emergencies, psychiatric emergencies, and obstetric emergencies.[10-15]

While reviewing CMP summaries for prior related studies, we incidentally noted that they often described scenarios involving individuals arriving to or departing from the ED accompanied by LEOs.[12-15] Hospitals have the same EMTALA obligations to an individual in law enforcement custody as any other individual who comes to the ED. Similarly, an individual being placed under custodial arrest while receiving care in an ED does not terminate EMTALA obligations. EMTALA obligations are the responsibility of the hospital, not law enforcement. An understanding of prior CMPs may serve to inform hospitals in their efforts to ensure EMTALA compliance when serving this particularly vulnerable population. The purpose of this study was to inform clinicians and hospital administrators working at Medicare-participating hospitals how EMTALA has been enforced by describing cases where involved patients were noted to arrive or depart from the ED with LEOs.

Population Health Research Capsule

What do we already know about this issue?
Patients in the ED often interact with law enforcement officers (LEOs). EMTALA established a duty for hospitals to screen and stabilize patients presenting to an ED.

What was the research question?
Our goal was to describe EMTALA-related civil monetary penalties involving LEO-involved ED patients.

What was the major finding of the study?
Fifteen of 260 cases involved LEO-involved patients, 12 with psychiatric concerns. Four were discharged to jail without a medical screening exam/stabilization.

How does this improve population health?
Emergency clinicians may benefit from education regarding EMTALA requirements to evaluate, stabilize and, when necessary, transfer LEO-involved ED patients.

METHODS

We obtained summaries of all EMTALA-related CMPs occurring between 2002–2023 from the OIG website.[16] Consistent with methodology applied in prior studies using this data, CMPs related to EMTALA violations were identified by the inclusion of "EMTALA" or "patient dumping" in the summary text.[12,14,15] Semiannual reports published by the OIG were additionally reviewed to ensure accuracy and completeness of the dataset.[16,17]

We systematically reviewed all 260 CMP settlement summaries for instances where patients were specifically noted to have arrived to or departed from the ED accompanied by law enforcement personnel (which we will refer to as LEO-involved) using keywords and stems: "law enforcement, police, sheriff, deputy, jail, prison, criminal-, detain-, charge-." Of note, summaries varied in the level of granularity of case details provided, and as a result some cases involving LEOs may not have been identified. Summaries were reviewed for context indicating that an involved patient was in the custody of law enforcement at the time of the ED visit or otherwise had arrived

to or departed from the ED with law enforcement personnel.

Summaries of all 260 CMPs that occurred within the study period were reviewed by three trained research assistants and flagged if reference of LEO-involvement was identified. Of the 260 CMPs, 17 CMPs were flagged and subsequently reviewed by a team of three practicing emergency physicians who determined that 15 met criteria for inclusion within the study (included in Supplementary Exhibit B), one additionally described the threat of LEO-involvement (included in Supplementary Exhibit C), and a final CMP only referenced a patient having been found down by LEOs in the field but who was not specifically noted to have arrived to the ED with LEOs or to have been in custody of LEOs. The CMP summaries describing LEO-involved patients were reviewed for the following key characteristics: 1) whether a patient was noted to arrive to the ED with a LEO, 2) patient features including age or condition, 3) whether a patient departed from the ED with a LEO, and 4) types of EMTALA deficiencies noted in the narrative CMP summary.

This study evaluating CMPs using publicly available data was determined not to be human subjects research by the Institutional Review Board of the University of Southern California.

Illustrative Case Studies

Inspection text from the EMTALA citation events preceding two of the CMPs involving patients arriving to or departing from the ED with LEOs were obtained from publicly available CMS hospital inspection data. These cases were selected by author consensus to highlight key learning points. For each, we summarized details of the EMTALA violation, investigation findings, and CMP findings to provide a richer understanding of the EMTALA enforcement and CMP settlement process.

RESULTS

Between 2002–2023, there were 260 CMPs related to EMTALA. Among these, 15 (5.8%) summaries described LEO-involved cases. A total of 17 patients are represented among the 15 CMPs; 13 CMPs involved a single patient, and two CMPs involved two patients each (Table 1). Overall,

Table 1. Characteristics of EMTALA-related civil monetary penalties involving patients arriving to or departing from the emergency department with law enforcement personnel 2002–2023 (N=260).

	Overall		Arriving with LEO		Not arriving with LEO	
Overall Characteristics	N	%	n	%	n	%
CMPs involving LEOs	15	100%	9	60%	6	40%
CMPs with multiple patients and LEO involvement	2	13.3%	0	0%	2	33.3%
Patient Characteristics						
Psychiatric condition	12	80%	8	88.9%	4	66.7%
Medical condition*	4	26.7%	0	0%	4	66.7%
Nature of condition not stated/unclear**	1	6.7%	1	11.1%	1	16.7%
Dispositions and Outcomes						
Discharged without mention of LEO involvement in disposition	3	20%	3	33.3%	0	0%
Discharged to jail with LEO***	4	26.7%	0	0%	4	66.7%
Transported to alternate ED by LEO at direction of ED staff	5	55.6%	5	55.6%	0	0%
Noted to have been admitted at alternate facility	2	13.3%	2	22.2%	0	0%
Disposition from alternate ED not specified	3	20%	3	33.3%	0	0%
Escorted from ED or campus by LEO****	2	13.3%	0	0%	2	33.3%
Disposition unclear	1	6.7%	1	11.1%	0	0%
EMTALA Deficiency Referenced in Penalty Summary						
Failure to provide appropriate MSE	15	100%	9	100%	6	100%
Failure to stabilize	10	67%	5	55.6%	5	83.3%
Failure to arrange appropriate transfer	2	13.3%	2	22.2%	0	0%

*Includes a patient who presented to the ED for a primary psychiatric complaint, who was reportedly injured without apparent medical treatment. Additionally includes a CMP involving patients with suicidality and overdose, and two patients escorted out, due to concerns about behavior. who were ultimately found to have serious medical conditions.
**Includes a CMP with 2 patients sent to jail, 1 without stabilization of a psychiatric emergency, and another without appropriate MSE.
*** One patient who was discharged to jail returned and was admitted for an overdose.
****EMS transported a patient from a parking lot to another facility where the patient was hospitalized for meningitis.
CMP, civil monetary penalty; *LEO,* law enforcement officer; *ED,* emergency department; *EMS,* emergency medical services; *MSE,* medical screening exam.

Table 2. Illustrative case 1.

A patient with a history of schizophrenia and a recent hospitalization at a mental health facility presented to an emergency department (ED) with psychosis and homicidal ideation toward his father. The patient was placed on an involuntary psychiatric hold after an emergency physician (EP) determined the patient to be a danger to himself or others. The patient was treated with an antipsychotic and transferred via emergency medical services for higher level of care to the ED of the cited facility for mental health evaluation. The patient was noted to be "combative, belligerent, uncooperative, rambling, delusional, hostile, impulsive, and inappropriate" upon arrival to the accepting ED. The patient became agitated and, despite de-escalation attempts by multiple personnel, struck an off-duty police officer contracted by the hospital for security. The patient sustained injuries as he was being restrained by security staff and handcuffed by the off-duty police officer. The patient was noted to be a threat to the staff. Shortly thereafter, an additional dose of antipsychotic medication was ordered, and the patient was medically "cleared for jail" by the EP with a discharge diagnosis of schizophrenia with acute agitation and a differential diagnosis of polysubstance abuse. The patient was arrested for battery and transported to jail by law enforcement.
Following a report of concern for an Emergency Medical Treatment and Labor Act (EMTALA) violation, the Centers for Medicare & Medical Services regional office authorized an investigation by the state. Findings related to that inspection are included below. Within two weeks, the hospital received citations related to EMTALA deficiency tags 2400 (compliance with responsibilities of Medicare-participating hospitals in emergency cases), 2402 (sign posting), 2406 (MSE), and 2407 (stabilizing treatment).
The inspection text indicated that the patient presented with manifestations of acute symptoms of sufficient severity such that his condition could reasonably be expected to place the health of the patient in serious jeopardy in the absence of immediate medical attention. Inspection text revealed that there was no documentation to indicate that a mental health evaluation was provided for the patient, and that the hospital failed to ensure that hospital policy was followed as evidenced by failing to ensure that the patient who was involuntarily committed received an appropriate mental health screening exam from the appropriate personnel (on-call psychiatrist) to determine whether or not a psychiatric emergency medical condition existed. Review of hospital records revealed that a psychiatrist was on call and that the facility's adult psychiatric unit was not at full capacity on the day of the patient's ED visit.
Investigation text revealed that actions taken by the off-duty police officer contracted for security were noted by the contracted security's account manager to be "more in line with what he/she would have been trained to do as a police officer." In an interview conducted as part of the inspection, the account manager for the contracted security stated that police officers "use their judgment as police officers," and that the account manager "could not interfere with them doing their job—they are in their uniform and representing their agency." The EP recalled that the patient did not receive a mental health evaluation because the physician had been told by security that the patient's violence at that point was beyond what the facility could safely control. Interview with the ED medical director revealed that an associated critical access hospital sent behavioral health patients to this facility for evaluations because the patients were difficult to manage, and the facility reportedly "lacked security there." He further stated that in general if a behavioral health patient arrived "swinging/punching, the EP would do a medical screening exam to determine medical clearance. If the patient already had laboratory studies performed and was uncontrollable, they may go to jail, depending on the severity of the signs/symptoms. The police officer was there to protect the staff."
The report indicated that the facility failed to ensure that their policy, "Care of the Patient with Assaultive Behavior," was followed as evidenced by failing to call a "Code Gray" for the involved patient. The facility also failed to follow their policy related to "Care of the Mental Health Patient" as evidenced by failing to ensure that the mental health screener was called to work collaboratively with patient/family, clinical staff, the EP, and the on-call psychiatrist to appropriately screen the patient and determine appropriate treatment.
Two years after the EMTALA citation was issued, the hospital agreed to a $50,000 civil monetary penalty settlement with the OIG to resolve allegations that the hospital had violated EMTALA in failing to evaluate and treat a mentally ill patient transferred from another hospital for involuntary inpatient psychiatric care despite having an on-call psychiatrist and capabilities to treat the patient.

15 (100%) CMPs referenced failure to provide appropriate MSE, and 10 (66.7%) referenced failure to provide stabilizing treatment. Only two specifically referenced penalties as being related to a failure to arrange appropriate transfers. Illustrative cases are included in Tables 2 and 3.

Nine CMPs (60%) involved patients arriving to the ED with LEOs, including eight patients (88.9%) with psychiatric concerns. Of these nine, five (55.6%) were transported to alternate facilities by LEOs at the direction of ED staff without receiving an appropriate MSE. One ED turned away paramedics transporting an incarcerated patient for whom the hospital had a "no trespass" order. Three CMP summaries described scenarios in which patients arriving to an ED with LEOs were discharged from the ED without LEOs. In one case, a patient brought to the ED by LEOs was placed on an involuntary hold and discharged five hours after ED arrival without the hold being lifted. Another involved a patient brought to the ED with unusual behavior and incoherent speech who was diagnosed with "altered mental status" and "mental health disorder" who was discharged without an appropriate MSE or stabilizing treatment after reportedly yelling and making threatening gestures. A third involved a patient held involuntarily in an ED for 38 days prior to discharge without management by an on-call psychiatrist or admission to an available inpatient bed for stabilizing care.

Table 3. Illustrative case 2.

Emergency medical services (EMS) responded to a county jail for a 59-year-old male with a chief complaint of seizures. EMS found the patient to be alert and oriented with normal vital signs and transported the patient to an emergency department (ED). Upon arrival, an ED Registered Nurse (RN) informed EMS that the patient had a restraining order at the facility due to previous encounters in which he was combative and aggressive towards staff. EMS stated that they were not aware of the restraining order and that the hospital was the patient's choice. Per reports, the ED RN instructed EMS to leave the ED with the patient without an medical screening exam (MSE). EMS transported the patient to an alternate ED where he received an MSE and stabilizing treatment, including phenytoin and phenobarbital levels, along with routine labs. The patient was discharged from the ED with instructions to call his physician the following day to manage his medications.
Following a report of concern for an Emergency Medical Treatment and Labor Act (EMTALA) violation, the Centers for Medicare & Medical Services regional office authorized an investigation within weeks. Inspection findings are summarized below. Approximately a month after the incident, the hospital received citations related to EMTALA deficiency tags 2400 (compliance with responsibilities of Medicare participating hospitals in emergency cases), 2405 (emergency room log), and 2406 (MSE).
Review of facility policy indicated a requirement that a central log be maintained for each individual who "comes to the ED" seeking assistance that documents whether he or she refused treatment, was refused treatment or whether he or she was transferred, admitted and treated, stabilized and transferred or discharged. The facility failed to ensure that their policy and procedure regarding the ED central log was followed when this patient presented to the ED requesting medical assistance.
A review of the hospital's ED central log dated on the day of the incident showed that the patient had never been entered into the Central Log. An interview with the RN involved in the patient's care stated that the RN recognized the patient and discussed with other ED staff. The RN reported having "assumed that the 'restraining order' and the 'no trespass order' were the same type of order that meant the patient couldn't be in the hospital unless in acute distress like postictal, coding, or active seizures," and reported not being aware that EMTALA applied if a patients had a restraining order.
Nearly two and a half years after the original incident, the facility entered into a $40,000 settlement agreement with the Office of the Inspector General to resolve allegations related to this EMTALA violation.

Four CMPs described patients who did not arrive to the ED with LEOs but were arrested in the ED and discharged to LEO-custody without appropriate MSE and/or stabilization of an EMC. All four involved one or more patients noted to display signs of psychiatric emergency conditions, or to be on an involuntary psychiatric hold. One CMP involved two patients, one of whom had an emergency psychiatric condition and was not provided with stabilizing treatment before being arrested and transferred to jail; a second patient not specified to have a psychiatric condition was not provided with an appropriate MSE before being arrested and sent to jail. Additionally, CMPs were levied against two hospitals after patients awaiting evaluation for psychiatric concerns were arrested after becoming physically aggressive in the ED and discharged without receiving an MSE and/or stabilization of an EMC.

One CMP involved two patients who presented to the ED for intentional overdose, both of whom also had concurrent alcohol intoxication. Both patients were discharged to jail per the hospital's policy regarding the transfer of patients with blood alcohol concentrations above a specified threshold by LEOs, in this case without MSE/stabilization. One of these patients, who returned to the hospital shortly thereafter following a repeat overdose attempt, required hospitalization in the intensive care unit (ICU).

Two CMPs involved patients without noted psychiatric issues who were escorted out of the ED with the assistance of LEOs. One case involved a patient with a headache who was escorted out by LEOs after acting agitated and resistant when asked to leave the waiting room. Emergency medical services (EMS) was called from the medical center parking lot, where the patient was found unresponsive, and they transported her to another facility where she was diagnosed with bacterial meningitis, requiring mechanical ventilation and hospitalization in the ICU. Another CMP involved a patient who was escorted off the property by LEOs after exhibiting "aggressive behaviors" shortly after arriving to the ED by ambulance. The patient returned to the ED five hours later in cardiac arrest and ultimately died. Additionally, a case in which hospital staff threatened to involve LEOs but did not do so is not included in analysis but is described in Supplementary Exhibit C.

DISCUSSION

Between 2002–2023, 5.8% of EMTALA-related CMPs were noted to involve patients arriving to or departing from the ED with law enforcement, and because of variability in detail of summaries we suspect the actual number may be much greater. Among these, the vast majority involved patients with psychiatric emergencies. The CMPs often involved failure to provide an appropriate MSE, stabilization or appropriate transfer. Perspective-taking has been identified as an effective de-biasing technique in other healthcare contexts and may also have broader applicability to improving mutual understanding

among hospital staff and LEOs.[18] Knowledge about aspects of EMTALA requirements has been previously identified as a barrier to EMTALA compliance.[19] A more nuanced understanding of EMTALA duties among hospital staff can help to ensure that EMTALA obligations are met, ensuring access to emergency care for LEO-involved patients, while maintaining safety for patients, visitors, and staff within the department. Based on themes identified from review of CMPs resulting from EMTALA citations, essential concepts for administrators and ED staff to know are highlighted below and ensure a broader appreciation of the factors that may influence law enforcement actions in EDs.

Patients presenting to the ED accompanied by law enforcement were frequently redirected to alternate facilities without an MSE to evaluate for an EMC, and they were often not entered into the central log. One CMS regulatory requirement related to EMTALA is that patients presenting to a dedicated ED must be entered into a central log (42 CFR 489.20(r)(3)) to provide accountability for fulfilling the EMTALA screening requirement.[20] The duty to perform an MSE applies to all individuals who request an evaluation for a medical condition, individuals who have an evaluation requested on their behalf by EMS, LEO or another person, or individuals who a prudent layperson would believe require evaluation for an EMC based on the individual's appearance or behavior. While EMTALA is a duty of the hospital, instances where LEOs were turned away highlight the potential utility of educating LEOs and paramedics about a hospital's EMTALA duties to facilitate advocacy for patients in scenarios where hospital staff fail to fulfill the hospital duty and attempt to re-route patients without a MSE to alternate facilities.

To ensure compliance with requirements, patients presenting to a dedicated ED must be entered into the central log and provided an appropriate MSE, regardless of whether they are LEO-involved, they will ultimately be criminally charged, or will receive further care at another facility such as a jail. If an appropriate MSE determines that the patient does not have an EMC, or if an identified EMC is ultimately stabilized, the EMTALA obligations end. Similarly, EMTALA obligations end if a patient either does not consent or withdraws consent to be evaluated and treated. Alternatively, if stabilizing the EMC requires capabilities not available at the hospital, the facility must arrange an appropriate transfer to another medical facility.

The most recent iteration of CMS EMTALA interpretive guidelines provides guidance regarding the use of EDs for non-emergency services, including, in some instances, by LEO-involved patients.[21] For example, if an individual presents to a dedicated ED and requests services that are not for a medical condition, such as preventative services or the gathering of evidence for criminal law cases (eg, sexual assault evidence collection, forensic blood alcohol test), the hospital may not necessarily be obligated to provide an MSE, in the absence of a request for examination or treatment for a medical condition (eg, intoxication, withdrawal, traumatic injury, injuries or exposures resulting from a sexual assault), or if a prudent layperson observer would not believe that the individual needed such examination or treatment.[21] However, guidelines indicate that if preceding circumstances suggest (eg, a motor vehicle accident or other situation where an individual may have sustained an injury, assault that may require pregnancy or HIV prophylaxis, substance ingestion), or if a prudent layperson observer would believe, that the individual needed such examination or treatment, an MSE to evaluate for the presence of an EMC would be warranted.[21] Furthermore, interpretive guidelines state that surveyors will evaluate each case on its own merit when determining a hospital's EMTALA obligation when LEOs request evidence collection for use as evidence in criminal proceedings.[21]

Several LEO-involved patients were noted to have psychiatric emergencies for which clinical staff initiated involuntary holds, which are a function of state law, not federal law. Criteria and process vary considerably state to state, with multiple states requiring LEO and/or judicial involvement.[22] In such cases, it is important that hospitals and law enforcement collaboratively develop local procedures to meet both the requirements of state involuntary commitment laws and federal EMTALA rules. Our study findings suggest that hospitals may be cited under EMTALA if they fail to use available resources, including on-call mental health specialists. Further guidance on these matters in future iterations of EMTALA interpretive guidelines would be helpful to hospitals and clinicians.

The EMTALA requirements of an appropriate transfer are important to consider as well. EMTALA requires that the transfer of a patient with an EMC be done through qualified personnel and equipment, among other requirements. While transfer to another facility via non-EMS mechanisms, either generally via laypersons private vehicle or via law enforcement, is not explicitly prohibited under EMTALA, hospitals would be wise to consider which qualified personnel and transportation equipment would be required for any given patient and assure evaluation is sufficient to ensure that benefits of such transfer outweigh risks. Stabilizing treatment, within the capabilities of the hospital, must also be provided to mitigate risks of transfer, regardless of ultimate means of transfer. Decisions regarding method of transfer should be individualized, appropriately reasoned, and documented. Authoritative guidance in this area would be helpful as well.

We also identified CMPs in which patients were discharged to jail after they were noted to have behavior described as aggressive and/or violent in the ED. While it is vital for the ED to ensure a safe environment for staff and other patients, and while law enforcement involvement may be necessary for safety and a discharge to law enforcement custody may be the ultimate disposition, the EMTALA obligations continue to apply. All patients must still receive

an appropriate MSE and receive stabilizing treatment for identified EMCs. Hospitals would be prudent to ensure the EMTALA obligations are fulfilled prior to any patient being discharged to the custody of law enforcement.

The CMP summaries describe several patients who were escorted from the premises by LEOs after behavior perceived to be aggressive or uncooperative without an adequate MSE/stabilization, and were later found to have primarily medical conditions that may have accounted for their behavior. These serve as a reminder that behavioral issues such as aggression or non-cooperation may result from primary physical health conditions and may also represent an EMC in their own right. Adequate assessment is needed to exclude presence of a medical cause for uncooperative or aggressive behavior. The CMP summaries describing discharge of patients later determined to have unstabilized EMCs to jail due to hospital policies involving alcohol intoxication, for example, also serve as a reminder that the MSE and stabilization requirements of EMTALA are enforceable regardless of any hospital, local, state or regional policies regarding dispositions. It is essential for all ED staff to consider EMTALA requirements when treating patients who present to an ED, regardless of whether the patient is arriving to or departing from the facility with law enforcement.

Many CMPs reviewed highlight the challenge of meeting a hospital's obligations under EMTALA, along with ensuring the safety of staff, other patients, and visitors under circumstances in which patients may be physically aggressive for a myriad of reasons, potentially due to underlying psychiatric emergencies, or with medical conditions impacting behavior. Further clarification from CMS in future iterations of the EMTALA Interpretive Guidelines may be helpful in guiding hospitals to develop policies and procedures to both ensure compliance with EMTALA, while simultaneously maintaining the safety of patients, visitors, and staff.

LIMITATIONS

Relatively few EMTALA violations result in a CMP, and our findings are limited to these violations, although this number may not account for CMPs that encompass multiple EMTALA violation events.[10,13] Settlement summaries varied considerably in length and detail across the study period. Therefore, it is possible that LEO-involvement may not have been identified for CMPs where details regarding arrival or departure or patient characteristics were not included (eg, the OIG alleged that the hospital failed to provide appropriate MSEs and stabilizing treatment to two patients). Therefore, described cases represent examples of CMPs with LEO-involvement, but the current study likely underestimates the proportion of LEO-involved clinical cases resulting in EMTALA-related CMPs. Additionally, available CMPs do not always include the full set of EMTALA deficiencies identified, and deficiencies are only called out when negligent violations are noted, perhaps explaining why there were far fewer noted failures to stabilize than failures to complete an MSE.

The CMPs, as reported by OIG, provide an analyzable, albeit limited, narrative summary that enables descriptions of events leading up to an EMTALA violation and the resulting CMP. However, data available for analysis is limited to the unstructured CMP summary of settlement text, which typically contains only brief narratives of the patient's ED encounter, often lacking the clinical detail and nuance that a clinician-reader might desire. The CMP summaries released by the OIG do not fully capture the context in which EMTALA violations occur, and whereas CMS has made limited redacted inspection text related to some EMTALA events publicly available, plans of corrective action and quality improvement determinations are not routinely publicly released. Attempts to obtain additional information about enforcement responses via the Freedom of Information Act have yielded variable responses. We also want to note that the purpose of this study was to describe how EMTALA has been enforced and not to establish whether CMS or OIG determinations were merited.

CONCLUSION

Every CMP describing a LEO-involved patient involved a failure to provide an adequate MSE, and two thirds additionally involved failure to provide stabilizing treatment. Findings indicate a need for education, both among hospital staff and LEOs, surrounding EMTALA requirements, regardless of whether the patient is accompanied by or in the custody of law enforcement. Transfers via law enforcement vehicles are not explicitly prohibited but should be carefully evaluated on a case-by-case basis. Findings may serve to guide future, more comprehensive evaluations of the universe of EMTALA citations related to the care of LEO-involved patients and to inform future iterations of interpretive guidelines that may benefit from additional clarification and examples regarding the duties pertaining to LEO-involved individuals for whom care is sought in EDs.

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Validating an Electronic Health Record Algorithm for Diabetes Screening Eligibility in the Emergency Department

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Objective: While the American Diabetes Association (ADA) screening guidelines have been used widely, the way they are implemented and adapted to a particular setting can impact their practical application and usage. Our primary objective was to validate a best practice advisory (BPA) screening algorithm informed by the ADA guidelines to identify patients eligible for hemoglobin a1c (HbA1c) testing in the emergency department (ED).

Methods: This cross-sectional study included adults presenting to a large urban medical center's ED in May 2021. We used sensitivity, specificity, likelihood ratios, and predictive values to estimate the algorithm's ability to correctly identify patients eligible for diabetes screening, with manual chart review as the reference standard. Eligibility criteria targeted patients at risk for diabetes who were likely unaware of their elevated HbA1c. We also calculated the area under the receiver operating characteristic curve (AUC).

Results: In May 2021, 2,963 (77%) of the 3,850 adults admitted to the ED had a routine lab ordered. Among those, 796 (27%) had a BPA triggered, and of those 631 (79%) had an HbA1c test completed. The algorithm had acceptable sensitivity (0.69, 95% confidence interval [CI] 0.66-0.72), specificity (0.91, CI 0.89-0.92), positive predictive value (0.75, CI 0.72-0.78) and negative predictive value (0.88, CI 0.86-0.89). The positive likelihood ratio (7.39, CI 6.35-8.42) was adequate, and the negative likelihood ratio (0.34, CI 0.30-0.37) was informative. The AUC of 0.74 (CI 0.72-0.77) suggests that the algorithm had acceptable accuracy.

Conclusion: Findings suggest that an electronic health record-based algorithm informed by the ADA guidelines is a valid tool for identifying patients presenting to the ED who are eligible for HbA1c testing and may be unaware of having prediabetes or diabetes. The ease of workflow integration and high yield of potentially undiagnosed diabetes and prediabetes makes the BPA algorithm an appealing method for diabetes screening within the ED. [West J Emerg Med. 2025;26(3)720–728.]

INTRODUCTION

Diabetes affects approximately 38 million adults and is the seventh leading cause of death in the United States.[1] Type 2 diabetes accounts for over 90% of all people with diabetes.[2] Approximately 23% of individuals with type 2 diabetes, and 80% of those with prediabetes (an intermediate high-risk condition for type 2 diabetes) are unaware of their condition.[1] While diabetes screening has commonly been offered in primary care settings,[3,4] certain populations do not routinely use primary care services.[5-9] These populations include those with less educational attainment,[10] low socioeconomic status,[11,12] no or inconsistent health insurance status,[13-15] certain racial and ethnic minority backgrounds,[16-18] and those with poor English literacy.[19,20] These groups are also more disproportionately burdened by diabetes and its associated complications.[21,22] Therefore, individuals at greater risk for diabetes are less likely to be screened for diabetes in primary care.[23]

Concurrently, those disproportionately affected by diabetes frequently use emergency department (ED) services.[24-28] The ED setting, traditionally thought to focus on providing emergent and urgent healthcare, may be an opportune environment to introduce targeted preventative services for populations that do not routinely use primary care services.[29,30] Studies in the US have shown that diabetes screening in the ED using hemoglobin A1c (HbA1c) as the diagnostic test is feasible.[31-36] Additionally, retrospective studies in the US have reported a higher prevalence of undiagnosed diabetes and prediabetes in the ED compared to the national average.[37,38] The higher prevalence of undiagnosed diabetes and prediabetes in the ED may reflect the prevalence of undiagnosed disease among vulnerable populations that frequently use the ED and are at greater risk for diabetes-related complications.[23,24] Therefore, offering diabetes screening and conducting HbA1c testing in the ED may provide a "safety net" to patients who underuse or have limited access to primary care services to prevent downstream complications and healthcare costs.[29,30]

Previously reported diabetes screening initiatives within the ED were conducted within a controlled research setting and do not reflect implementation efforts within a real-world ED practice setting.[31-33] Electronic health record (EHR)-based clinical decision support tools, such as a best practice advisory (BPA), have been used for screening patients in the ED and could be an efficient tool for identifying diabetes at-risk patients in the acute care setting.[39,40] A BPA is a pop-up message built into the EHR that can remind, guide, or prompt clinician action in the course of patient care.[41,42] Such automated EHR-driven tools have been used successfully for identifying and screening high-risk patients for HIV[43,44] and hepatitis C[45,46] in the ED. In 2020, the Innovating Diabetes Screening in Emergency Departments and Linkage Services (IDEAL) project implemented a routine, EHR-based diabetes screening BPA in the ED at the University of Illinois Hospital and Health Sciences (UI Health) System. The program was designed to identify ED patients with undiagnosed prediabetes or diabetes and facilitate appropriate linkage to care, which has been described elsewhere.[47] The BPA algorithm is informed by the American Diabetes Association (ADA) screening guidelines.[48]

While the ADA guidelines have informed previously reported diabetes screening efforts within the ED setting,[31-33,38,49] the way the guidelines are implemented and adapted to a particular setting can have an important impact on their practical application or utilization.[50-52] For example, using personnel to identify patients at risk for diabetes can be resource-intensive, difficult to implement within non-research settings, and prone to human error.[31,53,54] The advent of the EHR and its clinical decision support tools, like BPAs, make it possible to use technology to aid screening initiatives and eliminate inefficiencies.[55-58] While the use of clinical decision tools to identify at-risk patients is more common, only some tools have been validated to demonstrate that they are accurate in identifying the intended population.[55,59] The validation of an EHR-based algorithm informed by the ADA guidelines to identify ED patients with potentially undiagnosed prediabetes or diabetes has not been previously reported. Therefore, our objective was to validate an EHR-based diabetes screening BPA informed by the ADA guidelines in identifying eligible patients for HbA1c testing in the ED using commonly extractable elements from patients' health records.

Population Health Research Capsule

What do we already know about this issue?
Diabetes screening in the emergency department (ED) offers diabetes prevention opportunities to patients of low socioeconomic status who may be overlooked in primary care

What was the research question?
Can an algorithm embedded into an electronic health record system validly screen patients at risk for diabetes in the ED?

What was the major finding of the study?
The algorithm is valid based on performance characteristics (eg, sensitivity, specificity, area under the ROC curve).

How does this improve population health?
The ease of workflow integration and high yield of potentially undiagnosed diabetes and prediabetes make the algorithm an appealing method for diabetes screening within the ED.

METHODS

Study Population

We performed a cross-sectional cohort study of adults (≥18 years old) presenting to the UI Health ED in May 2021 with a routine diagnostic lab ordered. An automatic report generated through the hospital's EHR (Epic Systems Corporation, Verona, WI) identified the cohort. The University of Illinois Chicago Institutional Review Board reviewed and approved this study. A visual representation of the program can be seen in the Appendix figure.

The screening algorithm was informed by the ADA guidelines and was simplified for ease of implementation.[48] The algorithm identified those eligible for HbA1c testing based on the following criteria: 1) patients ≥45 years old; or 2) patients ≥18 years old with a body mass index (BMI) of ≥25 kg/m^2; and 3) no history of diabetes; and 4) no HbA1c test result three years preceding the ED visit. If BMI was missing at the visit, the algorithm used the most recent BMI on file. The algorithm did not trigger a BPA if no previous BMI was available or if age was missing. The algorithm used diagnosis-related group codes associated with diabetes to identify a history of diabetes within specific searchable fields. The algorithm searched for a previous HbA1c test result in the patient's lab results in the EHR. The algorithm could not search through free text or information shared by other health systems via the integrated EHR network (ie, EpicCare Everywhere). If a patient presenting to the ED with a routine diagnostic lab ordered met the screening criteria, the algorithm triggered a BPA, which would notify the clinician that the patient could be at risk for diabetes and was eligible for diabetes screening (ie, HbA1c testing). The clinician could then "add" a preselected HbA1c test to the existing lab order.

Measures

The following parameters informed the EHR algorithm: age (continuous); BMI (continuous); history of diabetes (dichotomous); and history of HbA1c test within three years (dichotomous) at the time of the ED visit. The inputs for the algorithm were obtained using automatic reports generated via the EHR and manual chart extraction. Automatic reports for algorithm inputs were available for patients with a BPA triggered. No report for "potential inputs" was available for patients who did not have a BPA triggered. In the interest of time, researchers randomly sampled 10% of all patients without a BPA triggered, stratified by race and ethnicity, and identified the inputs that likely informed the BPA during the ED visit via manual chart review. Five individuals (MS, PP, JP, AA, PK) conducted a manual chart review from September 2021–October 2022 to identify reference values for checking against the algorithm inputs to verify whether the BPA was triggered or failed to be triggered appropriately. For all manual data extraction, one individual initially extracted the data, and a second individual double-checked each item.

Personnel manually verified the algorithm input for BMI against the BMI taken during the ED visit and the algorithm input for age reported against the date of birth entered in the patient's EHR. A history of diabetes was assessed by searching for the words "diabetes," "DM," "type 2 diabetes," "T2D," "T2DM," "preDM," and "prediabetes" using the chart search function in Epic, which searches through notes, entries, and scanned documents for the keywords (including their synonyms) within the EHR and across the Care Everywhere network. Similarly, HbA1c history was assessed using keywords such as "HbA1c" and "hemoglobin a1c" to help parse through laboratory results. Hemaglobin A1c testing is unreliable for diagnosing prediabetes or diabetes in patients with sickle cell anemia or HIV, or in women who are pregnant.[48] To maximize the ease of implementation, no associated exclusion criteria was built into the algorithm at the time. During the chart review, BPA triggers among patients who were identified with the aforementioned conditions during their ED visit were flagged and counted against the algorithm since further assessment is needed to diagnose these patient populations (ie, false positives).

Statistical Analysis

We used the Student *t*-test (and Wilcoxon rank sum test for non-normally distributed data) and chi-square tests to compare continuous and categorical demographic characteristics, respectively, for the BPA-triggered and no BPA-triggered groups. We generated two-by-two tables for BPA alerts against manual chart review results. We reported estimates for sensitivity, specificity, predictive values, and likelihood ratios. The sensitivity and specificity were considered acceptable if the sum of the two values was at least 150%.[60,61] The sensitivity is the algorithm's ability to correctly identify the proportion of patients who are truly eligible for HbA1c testing in the ED. Specificity is the algorithm's ability to identify the proportion of ED patients who are truly ineligible for HbA1c testing.[60] The positive predictive value (PPV) represents the probability of an individual who had a BPA triggered being truly eligible for HbA1c testing, while the negative predictive value (NPV) represents the probability of an individual who did not have a BPA triggered being truly ineligible for HbA1c testing.[61]

Based on existing literature, the prevalence of undiagnosed diabetes in the ED is approximately 30%.[37,62] Assuming a minimum sensitivity and specificity of 75% for both with a 30% prevalence, the minimum desired PPV and NPV are calculated to be 56% and 88%, respectively.[61] Likelihood ratios are not influenced by disease prevalence and summarize the extent to which the algorithm changes the initial likelihood of the patient's eligibility for HbA1c testing (ie, pretest probability) to a more accurate estimate of the patient's eligibility (ie, posttest probability).[63,64] A positive likelihood ratio (LR+) between 5-10 and a negative likelihood ratio (LR-) between 0.1-0.2 were deemed acceptable.[64] We reported associated standard errors and 95% confidence intervals (CI).

We built receiver operating characteristic (ROC) curves to evaluate the algorithm's accuracy using age, BMI, history of diabetes, and history of HbA1c test within three years of the ED visit based on a weighted logistic regression model. The binary outcome of interest was correct BPA determination of HbA1c eligibility, defined as the BPA firing (or not firing) appropriately when verified by the medical chart review as the reference standard. We estimated sampling weights based on the underlying distribution of race and ethnicity within the overall population. The area under the curve (AUC) was generated for each model.[65] An AUC between 0.7-0.8 is acceptable, and above 0.8 is considered excellent.[66] We performed all statistical analyses using SAS software version 15.2 (SAS Institute Inc., Cary, NC). Statistical analysis was completed in April 2023.

RESULTS

In May 2021, 2,963 (77%) of the 3,850 adults presenting to the UI Health ED had a laboratory test ordered**.** Of those, 796 (27%) had a BPA triggered, with 631 (79%) of those triggers leading to completed HbA1c tests. A cohort of 221 patients was randomly selected for manual data extraction among the 2,167 patients who did not trigger a BPA. A cascade diagram of the algorithm can be seen in the Figure. A greater proportion of males had a BPA triggered compared to the proportion of females (33% vs 23%, $P<0.01$) (Table 1).

The BPA-triggered group tended to be older (51 vs 46, $P<0.01$) with a similar BMI (30 vs 30, $P = 0.124$) compared to the no-BPA-triggered group. Most patients across both groups were non-Hispanic Blacks, although a smaller proportion of non-Hispanic Blacks (24%) and Hispanics (29%) had a BPA triggered compared to other identified racial groups. There was a greater proportion of uninsured (39%), other (39%), and privately insured patients (33%) compared to those with Medicare (25%) and Medicaid (23%). A two-by-two table can be seen in Table 2.

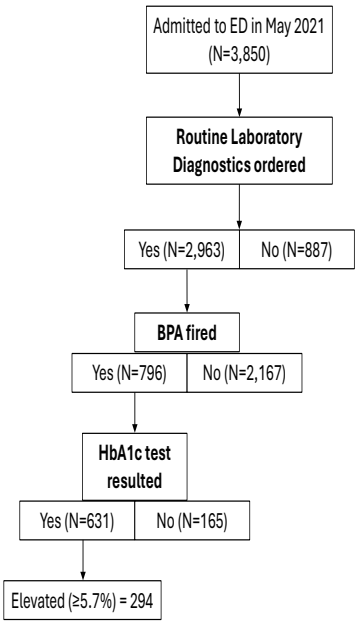

Figure. Cascade diagram of patients eligible for diabetes screening in the emergency department.
ADA, American Diabetes Association; *BPA,* best practice advisory; *ED,* emergency department.

The algorithm had an acceptable sensitivity (0.69, 95% CI 0.66-0.72), specificity (0.91, CI 0.89-0.92), PPV (0.75, CI 0.72-0.78) and NPV (0.88, CI:0.86-0.89) (Table 3). The LR+ was also acceptable (7.39, CI 6.35-8.42), and although the LR- (0.34, CI 0.30-0.37) was greater than the predetermined cut-off, values between 0.2 and 0.5 can still be significant in driving change in pretest to posttest probability.[64] The AUC of 0.74 (CI 0.72-0.77) suggests that the algorithm displayed acceptable accuracy.[66]

DISCUSSION

We sought to evaluate the accuracy of adapting the ADA guidelines to identify ED patients at risk of diabetes who were likely unaware of their condition via an EHR-based algorithm. To our knowledge, this is the first study validating a BPA diabetes screening algorithm informed by the ADA guidelines to identify eligible patients for HbA1c testing within the ED. The performance characteristics of the algorithm were acceptable, especially given the ease with which screening was integrated into the existing ED workflow and the yield of patients identified with abnormal HbA1c who would require resources to facilitate linkage to primary care. We conclude that the EHR-based algorithm informed by the ADA is a valid tool to identify patients with potentially undiagnosed prediabetes and diabetes within the ED.

The algorithm had high specificity (0.91), indicating that it was effective in correctly excluding patients who were not eligible for HbA1c testing, which is desirable when resources are limited.[67] The high yield of abnormal HbA1c among those screened (Figure) who will require follow-up and possible linkage to care makes a highly specific screening algorithm desirable.[61,68] The high NPV (0.88) minimizes the likelihood of missing eligible patients for testing among those who did not have a BPA triggered.[68] This is important since screening in the ED provides a safety net for patients who may not be screened in other settings (ie, primary care).[29] The PPV (0.75) is acceptable while moderate, given that the HbA1c lab draw is easily added due to the BPA and is relatively inexpensive to run.[68,69]

Also, the LR+ and LR- are intuitively related to ruling out and ruling in, respectively, of patient's true eligibility for diabetes screening in the ED.[64,70] The LR+ (7.4) gives moderate assurance that when the BPA did not trigger, the patient was truly ineligible for HbA1c testing. The LR- (0.34) may mean that when the BPA triggers, the patient may actually not have been eligible for testing. This likely reflects the algorithm's inability to identify accurate identify certain inputs, which results in the BPA misfiring (eg, a patient with a history of

Table 1. Patients with best practice advisory triggered vs none triggered based on the modified American Diabetes Assocation screening algorithm.

	Total cohort (N=2,963)	BPA triggered[a] (n=796)	No BPA triggered (n=2,167)	P-value[b]
Sex, n (%)				<0.01
Male	1,182 (39.9)	394 (33.3)	788 (66.7)	
Female	1,781 (60.1)	402 (22.6)	1,379 (77.4)	
Age, mean (SD)	48 (17.9)	51 (17.1)	46 (18.1)	<0.01
Age, n (%)				<0.01
18-44, n (%)	1,376 (46.4)	279 (20.3)	1,097 (79.7)	
45-64, n (%)	1,003 (33.9)	330 (32.9)	673 (67.1)	
65+, n (%)	584 (19.7)	187 (32)	397 (68)	
BMI, mean (SD)	30.1 (8.8)	30.4 (8.7)	30 (8.9)	0.24
Race/ethnicity, n (%)				<0.01
Hispanic	763 (25.8)	218 (28.6)	545 (71.4)	
White, non-Hispanic	290 (9.8)	114 (39.3)	176 (60.7)	
Black, non-Hispanic	1,649 (55.7)	389 (23.6)	1,260 (76.4)	
Asian, non-Hispanic	99 (3.3)	38 (38.4)	61 (61.6)	
Other, non-Hispanic	125 (4.2)	29 (23.2)	96 (76.8)	
Unknown	37 (1.3)	8 (21.6)	29 (78.4)	
Insurance, n (%)				<0.01
Medicaid	1,374 (46.4)	316 (23)	1,058 (77)	
Medicare	760 (25.7)	192 (25.3)	568 (74.7)	
Private	613 (20.7)	204 (33.3)	409 (66.7)	
Other	36 (1.2)	14 (38.9)	23 (63.9)	
Uninsured	180 (6.1)	70 (38.9)	110 (61.1)	

[a]Informed by the American Diabetes Association 2020 screening guidelines, focused on patients 1) ≥18 with a BMI ≥ 25 kg/m2 or ≥ 45 years old; and 2) without a previous diabetes diagnosis and without a previous hemoglobin A1c test in their chart within the previous 3 years.[48]
[b]Boldface indicates statistical significance (P<0.05).
BMI, body mass index; *BPA,* best practice alert.

Table 2. Modified American Diabetes Assocation- and simulated US Preventive Services Task Force-electronic health record algorithm best practice alerts by manual chart review.[a]

	ADA Manual chart review		
EHR algorithm	The BPA should have triggered	The BPA should not have triggered	Total
BPA triggered	599	197	796
No BPA triggered	265	1,902	2,167
Total	864	2,099	2,963

[a]The upper left-hand quadrant represented true positives (ie, patients for whom BPA triggering was deemed appropriate after verifying the four parameters of interest through the manual chart review process). The lower right-hand quadrant represented true negative (ie, patients for whom BPA correctly failed to trigger, also verified by manual chart review). The upper right-hand quadrant represented false positives (ie, patients for whom a BPA was triggered when it should not have been based on manual chart review. Finally, the lower left-hand quadrant represented false ineligible patients (ie, patients for whom the BPA failed to trigger but should have based on manual chart review).
ADA, American Diabetes Association; *BPA,* best practice advisory; *EHR,* electronic health record.

diabetes or previous HbA1c test was not searchable in the UI Health EHR). However, overall, the algorithm displayed acceptable accuracy, as seen in the AUC value of 0.74,[66] especially when considering that the screening implementation method (ie, EHR-based BPA) allowed for easy integration into the existing ED workflow, the cost of testing is relatively inexpensive, and the volume of patients identified with abnormal HbA1c that require care coordination follow-up.[69]

Table 3. Test characteristics of modified American Diabetes Association- and simulated US Preventive Services Task Force-informed electronic health record screening algorithm.

	ADA		
	Estimate	SE	95% CI
Sensitivity	0.69	0.02	(0.66 - 0.72)
Specificity	0.91	0.01	(0.89 - 0.92)
PPV	0.75	0.02	(0.72 - 0.78)
NPV	0.88	0.01	(0.86 - 0.89)
LR+	7.39	0.53	(6.35 - 8.42)
LR-	0.34	0.02	(0.30 - 0.37)
AUC	0.74	0.01	(0.72 – 0.77)

AUC, area under the receiver operator curve; *CI,* confidence interval; *ED,* emergency department; *HbA1c,* hemoglobin A1c; *LR+,* positive likelihood ratio; *LR-,* negative likelihood ratio; *NPV,* negative predictive value; *PPV,* positive predictive value; *SE,* standard error.

Previously reported diabetes screening programs in the ED within the US are resource-intensive and can be burdensome to implement, particularly if screening procedures disrupt the ED workflow.[31-33,53] Screening strategies that are easily integrated into existing system processes will be essential for successful program implementation and maintenance across ED health systems.[71,72] An EHR-based algorithm facilitates the ease of ED workflow integration, given that most hospitals in the US use an electronic record system and are familiar with BPAs.[73,74] Previous EHR-based screening programs have been successfully implemented in acute care settings (ie, such as those for HIV and hepatitis C).[44,56,75] Our findings and other reports from the IDEAL program affirm the feasibility and efficiency of using a routine EHR-based diabetes screening algorithm and a clinical decision support tool (such as the BPA) in the emergency care setting.[47]

The IDEAL program has found that approximately half of those tested had an abnormal HbA1c, and 75% of patients with abnormal results who were successfully followed up indicated they were unaware of their condition.[47] This suggests that patients eligible for HbA1c testing at the UI Health ED have a significant likelihood of having an abnormal HbA1c result, likely indicative of an undiagnosed condition. These findings are consistent with previously published literature and highlight the impact this EHR-based diabetes screening tool may have.[37,47,62]

LIMITATIONS

There are several limitations to the study. The algorithm cannot search free text (eg, clinician notes) or information shared via Epic Care Everywhere, which is a literature-reported limitations and source of misclassification errors in EHR data.[76] Additionally, the algorithm was developed using the 2020 ADA guidelines,[48] and our findings do not directly reflect the updated 2022 ADA guidelines, which lowered the screening age to 35.[77] However, recent literature has found that the ADA guidelines maintained high sensitivity even when lowering the age threshold for screening.[78] To ease the implementation process, the algorithm did not differentiate based on race (eg, Asian American), comorbidities (eg, hypercholesterolemia or hypertension), or family history (eg, first-degree relative with diabetes) since these parameters are often unreliably entered into the records but are recommended factors for consideration in the guidelines.[48,79] Additionally, the algorithm did not exclude patients with a history of sickle-cell anemia, HIV, or women who were pregnant; however, BPA firings among these patients counted against the algorithm as predetermined by the research team, since HbA1c testing is unreliable in diagnosing prediabetes and diabetes in these patients.[48] Future versions may attempt to account for these specifications. While we could not measure the true prevalence of HbA1c testing eligibility, we used previously reported estimates of undiagnosed diabetes in the ED to inform our acceptable ranges for PPV and NPV, which are influenced by disease prevalence.

Our present validation study was conducted at a single site within a one-month period. Upon expansion of the program, future validation efforts should include multiple sites across a wider timeframe. Finally, the UI Health care coordination team attempted to follow up with patients with an abnormal HbA1c result and found that approximately 25% of those who were followed up by care coordination services indicated they were previously aware of an existing prediabetes or diabetes condition. However, we could not verify this information during the chart review and possibly misclassified these patients due to missing EHR information.

CONCLUSION

Findings suggest that an electronic health record-based algorithm informed by the American Diabetes Association guidelines is a valid tool for identifying patients presenting to the ED who were at risk for diabetes and, if upon testing had an elevated HbA1c, were likely unaware of having prediabetes or diabetes. The ease of workflow integration and high yield of potentially undiagnosed diabetes and prediabetes make the BPA algorithm an appealing method for diabetes screening within the acute care setting. Future research initiatives include validating any updates to the algorithm and exploring effective linkage to care strategies and cost-effectiveness studies.

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Coronary Artery Bypass Grafting Is Rarely Done in the Acute Care of ST-elevation Myocardial Infarction Patients Treated by Emergency Medical Services

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Introduction: The use of coronary artery bypass grafting (CABG) for primary revascularization during the acute care of ST-elevation myocardial infarction (STEMI) patients has declined significantly in the past decade; but there is little data to determine whether there has been a change in the use of CABG for STEMI patients treated by emergency medical services (EMS). In this study we described the incidence of urgent or emergent CABG for STEMI patients treated in a large, regionalized cardiac care system.

Methods: We obtained data obtained for patients transported by EMS between January 2011–December 2022 who were diagnosed with acute STEMI on prehospital or emergency department (ED) electrocardiogram and taken for primary diagnostic catheterization. All STEMI patients were transported by EMS to one of 34 STEMI receiving centers (SRC) in a regionalized cardiac care system, all of which are required to maintain onsite cardiac surgery as a condition of their SRC designation. Patients were considered to have undergone urgent or emergent CABG if it was performed within 72 hours of the primary diagnostic cardiac catheterization. We excluded patients if no diagnostic catheterization was performed or if CABG was performed >72 hours after diagnostic catheterization. The primary outcome was the incidence of urgent or emergent CABG. Patients were further stratified by time between diagnostic catheterization and CABG (<24 hours, 24-48 hours, 48-72 hours).

Results: A total of 28,349 patients were transported by EMS and diagnosed with an acute STEMI during the study period. Only 384 (1.35%) patients underwent CABG within 72 hours of diagnostic catheterization: 268 (0.95%) underwent CABG in <24 hours; 71 (0.25%) in 24-48 hours, and 45 (0.16%) in 48-72 hours. The median age of patients undergoing CABG was 64 years (interquartile range 58-72). Twenty-eight (7.3%) experienced prehospital cardiac arrest, and eight (2.1%) required vasopressors. Prior to undergoing CABG, 137 patients (36%) underwent primary percutaneous coronary intervention. The proportion of patients undergoing CABG within 72 hours remained relatively stable between 2011–2022 at 1.19% and 1.96%, respectively.

Conclusion: Urgent or emergent CABG remained infrequently performed for acute STEMI patients after primary diagnostic catheterization. There was little change in the percentage of STEMI patients who received CABG within 72 hours of diagnostic catheterization over the past decade. These findings suggest that regional or local policies requiring on-site cardiac surgery at SRCs may be reconsidered. [West J Emerg Med. 2025;26(3)729–736.]

INTRODUCTION

The use of emergency coronary artery bypass grafting (CABG) for revascularization during the acute phase of ST-elevation myocardial infarction (STEMI) care has decreased over the past decade.[1,2] Primary percutaneous coronary intervention (PCI) is the modality of choice for myocardial reperfusion in STEMI patients; emergency CABG is typically necessitated as a rescue modality for patients with ongoing ischemia, shock, coronary anatomy not amenable to PCI, post-MI mechanical complications, or PCI complications.[3,4] In the United States, use of emergency CABG for primary revascularization after STEMI care has declined to less than 5% annually.[1,2,5,6]

Historically, all acute STEMI patients treated by emergency medical services (EMS) were transported to receive primary PCI at hospitals with on-site cardiac surgery backup.[7] Nonetheless, more recent evidence suggests comparable patient outcomes after primary PCI at STEMI receiving centers (SRC) with and without on-site cardiac surgery.[8] From these studies, it was found that there were no differences observed in the rates of emergency cardiac surgery or mortality at SRCs without cardiac surgery backup.[8] National policy guidelines by the Society for Cardiovascular Angiography and Interventions, American College of Cardiology Foundation, and American Heart Association (AHA) have aligned with this evidence and now support the use of primary PCI for STEMI patients at SRCs without on-site cardiac surgery if proper transfer agreements to facilities with cardiac surgery have been established.[9,10] Despite this change in national recommendations, policies for SRC designations remain variable between states and in major metropolitan centers in California.[11-13] Furthermore, it is increasingly challenging to transfer patients rapidly between hospitals for those patients needing emergent specialty intervention. Overall, delays in care can lead to worse outcomes.[14] This has implications for both hospital services and EMS routing policies within regional cardiac systems of care.

The purpose of this study was to quantify the current incidence of urgent or emergent CABG performed for EMS-treated patients diagnosed with an acute STEMI and taken for primary diagnostic catheterization in a large regionalized cardiac care system over the past decade. We further sought to assess times from primary diagnostic catheterization to urgent or emergent CABG to understand whether this group of patients could be safely transferred for higher level of care within a regionalized system. These study results may guide the designation of SRCs within a regionalized cardiac care system and are relevant to administrators and physicians from the fields of EMS, emergency medicine, and cardiology.

Population Health Research Capsule

What do we already know about this issue?
The incidence of cardiac artery bypass grafting (CABG) during acute STEMI care is rare, yet policies continue to require 24/7 cardiac surgery coverage at STEMI centers.

What was the research question?
What is the incidence of CABG at <72 hours for STEMI patients?

What was the major finding of the study?
Annually, <2% of EMS-treated STEMI patients received urgent or emergent CABG at <72 hours after primary diagnostic catheterization.

How does this improve population health?
Designation of STEMI receiving centers without requiring 24/7 cardiac surgery coverage may increase access to STEMI care.

METHODS

Study Design

This retrospective study quantified the incidence of urgent and emergent CABG among EMS-transported patients who were diagnosed with an acute STEMI in the ED and taken for primary diagnostic catheterization within the regionalized cardiac care system in Los Angeles County. We followed the relevant retrospective chart review guidelines set forth by Worster el al and established a case selection criteria, defined variables, described the medical database, and outlined the sampling method used.[15] This study was determined to be exempt by the Institutional Review Board at the Lundquist Institute for Biomedical Innovation at Harbor-UCLA Medical Center.

Population and Setting

Los Angeles County has a population of nearly 10 million in a region spanning over 4,050 square miles and including rural, suburban, and urban areas.[16] The EMS 9-1-1 response is provided by 29 fire departments and one law enforcement agency, with Basic and Advanced Life Support units.[17] The Los Angeles County EMS Agency provides medical oversight and standardized treatment protocols used by all EMS responders operating within the county. The county uses a combination of direct and indirect medical oversight, with 21 base hospitals providing direct oversight for patients with high-risk or complex presentations.

The Los Angeles County EMS Agency oversees our regionalized cardiac care system; paramedics transport all patients with STEMI on prehospital electrocardiogram (ECG) to one of 34 designated SRCs.[18] Per current county treatment

protocols, ECGs with STEMI detected by the evaluating paramedic or by automated report of the EMS monitor-defibrillator are transmitted to the nearest designated SRC for physician review and potential activation of the cardiology catheterization team. The EMS agency designates all SRCs in Los Angeles County and requires each SRC to have cardiac catheterization and cardiothoracic surgery services 24 hours/7 days a week/365 days a year. All SRCs must also submit data to the Los Angeles County EMS Agency for system quality improvement for patients transported by EMS to a SRC with suspected acute STEMI or a confirmed STEMI in the ED within one hour of arrival.

Patient Population

For this study, we included adult patients who were transported by EMS between January 1, 2011– December 31, 2022 to a designated SRC, and who were diagnosed with an acute STEMI by the cardiologist at the SRC based on prehospital or ED ECG and taken for primary diagnostic cardiac catheterization. Patients were excluded if they were <18 years of age, did not receive a diagnostic catheterization prior to CABG during their index hospitalization (either due to false-positive prehospital STEMI activation based on the prehospital ECG, contraindication to catheterization, or refusal), or if the CABG date and time were missing.

Data Collection

We etracted data from consecutive EMS-transported acute STEMI patients from the county SRC database, which combines prehospital information from electronic patient care reports (eg, field care data) and from hospital electronic health records (eg, hospital outcome data). We extracted demographic variables including age and sex, and clinical variables including whether the patient experienced an out-of-hospital cardiac arrest, and whether the patient received vasopressors prior to PCI or CABG, primary diagnostic catheterization, PCI, and CABG during hospitalization. We also extracted the date and time of primary diagnostic catheterization, PCI, CABG, hospital disposition, hospital length of stay, and survival to hospital discharge. The interval between primary diagnostic catheterization and CABG was measured in minutes. Reasons for not performing primary PCI as reported by the interventional cardiologist were also extracted.

For patients transported between July 2019–December 2022, changes in the structure of the regional SRC database allowed for an additional variable to be extracted from this time period, which was the urgency of the CABG (ie, salvage, emergent, urgent, elective).[19] This variable is defined as follows: salvage refers to the presence of ongoing cardiopulmonary resuscitation enroute to the operating room or prior to induction of anesthesia; emergent, any procedure required for a patient with ischemic or mechanical dysfunction who was not responsive to any therapy except surgery; urgent, any surgery required during the same hospitalization to minimize patient deterioration; and elective, surgery conducted on a patient whose cardiac function has been stable prior to the operation. Level of urgency was based on the judgment of the primary cardiothoracic surgeon.

Outcomes

The primary outcome was the proportion of EMS-transported patients who underwent CABG within 72 hours after an acute STEMI diagnosis in the ED and primary diagnostic catheterization. The secondary outcome was the proportion who underwent CABG based on stratified time intervals (<24 hours, 24-48 hours, and 48-72 hours). We considered CABG performed within 72 hours of primary diagnostic catheterization to be urgent or emergent. Review of prior literature found no temporal definition of urgent or emergent CABG that could be easily applied to our dataset.[20] Generally, an emergency CABG during the acute phase of STEMI care has been defined as an unscheduled surgical procedure performed due to ongoing ischemia and/or refractory cardiogenic shock not amenable to PCI.[4,21] While no specific time cut-off has been suggested, one study defined emergency CABG as any operation that was performed before the next working day.[22] We chose a 72-hour cut off to capture those patients who underwent an urgent or emergent CABG early in their hospitalization. When creating time interval stratifications, we chose the <24-hour interval to represent a period during which transfer of a critically ill cardiac patient to higher level of care would be challenging within our system.

Analysis

We reported continuous variables as medians and interquartile ranges (IQR) and categorical variables as frequencies and percentages. For continuous variables, we used the Kruskal-Wallis rank-sum test as the test for statistical significance; and for categorical variables, we used the chi-squared test or Fisher exact tested. *P*-values <0.05 were considered statistically significant. We conducted all analyses and data visualization via R software v 4.3.3 (RStudio, Posit, PBC, Boston, MA).

RESULTS

Of 70,073 EMS-transported patients with a STEMI-activation based on the prehospital or ED ECG during the 12-year study period, 28,349 were diagnosed with an acute STEMI in the ED by the cardiologist and were taken for primary diagnostic cardiac catheterization. Of these 28,349 patients transported by EMS with confirmed STEMI, who represent the study population, 506 (0.82%) patients underwent urgent or emergent CABG during their hospital course. After exclusion of patients receiving CABG outside the specified 72-hour interval and those with incomplete data (Figure 1), 384 (1.35%) patients received CABG within 72 hours of primary diagnostic catheterization; 268 (0.95%)

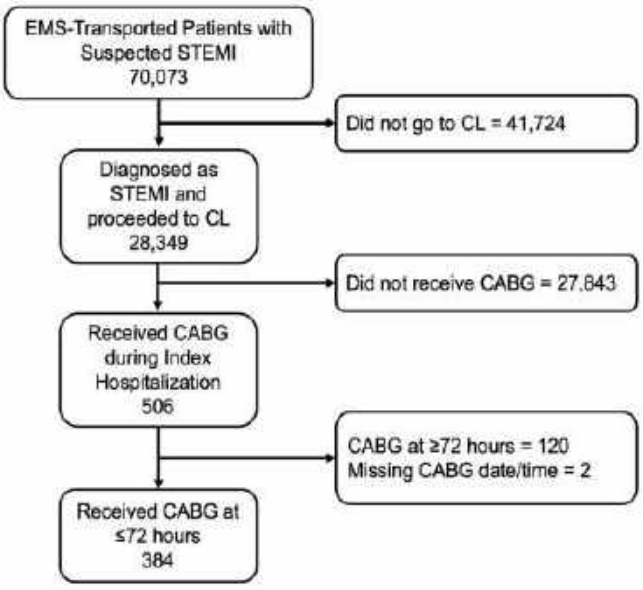

Figure 1. Flow diagram.
EMS, emergency medical services; *STEMI*, ST-elevation myocardial infarction; *CABG*, coronary artery bypass graft; *CL*, catheterization lab.

received CABG within 24 hours, 71 (0.25%) in 24-48 hours, and 45 (0.16%) in 48-72 hours. Less than half of patients received PCI prior to CABG in the <24-hour and 24-48-hour subgroups, and in slightly more than half in the 48-72-hour subgroup. Demographic and clinical characteristics for the study population are shown in Table 1.

The median intervals from primary diagnostic catheterization to CABG are reported in Table 2. For patients in the <24-hour group, the median interval to CABG was 303 minutes (5.1 hours). The most common reported reasons for not performing PCI prior to CABG was that the patient required CABG for multivessel disease, frequently with the use of an intra-aortic balloon pump (Table 3).

When evaluating temporal trends between 2011–2022 (Figure 2), the overall proportion of EMS-transported patients diagnosed with an acute STEMI that underwent CABG within 72 hours remained relatively stable between 2011–2022 at 1.19% and 1.96%, respectively, and this finding was similar in the other time intervals assessed. When assessing the time of day that CABG took place, 204 (8%) took place between the hours of 7 AM and 6 PM (Figure 3).

Among EMS-transported patients diagnosed with an acute STEMI between July 2019–December 2022 who underwent CABG, a pre-planned subanalysis to understand perceived CABG urgency demonstrated that the majority of cases in all time interval subsets were classified as "urgent." Of those categorized as "emergent," 90% received CABG within 24 hours. A complete breakdown is shown in Table 4.

DISCUSSION

In our investigation of EMS-transported patients who were diagnosed with an acute STEMI in the ED and taken for primary diagnostic catheterization we found that emergency CABG was infrequent. Over the 12-year study period, the proportion of acute STEMI patients undergoing urgent or emergent CABG was consistently below 3% each year. Among patients undergoing operative intervention within 24 hours, few required vasopressor support prior to CABG, and the median time to CABG was approximately five hours. These results suggest that the potential rate of emergent interfacility transfers for higher level of care for urgent or emergent CABG would be low in our system and aligns with prior evidence suggesting that primary PCI may be performed at hospitals without cardiac surgery backup if appropriate transfer agreements are in place.[8]

In the United States, the overall incidence of emergency CABG during the acute phase of STEMI care has been evaluated in multiple prior studies. A nationwide study by Keeling and colleagues reported that the incidence of emergent CABG for all STEMI patients remained consistently below 5% between 2005–2017 in the US.[2] Other studies have reported similarly low rates of CABG for all STEMI patients

Table 1. Descriptive characteristics.

	Overall N = 384 n (%)	<24 hours n = 268 n (%)	24-48 hours n = 71 n (%)	48-72 hours n = 45 n (%)	*P*-value
Age (years), median (IQR)	64 (58, 72)	63 (57, 72)	65 (60, 73)	65 (58, 72)	0.46
Male	314 (82)	219 (82)	55 (77)	40 (89)	0.30
Cardiac arrest	28 (7.3)	20 (7.5)	5 (7.0)	3 (6.7)	>0.99
Received vasopressors	8 (2.1)	6 (2.2)	2 (2.8)	0 (0)	0.63
Received PCI	137 (36)	89 (33)	25 (35)	23 (51)	0.07
Survived to hospital discharge	348 (91)	236 (88)	67 (96)	45 (100)	0.007
Hospital length of stay (days), median (IQR)	7.0 (5.0, 10.0)	7.0 (5.0, 9.0)	7.0 (6.0, 10.0)	8.0 (7.0, 10.0)	<0.001

Note: There was one missing value for sex, and two missing values for survival to hospital discharge and hospital length of stay.
IQR, interquartile range; *PCI*, percutaneous coronary intervention.

Table 2. Average time from primary diagnostic catheterization to coronary artery bypass graft.

	Overall N = 384 Median (IQR)	<24 hours n = 268 Median (IQR)	24-48 hours n = 71 Median (IQR)	48-72 hours n = 45 Median (IQR)
Cath Lab to CABG (hours)	13.58 (3.42, 28.28)	5.05 (2.67, 14.43)	34.12 (28.02, 41.03)	62.03 (55.65, 66.8)

IQR, interquartile range; *CABG*, coronary artery bypass graft; *cath lab,* cardiac catheterization laboratory.

in the US.[1,5,6] This study focused specifically on EMS-transported patients who were diagnosed with an acute STEMI in the ED by the treating cardiologist and taken for primary diagnostic catheterization, and also found consistently low rates of urgent or emergent CABG.

Multiple prior studies have evaluated outcomes after primary PCI for STEMI patients at centers with and without on-site cardiac surgery.[8,23,24] One prior randomized trial in 2004 found that mortality outcomes were similar for MI patients who received primary PCI at a hospital without on-site cardiac surgery compared to those transferred for primary PCI.[24] Additionally, a 2015 meta-analysis by Lee and colleagues compared outcomes of primary PCI after STEMI at hospitals with and without on-site cardiac surgery using 23 studies in an analysis totaling >1 million patients.[8] The authors found similar mortality outcomes in patients undergoing primary PCI for STEMI between hospitals with and without on-site cardiac surgery, and that the need for emergency cardiac surgery was rare in a pooled analysis (2.4% and 1.5% in hospitals with and without cardiac surgery, respectively). These studies provide evidence that primary PCI at hospitals without on-site cardiac surgery is likely safe and feasible in the modern era.

In 2021, the AHA released policy guidelines for the implementation of STEMI systems of care and outlined new recommended levels of care.[10] These guidelines described that primary heart attack centers (PHAC) must have 24/7/365 PCI capability and cardiac surgery backup is not required, while comprehensive heart attack centers (CHAC) must have 24/7/365 PCI capability and on-site cardiac surgery. The PHACs must have transfer agreements with CHACs to facilitate timely advanced cardiac care when needed. Our results demonstrated consistently low numbers of patients undergoing urgent or emergent CABG after a diagnosis of acute STEMI and primary diagnostic catheterization; the results from this study support the guidance and levels of care outlined in these national recommendations.

Nonetheless, widespread implementation of these guidelines in regional EMS systems has been slow. California state regulations allow SRCs to perform PCI without on-site cardiac surgery if written transfer agreements are in place.[25] Within each county in the state of California, local EMS agency policy governs EMS operations; thus, the practice of EMS clinicians may vary between regions. The LA County EMS Agency policy requires all SRCs to have on-site cardiac surgery. Among the 34 local EMS agencies (LEMSA) in California, 21 allow SRCs to perform primary PCI without on-site cardiac surgery, seven require on-site cardiac surgery at all SRCs, and three allow SRCs to perform primary PCI without on-site cardiac surgery only with permission from the LEMSA (Supplement). The reasons for this variation in policy are likely due to region-specific considerations (ie, rurality, population density, number of hospitals, interfacility transfer policies, and resources), a lag effect between national recommendations and policy implementation, a desire to adhere to the highest level of care recommendations set by the AHA (ie, CHACs), and existing community standards and expectations.[26]

The ability to rapidly and safely transfer an acute STEMI patient requiring urgent or emergent CABG from an

Table 3. Reason for not performing percutaneous coronary intervention prior to coronary artery bypass graft.

	Overall N = 247 n (%)	<24 hours n = 179 n (%)	24-48 hours n = 46 n (%)	48-72 hours n = 22 n (%)
Reason PCI was not performed				
Aortic dissection	1 (0.4)	1 (0.6)	0 (0)	0 (0)
Candidate for CABG/multivessel disease	229 (93)	162 (91)	46 (100)	21 (95)
Coronary artery dissection	1 (0.4)	1 (0.6)	0 (0)	0 (0)
Difficult cath/unable to cannulate/dilate vessel/cross lesion/locate artery	13 (5.3)	12 (6.7)	0 (0)	1 (4.5)
No reason provided	1 (0.4)	1 (0.6)	0 (0)	0 (0)
Other	2 (0.8)	2 (1.1)	0 (0)	0 (0)

PCI, percutaneous coronary intervention; *CABG*, coronary artery bypass graft; *cath*, catheterization.

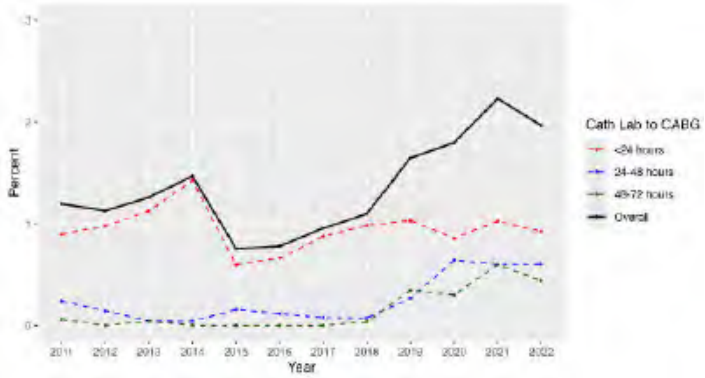

Figure 2. ST-elevation myocardial infarction patients transported by emergency medical services and to CABG after primary diagnostic catheterization lab. Patients are stratified by the time interval (<24 hours, 24-48 hours, and 48-72 hours)
EMS, emergency medical services; *STEMI*, ST-elevation myocardial infarction; *CABG*, coronary artery bypass graft; *Cath Lab*, catheterization lab.

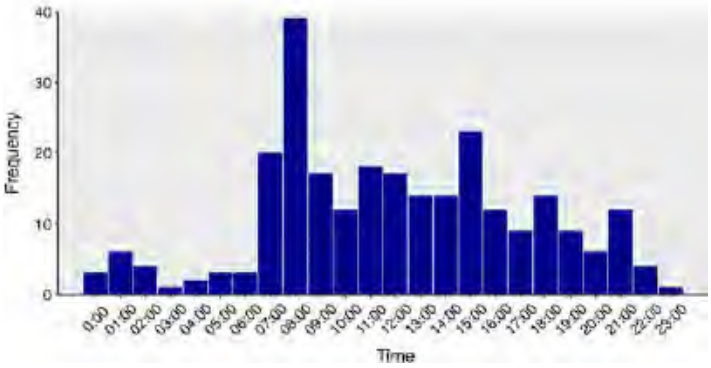

Figure 3. Time of day when the coronary artery bypass graft operation took place for the <24-hour group.

SRC without on-site cardiac surgery to a higher level of care has been a persistent concern. Emergency medical services systems continue to experience ambulance shortages leading to long wait times for ambulances, including critical care transports.[27,28] These concerns have likely contributed to hesitancy surrounding the removal of the requirement for on-site cardiac surgery at SRCs in some areas. In our study, the 24-hour time frame is an interval during which we anticipated it would be logistically challenging to arrange critical care transport and prepare the patient for surgery at the receiving facility. Only 23 (0.92%) EMS-transported STEMI patients underwent CABG in the first 24 hours of hospitalization across the SRCs during 2022, equating to fewer than two patients per month across a system of 34 SRCs. These patients rarely required vasopressor support prior to CABG. Further, our subanalyses found no cases of CABG marked with an urgency of "salvage" and a majority of cases with CABG within 24 hours had operative case start times during daytime hours. These findings build upon prior investigations in the US[1,2,5] and support wider acceptance of SRCs without on-site cardiac surgery back up as along as appropriate transfer aggrements are in place.

LIMITATIONS

This study was not free from limitations. We were unable to stratify our analysis by patients needing urgent or emergent CABG for primary revascularization vs PCI complications due to limitations in the available data. Nonetheless, only 0.4% (136/28,349) of STEMI patients during the entire study period underwent CABG after PCI and, thus, the rate of PCI complication leading to CABG could be, at most, 0.4% in our system. In our subanalysis between July 2019–December 2022, we also noted the inclusion of three cases deemed elective by the treating cardiothoracic surgeon. Given that we did not have data on reported urgency for the entire study population, we were unable to exclude these rare elective CABG cases performed within 72 hours of prior diagnostic catheterization.

Additionally, SRCs in our EMS system had on-site cardiac surgery; therefore, actual emergent interfacility transfer rates could not be measured. However, potential emergent interfacility transfer rates for a higher level of care may be extrapolated from our results. Finally, we evaluated only the incidence of CABG in patients with confirmed

Table 4. A subanalysis for reported urgency of coronary artery bypass graft operation.

	Overall N = 178 n (%)	<24 hours n = 83 n (%)	24-48 hours n = 51 n (%)	48-72 hours n = 44 n (%)
CABG Status				
Urgent	135 (76)	46 (56)	46 (90)	43 (98)
Emergent	40 (22)	36 (43)	4 (8)	0 (0)
Elective	3 (2)	1 (1)	1 (2)	1 (2)

Note: Data was only present for July 2019–December 2022. Additionally, there were zero cases reported as "salvage" during this period.
CABG, coronary artery bypass graft.

STEMI diagnosed in the ED, rather than the larger population of patients transported to STEMI receiving centers with prehospital-suspected STEMI. Including this broader population would have further decreased the proportion of prehospital patients at risk for requiring urgent or emergent cardiac surgery during their index visit.

CONCLUSION

Among EMS-treated patients who were diagnosed with an acute STEMI and taken for primary diagnostic catheterization, the incidence of urgent or emergent cardiar artery bypass graft within 72 hours of primary diagnostic catheterization was low and remained low during the 12-year study period. Our results showed that on average there was less than one case of emergent CABG performed at each facility annually. Based on these findings, regional or local policies requiring onsite cardiac surgery at STEMI receiving centers may be reconsidered.

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Real-time Ultrasound-guided Lumbar Puncture: A Comparison of Two Techniques Using Simulation

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Introduction: The current literature on the use of real-time ultrasound-guidance for lumbar punctures (LP) is limited. Two techniques have been described: the paramedian sagittal oblique (PSO); and the transverse interlaminar (TL) approach. Our objectives in this study were to compare the procedure outcomes between these two techniques and assess the ability of emergency physicians to perform ultrasound-guided LPs.

Methods: This was a prospective study whose participants included emergency physicians. Participants were randomized into either Group P (PSO technique) or Group T (TL technique). After a didactic session, participants then performed an ultrasound-guided LP on a training manikin, during which we collected procedure data. A survey was administered after completion of the procedure.

Results: A total of 31 participants were included, 16 in Group P and 15 in Group T. Most participants (90.3%) successfully performed the procedure, without a statistical difference between Group P and Group T (15/16 vs 13/15, $P = 0.95$). Group T required a longer average time to complete the procedure (176.7 ± 140.4 seconds [s] vs 311.2 ± 202.3 s, $P = 0.04$). There was no statistically significant difference between Group P and Group T with regard to average time needed to obtain the required ultrasound view (18.3 ± 14.6 s vs 35.1 ± 32.9 s, $P = 0.09$); number of needle redirections; total number of needle passes; first puncture success; number of participants who advanced the needle without visualization of the tip (13/16 vs 14/15, $P = 0.64$); penetration of the anterior dura; and needle contact with bone. The Likert-style questionnaire responses (reported on a 1-10 scale) revealed no difference between Group P and Group T as to perceived difficulty of finding the required ultrasound view (3 [interquartile range (IQR) 2-5) vs 5 (IQR 3-6.5), $P = 0.10$), perceived difficulty of needle tracking, or rating of the needle view when entering the intrathecal space. However, Group T reported a higher overall perceived level of difficulty (4 [IQR 3-5] vs 6 (IQR 5.5-7.5), $P = 0.01$).

Conclusion: This study suggests emergency physicians can be trained to use ultrasound-guidance for lumbar puncture in the simulation setting without significantly prohibitive training. Both techniques were performed with high success rates. There may be a preference for implementing the paramedian sagittal oblique approach over the transverse interlaminar. [West J Emerg Med. 2025;26(3)737–742.]

INTRODUCTION

Lumbar puncture (LP) is a valuable diagnostic and therapeutic procedure used in emergency medicine (EM) and other specialties for the evaluation and treatment of serious illnesses. Many procedures, including LP, have long been performed using "blind" landmark-based techniques, which depend on superficial anatomic structures as surrogate markers for deeper targets. The incorporation of ultrasound (US) has

become more common with many of these procedures due to demonstrated increases in success rates and fewer complications.[1,2] Procedural US may particularly benefit patients who are obese, have poorly palpable landmarks, or have atypical anatomy. It can be useful both for pre-procedure landmark identification (US-assisted) and real-time needle visualization during procedures (US-guided).

One of the most notable examples is central venous access.[3] Ultrasound-guided central venous cannulation has garnered such positive support from the literature that it has been endorsed by the Agency for Healthcare Research and Quality, has been given a Level 1 recommendation by the American College of Emergency Physicians, and is now considered the standard of care.[4,5] However, literature examining the use of real-time US-guidance for other procedures often used by emergency physicians, such as LPs, is less prevalent. Even more sparse is the literature evaluating the ability of emergency physicians to learn and perform the various techniques for US-guided LP.

Several US-guided LP techniques have been described in the literature. Two proposed methods are the paramedian sagittal oblique (PSO) approach and the transverse interlaminar (TL) approach.[6-12] The two techniques differ in the ultrasonographic view of the interlaminar space that is used during the procedure. While the US-guided PSO and TL methods have been independently described in the literature, they have never been directly compared. In this study our goal was to compare these techniques using an adult LP simulator to assess for possible differences between the two techniques with regard to procedure outcomes (success rate, procedure time, and potential complications) and perceived difficulty of the procedure. Secondary objectives included assessing the effectiveness of a procedure training program.

Population Health Research Capsule

What do we already know about this issue?
Two techniques for ultrasound-guided lumbar puncture (LP) include the paramedian sagittal oblique and transverse interlaminar approaches.

What was the research question?
We compared outcomes between the two techniques and assessed the ability of emergency physicians to perform simulated ultrasound-guided LPs.

What was the major finding of the study?
Most participants (90.3%) successfully performed the procedure, without a statistical difference between groups (P = 0.95).

How does this improve population health?
Emergency physicians can be trained to use ultrasound-guidance for LP in the simulation setting without time-intensive training.

METHODS

This was a prospective study conducted at two academic medical centers with two categorical EM residencies and one combined EM/pediatrics residency program. There is an emergency ultrasound fellowship program affiliated with both centers and a robust training program for residents and faculty. This study received institutional review board approval.

Study participants included EM attendings and resident physicians with variable US and procedural experience. Participants were randomized into either Group P using the PSO technique or Group T using the TL technique. They completed a 30-minute training that included an instructional video and a hands-on session to practice identification of spine sonographic anatomy and real-time needle tracking. A low-frequency, curvilinear transducer was used for this study. Both methods use an in-plane technique for needle tracking in real time.

To perform the PSO approach, the US probe is positioned in the sagittal direction, approximately 1 centimeter (cm) lateral to the midline above the sacrum and angled medially. The transducer is moved cranially until an interspace is reached and an optimal view into the spinal canal is obtained. Once a clear view is obtained, a puncture is performed paramedially, approximately 1 cm lateral to the midline on the opposite side. The needle is advanced into the field of the transducer. The target should directly lie beneath the ligamentum flavum in the spinal canal between the two adjacent laminae. For the TL view, the spinous process is first identified and centered on the US screen with the transducer in a transverse orientation. The transducer is then either moved cephalad or caudad to the interspinous space to identify the interlaminar space. The needle is introduced in a long-access approach with trajectory toward the interlaminar space, continuing until the intrathecal space is reached (Image 1).

After the training session, participants performed an US-guided LP on a patient care manikin, during which we collected procedure data. As the study participants performed the LP procedure, an investigator observed the procedure and obtained the following information in real time: time to obtain the correct US view; total time to perform the procedure; success of procedure (ability to aspirate simulated cerebrospinal fluid); and number of skin punctures with the number of times the needle was redirected. Observers were emergency physicians, who were fellowship-trained in emergency ultrasound. After completion of the procedure, participants were surveyed on the perceived difficulty of the steps of the procedure, the helpfulness of the educational

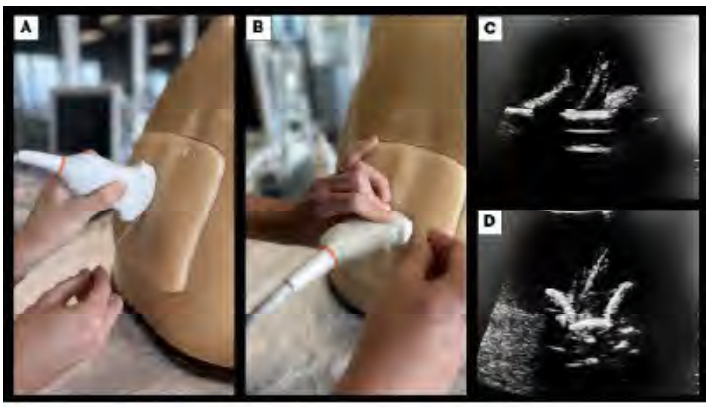

Image 1. Representation of probe orientation and sonographic views for the paramedian sagittal oblique (PSO) and transverse intralaminar (TL) ultrasound (US)-guided lumbar puncture approaches. A. Photograph of the PSO approach to US-guided lumbar puncture. B. Photograph of the transverse intralaminar (TL) approach to US-guided lumbar puncture. C. US image depicting needle guidance using the PSO approach. D. US image depicting needle guidance using the TL approach.

program, and the likelihood of considering the use of US-guided LP in the future. Participants were also asked to provide limited demographic information on the survey, such as level of training, prior experience with performing LP, and prior experience with performing US-guided procedures.

We summarized data by descriptive statistics using a confidence level of 95%. Procedure data were reported as the mean and standard deviation, while Likert-style questionnaire responses were reported as the median and interquartile range (IQR). We measured subjectively reported secondary endpoints obtained from the survey on a Likert scale. This included the perceived difficulty of the steps of the procedure, the helpfulness of the educational program, and the likelihood of considering the use of US-guided LP in the future.

RESULTS

A total of 31 participants were included in this study, 16 in Group P and 15 in Group T. The characteristics of each group are outlined in Table 1. Of the 31 participants, 14 had prior experience using the US-assisted technique for LPs and two had experience using the US-guided technique. Procedural outcomes are presented in Table 2. The majority of participants (90.3%) successfully performed the procedure, without a statistical difference between Group P and Group T (15/16 vs 13/15, $P = 0.95$). Group T required a longer average time to complete the procedure (176.7 ± 140.4 seconds [s] vs 311.2 ± 202.3 s, $P = 0.04$). There was no statistically significant difference between Group P and Group T with regard to average time needed to obtain the required US view (18.3 ± 14.6 s vs. 35.1 ± 32.9 s, $P = 0.09$), number of needle redirections, total number of needle passes, first puncture success, number of participants who advanced the needle without visualization of the tip (13/16 vs 14/15, $P = 0.64$), penetration of the anterior dura, and needle contact with bone.

The post-questionnaire responses revealed no difference between Group P and Group T with regard to perceived difficulty of finding the required US view (3, [interquartile range] (IQR) 2-5) vs 5, IQR 3-6.5), $P = 0.10$), perceived difficulty of needle tracking, or rating of the needle view when entering the intrathecal space (Table 3). However, Group T reported a higher overall perceived level of difficulty (4, IQR 3-5) vs 6, IQR 5.5-7.5), $P = 0.01$). Additionally, survey respondents reported their likeliness of routinely using US-guidance for LP in the future (5, IQR 4-7), considering the use of US-guidance in difficult LP

Table 1. Characteristics of emergency physicians who participated in simulation training for ultrasound-guided lumber punctures (LP).

Participant characteristics		Group P (n=16)	Group T (n=15)	P-value
Training level	PGY 1	0.250 (4/16)	0.333 (5/15)	0.91
	PGY 2	0.313 (5/16)	0.020 (3/15)	0.76
	PGY 3	0.125 (2/16)	0.067 (1/15)	1.00
	Attending	0.313 (5/16)	0.040 (6/15)	0.89
Number of ultrasounds performed	1-49	0.063 (1/16)	0.067 (1/15)	1.00
	50-149	0.063 (1/16)	0.200 (3/15)	0.95
	150-499	0.625 (10/16)	0.600 (9/15)	1.00
	≥ 500	0.250 (4/16)	0.133 (2/15)	0.71
Number of traditional LPs performed	1-14	0.625 (10/16)	0.533 (8/15)	0.88
	≥ 15	0.375 (6/16)	0.467 (7/15)	0.88
Number of in-plane procedures performed	0	0.063 (1/16)	0.200 (3/15)	0.55
	1-19	0.375 (6/16)	0.333 (5/15)	1.00
	≥ 20	0.563 (9/16)	0.467 (7/15)	0.86

PGY, postgraduate year.

Table 2. Lumbar puncture outcomes by group.

	Group P (n=16)	Group T (n=15)	P-value
Time to obtain ultrasound view (seconds)	18.33 (14.61)	35.13 (32.86)	0.085
Total procedure time (seconds)	176.69 (140.370)	311.20 (202.29)	0.043
Number of attempts (skin punctures)	1.81 (1.05)	3.13 (1.92)	0.042
Number of needle redirections	3.19 (3.31)	2.40 (2.72)	0.519
Total number of needle passes (attempts + redirections)	5.0 (3.85)	5.53 (3.27)	0.473
First puncture success	0.563 (9/16)	0.267 (4/15)	0.192
First pass success	0.188 (3/16)	0.133 (2/15)	1.00
Overall success	0.938 (15/16)	0.8 (13/15)	0.953
Hit bone with needle	0.313 (5/16)	0.533 (8/15)	0.378
Penetrated anterior dura with needle	0.5 (8/16)	0.4 (6/15)	0.843

candidates (8, IQR 7-9), and considering the use of US-guidance in patients who have already had an unsuccessful LP attempt (9, IQR 7-10).

DISCUSSION

Lumbar puncture remains a frequently used and important diagnostic procedure within the scope of EM. Although many procedures, such as central venous access, paracentesis, and thoracentesis have shifted toward the US guidance or assistance as the standard of care, LPs remain a procedure commonly done with only landmark guidance when performed in the emergency setting. Retrospective reviews and meta-analysis have shown that LPs using the standard landmark palpation technique have relatively high failure rates,[13,14] whereas US-guided LPs are associated with higher success rates and fewer attempts.[15-17] Ultrasound allows deeper structures and poorly identifiable landmarks to be visualized as opposed to identification through palpation alone. This may be of particular benefit to patients who are obese, have poorly palpable landmarks or atypical anatomy, and pediatric patients. The US-guided procedure provides the added benefit of using US to visualize the trajectory of a needle to its intended target in real time. Studies have shown that other procedures commonly performed in the emergency setting, such as central venous access and thoracentesis, have higher success rates and fewer complications when a real-time US-guided technique is used.[18-20] However, the use of US-guidance for LPs in the emergency setting has been less explored.

The EM literature has long focused on the use of US-assistance to identify landmarks when performing LPs. It has been shown to decrease complications and the number of attempts when compared to the standard technique of palpating landmarks[21,22] Literature, beyond case reports, on the use of US-guided LPs in EM has only emerged in recent years. When compared to the US-assisted technique, US-guidance has the benefit of improving safety by visualizing the needle during the procedure; however, this technique requires more advanced ultrasound skill, which could be seen as a deterrent for some emergency physicians. In addition to evaluating two US-guided techniques, we hoped to demonstrate that this was a skill emergency physicians could attain with training. The field of EM could benefit from larger prospective studies and, specifically, studies directly comparing guided vs assisted techniques when used by emergency physicians and their ability to translate training into the work environment.

Much of the existing knowledge on US-guided LPs is extrapolated from research in the field of anesthesia.[23-25] Literature in this area focused on the use of US guidance to visualize and access the spinal canal for not only LPs, but for injections and nerve blockades. While many of these studies tend to use a PSO of the transducer, rather than TL, past reviews have found it

Table 3. Participants' post-procedural perceptions by group.

	Group P (n=16) Median [IQR] Mean	Group T (n=15) Median [IQR] Mean	P-value
Difficulty of obtaining ultrasound window	3 [2-5] 3.38	5 [3-6.5] 4.86	0.099
Difficulty of needle tracking	5 [4-6] 5.15	5 [4-7] 5.21	0.688
Rating of view of needle tip in spinal canal	7 [6-9] 7.08	7 [5.5-7] 6.79	0.335
Overall difficulty	4 [3-5] 4.38	6 [5.5-7.5] 6.36	0.008

IQR, interquartile range.

difficult to come to any definite conclusion on whether this view is superior to others based on current existing literature.[26] Of note, one prospective study performed in the perioperative setting evaluated the use of a paramedian transverse approach, similar to the TL approach used in our study. This study suggested that the paramedian transverse view may be superior as a means of achieving epidural access relative to a sagittal approach, since the paramedian transverse approach had significantly shorter procedure duration times and fewer number of attempts.[27]

The results of our study demonstrated that US-guided LP by both the PSO and TL had high success rates. Despite most of the participants not using US guidance for LPs previously, the instructional video and hands-on session provided enough training for the vast majority to succeed on the simulation models. Both the PSO and the TL approach provide an in-plane view for needle tracking throughout the lumbar puncture and had no difference in overall success. Although the views and approaches seem similar, some procedural differences were noted. For example, the PSO approach had a significantly decreased procedural time with an average of 176 seconds (s) vs 311 s on the TL approach ($P = 0.04$). The ease in obtaining the desired ultrasound view with a mean time of 18.3 was less in the PSO group relative to 35.1 in the TL group; however, did not meet statistical significance ($P = 0.09$).

The PSO group provided statistically fewer skin punctures as well without increasing the number of needle redirections and showing no significant difference in number of total needle passes. This information is of particular importance as many of the known complications of LPs (post-LP headache, infection, bleeding, radicular pain, paresthesias, back pain, spinal hematoma, and traumatic tap) are associated with the number of attempts. For example, one study found an association between multiple dural punctures and post-LP headache.[28] Prior literature has found that multiple attempts and/or needle redirections are associated with more soft tissue damage, post-procedure pain, and traumatic taps.[29-31] Additionally, we assessed whether the needle hit bone during the procedure, as this could lead to pain or bleeding from the innervated and vascular periosteum or penetrates the anterior thecal sac, which may cause injury to the anterior epidural venous plexus or intervertebral discs that lie just beyond the anterior dura. No significant differences in the occurrence of this was found between the two groups.

Findings from the post-procedural survey found no statistically significant difference in the overall ratings of difficulty for obtaining the ultrasound window for the PSO vs the TL method. This was also true for participants' perceived difficulty of needle tracking. However, participants felt that overall, the PSO approach was less difficult than the TL approach. This was in agreement with some of the subjective findings obtained from procedural results. Subjective results found increased procedural time for the TL technique. There was also difficulty maintaining the view with needle in-plane as the majority of participants advanced the needle without the needle tip fully in view.

This study suggests emergency physicians can be trained to use US-guidance for LP. As mentioned, this study found that US-guided lumbar puncture by both the PSO and TL had high success rates. This was also in light of minimal instruction specific to these approaches prior to the study. There may be a preference for implementing the PSO approach over the TL view given its decreased overall procedural time and perceived level of difficulty.

LIMITATIONS

This study has several limitations, among them the controlled environment of the simulation laboratory, which may not be reflective of an actual clinical scenario with a real patient. The study was performed on a standard LP manikin, which may limit generalizability given the difficulties in clinical practice including positioning and body habitus. For example, the depth from skin-to-spinous process and skin-to-intrathecal space is 3.5 cm and 5.5 cm, respectively. This depth will not translate to patients with large body habitus. Should this same study be performed on a model simulating large body habitus or perhaps spinal pathology (eg, scoliosis), we may have experienced different results. This underscores the need for future studies on live patients. An additional limitation is the small sample size, which may limit the study's generalizability and the ability to identify small differences in performance. We also used a convenience sample of residents and attending physicians, which might have introduced selection bias.

CONCLUSION

This study suggests emergency physicians can be trained to use ultrasound-guidance for lumbar puncture in the simulation setting without significantly prohibitive training. Both techniques were performed with high success rates. There may be a preference for implementing the paramedian sagittal oblique approach over the transverse interlaminar approach. Future studies should focus on the use of these techniques on live patients in the emergency setting.

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Post-Concussion Syndrome Following Blast Injury: A Cross-Sectional Study of Beirut Blast Casualties

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Introduction: The massive 2020 blast in Beirut, Lebanon, caused by improperly stored ammonium nitrate, was one of the most powerful non-nuclear explosions in history, Following the blast, head injuries emerged as a predominant presentation to the emergency department (ED). Blast-induced head injuries can lead to mild traumatic brain injuries (mTBI) mediated via primary blast overpressure without direct head trauma. The recovery process from mTBIs can be prolonged and affected by several factors. If symptoms persist for more than three months, patients should be evaluated for post-concussion syndrome (PCS). While clinical blast-injury studies have focused on repetitive blast exposure, this study evaluates a cohort exposed to a single blast. We hypothesized that a single blast exposure is sufficient to induce PCS symptoms similar to those exposed to repetitive blasts.

Methods: This cross-sectional study explores PCS in patients presenting to the ED of a tertiary-care center following the Beirut blast. Patients were identified through medical charts, contacted by phone, and consented to participate at least three months post-blast (beginning in November 2020). We used the Rivermead Post-Concussion Questionnaire (RPQ) to assess for PCS. We analyzed the association of PCS with patients and injury characteristics.

Results: Of 370 patients presenting to the ED, 145 (58.5%) completed the study questionnaire. Mean age was 39.8 ± 15.4 years, and 40% were females. Head trauma (46.9%) was the most common presentation. A total of 112 patients (77.2%) met the criteria for PCS, with a median RPQ score of 25 (interquartile range 18.75). After adjusting for injury types and distance from the blast, younger patients (adjusted odds ratio [aOR] 0.972, 95% confidence interval [CI] 0.947-0.998) and females (aOR 2.836, 95% CI 1.114-7.220) were more likely to suffer from PCS.

Conclusion: Our study revealed a remarkably high prevalence of PCS among survivors of the Beirut blast, with younger individuals and females disproportionately affected. This highlights the need for age- and sex-specific rehabilitation and support programs. However, the study was limited by incomplete patients records and contact information, leading to the exclusion of a significant number of patients who initially presented to the ED. Ultimately, this study underscores the crucial role of robust public health preparedness and specialized care pathways against future large-scale catastrophes. Further assessment, including neurobiomarker evaluation, will be conducted on these survivors. [West J Emerg Med. 2025;26(3)743–750.]

INTRODUCTION

On August 4, 2020, 2.7 kilotons of improperly stored ammonium nitrate accidentally detonated in the Port of Beirut, Lebanon, resulting in one of the most devastating urban explosions in history.[1] Equivalent to a 3.3 magnitude earthquake, the blast generated a supersonic positive pressure wave followed by a protracted vacuum, with a seismic shockwave traveling up to 250 kilometers (km) and causing widespread destruction as fast as 10 km away.[1,2] This catastrophic event claimed over 200 lives and injured around 7,000 individuals.[3]

A prominent injury type observed in the aftermath was head trauma, with variations in prevalence across major hospitals in Beirut. One center reported 34% of patients suffering head injuries,[4] while another found 46.9% among those presenting within three days of the blast[5] and 20.1% overall.[6] Multicenter studies further confirmed this range, with head injuries accounting for 26.4-40.3% of casualties.[7,8] Among these head injuries, a significant subset emerged: blast-induced traumatic brain injuries (bTBI) as a form of mild traumatic brain injuries (mTBI). Defined as "an alteration in brain function, or other evidence of brain pathology, caused by an external force,"[9] bTBIs form a distinct and complex category within the broader spectrum of TBIs. Classification primarily hinges on the cause of injury, categorized as primary, secondary, and tertiary. Secondary and tertiary bTBIs result from projectile contact or physical displacement forces, respectively.[10]

However, the mechanism of primary bTBI, caused by the direct impact of the high-frequency pressure wave, remains enigmatic.[10] Animal studies propose several hypotheses, including shearing of brain tissue due to acceleration, direct skull absorption of the pressure leading to brain damage, and transmission of the pressure wave through hollow organs, then transmitted via veins and arteries and potentially breaching the blood-brain barrier. [10,11] Although primary blast injuries to other organs has been long recognized in the International Classification of Diseases (ICD), it was not until October 2022 that the ICD 10th modification added "Primary blast injury of brain, not elsewhere classified."[12]

Similar to other forms of TBIs, bTBI can be classified into three categories—mild, moderate, or severe—based on the severity of the injury.13 Clinically, mTBI, often used interchangeably with concussion,14 presents with brief loss of consciousness (less than 30 minutes), post-traumatic amnesia (less than 24 hours), and a Glasgow Coma Score (GCS) of 13-15.15 Symptoms commonly include headaches, dizziness, disorientation, poor concentration, emotional lability, and irritability.14 While most patients recover within two weeks,16 persistent symptoms exceeding three months define post-concussion syndrome (PCS).17 Recovery times are influenced by several factors such as age,18-20 sex,20-22 distance from the blast,23 and presence of associated injuries.24 Prolonged recovery poses significant burdens on individuals and society, with PCS patients experiencing reduced quality of life, increased number of hospitalizations, and lower work return rates.25 Given the Beirut blast's magnitude and the high prevalence of head injuries, understanding the long-term impact on survivors, particularly the development of PCS, becomes crucial. In this study we aimed to assess the prevalence of PCS among patients who presented to the emergency department (ED) at one of the largest tertiary-care centers following the explosion.

Population Health Research Capsule

What do we already know about this issue?
The 2020 Beirut blast resulted in widespread injuries, with head trauma being prominent. Some patients experienced prolonged recovery and post-concussion syndrome (PCS).

What was the research question?
What was the prevalence of PCS among patients presenting to the ED after the Beirut blast?

What was the major inding of the study?
Of 145 patients, 77.2% met PCS criteria. Younger (aOR 0.97, p=0.04) and female (aOR 2.84, p=0.03) patients were more affected.

How does this improve population health?
The study emphasizes the need for age- and sex-specific rehabilitation for blast survivors, which would help improve recovery, public health preparedness, and disaster response.

METHODS

Patient Identification and Data Collection

This cross-sectional study is reported in accordance with Strengthening the Reporting of Observational Study in Epidemiology (STROBE) guidelines and approved by the institutional review board (Protocol ID: BIO-2020-0357).

Given that concussion can occur without direct head trauma and can be caused solely by the blast pressure, all patients who presented to the ED of the tertiary-care center on the day of the explosion and the following three days (August 4-7, 2020) were identified using electronic health records. Those patients who could be reached via a phone number were included in the study. We used medical charts to collect patient demographics and injury characteristics.

Starting in November 2020, three months after the blast, patients were contacted by phone and orally consented to

participate in the study. We collected variables pertaining to their presentation and exact location on the day of the blast. Patients were also asked about the severity of the concussion symptoms they experienced in the prior 24 hours compared to pre-blast. We used Google Earth to calculate the patient's distance from the blast location.

Primary Outcome

To assess the primary outcome, PCS, we used the Rivermead Post-Concussion Questionnaire (RPQ), a validated questionnaire with good test-retest and inter-rater reliability.[26] The RPQ inquires about 16 concussion symptoms experienced in the prior 24 hours as compared to the pre-injury period. Participants rate each symptom on a Likert scale of 0 (not experienced at all), 1 (no more of a problem than pre-injury), 2 (a mild problem), 3 (a moderate problem), and 4 (a severe problem). Scores of "1" were considered as "0" since they were symptoms present before the injury,[26,27] resulting in a total score range of 0-64. We defined PCS as the presence of ≥3 symptoms on the RPQ (score of ≥2 on each symptom).[28] We then categorized the severity of PCS into minimal (0-12), mild (13-24), moderate (25-32), and severe (≥33) based on the levels of self-reported symptoms.[29]

Statistical Analysis

We performed statistical analysis using SPSS Statistics for Windows, v28.0 (IBM Corp., Armonk, NY). Two-sided $p < 0.05$ was considered to be statistically significant. We present categorical variables as percentages and frequencies, while continuous variables are expressed as means ± standard deviation or median with interquartile range (IQR). We evaluated the differences between PCS groups using Pearson chi-square or Fisher exact test for categorical variables and the Student *t*-test for continuous variables. We constructed a multivariable logistic regression model to determine independent predictors of PCS. Variables were included in the model if they were clinically relevant or found to be significant on bivariate analysis.

RESULTS

A total of 370 patients presented to the ED between August 4-7, 2020, of whom 248 (67.0%) were eligible to participate in the study. Among them, 103 patients refused to consent, while 145 patients (58.5%) completed the study questionnaire and were included in the final analysis (Figure 1).

The mean age of participating patients was 39.8 ± 15.4 years, with 58 (40%) being females. Fifty-six (38.6%) of the injured patients were within a one km radius of the blast epicenter. Head trauma (46.9%) and alteration in mental status (45.5%) were the two most common presentations, while 42 (29.0%) patients did not present with any neurological complaint. The most frequently injured body part was the upper extremity (19.9%), followed by the head/face (19.1%) (Table 1).

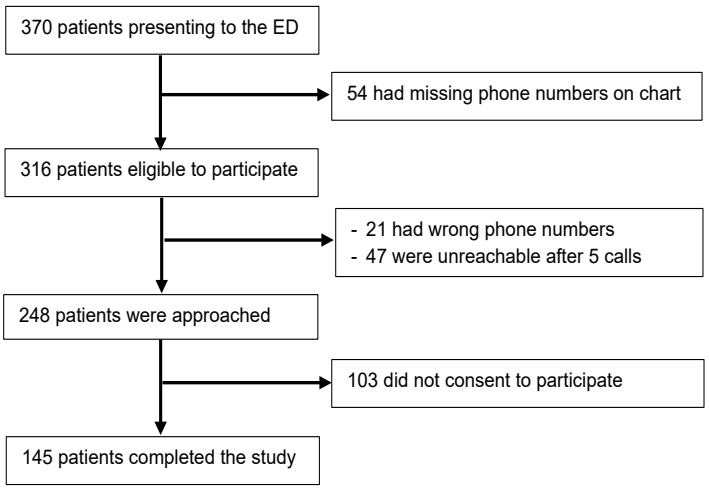

Figure 1. Flow chart describing the identification and enrollment of patients presenting to the ED* following the Beirut, Lebanon, explosion in August 2020.
ED, emergency department.

The majority of patients (77.2%) met the criteria for PCS. Among them, 13 (11.6%) experienced minimal symptoms, 41 (36.6%) had mild symptoms, 25 (22.3%) had a moderate presentation, and 33 (29.5%) suffered from severe symptoms three months after the blast. On bivariate analysis, sex (female) was found to be the only variable associated with having PCS (p=0.04) (Table 1). Additionally, being female was significantly associated with having severe symptoms (Figure 2).

Patients with PCS mostly suffered from fatigue (81.3%), noise sensitivity (78.6%), restlessness (77.7%), sleep disturbances (74.1%), and feeling depressed (73.2%). Light sensitivity (17.0%) was the least reported symptom. On the other hand, those with no PCS (22.8%) complained mostly

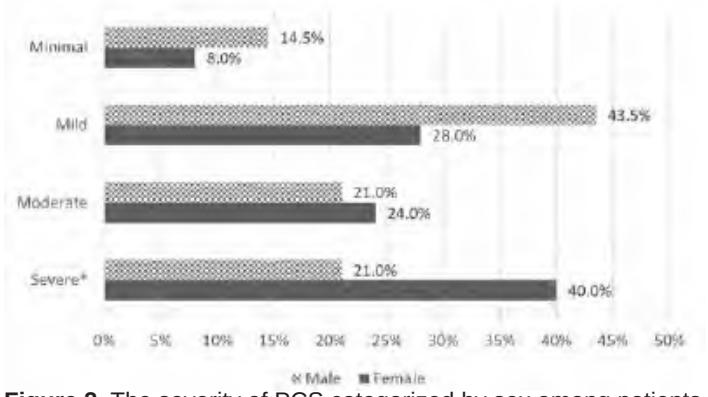

Figure 2. The severity of PCS categorized by sex among patients presenting to the ED following the Beirut blast. *p<0.05.
ED, emergency department; *PCS*, post-concussion syndrome.

Table 1. Demographic and injury characteristics of patients affected by injuries following the Beirut blast.

Variable		Total (145)	No PCS (33)	PCS (112)	P-value
Age (years, mean ± SD)		39.8 ± 15.4	44.1 ± 16.5	38.5 ± 14.9	0.07
Female		58 (40.0%)	8 (24.2%)	50 (44.6%)	0.04
Comorbidity*		24 (18.5%)	5 (15.6%)	19 (19.4%)	0.63
Neurological presentation					
Head trauma		68 (46.9%)	17 (51.5%)	51 (45.5%)	0.55
Loss of consciousness		29 (20.0%)	6 (18.2%)	23 (20.5%)	0.77
Pre- or post-blast amnesia		37 (25.5%)	10 (30.3%)	27 (24.1%)	0.47
Alteration in mental status		66 (45.5%)	15 (45.5%)	51 (45.5%)	0.99
Any other neurological deficit		26 (17.9%)	6 (18.2%)	20 (17.9%)	0.97
None		42 (29.0%)	10 (30.3%)	32 (28.6%)	0.85
Body part injured					
Head/Face		27 (19.1%)	7 (21.9%)	20 (18.3%)	0.66
Spine		2 (1.4%)	0 (0.0%)	2 (1.8%)	1.00
Shoulder/Arm		28 (19.9%)	5 (15.6%)	23 (21.1%)	0.49
Hip/Leg		21 (14.9%)	2 (6.3%)	19 (17.4%)	0.16
Ear		3 (2.1%)	1 (3.1%)	2 (1.8%)	0.54
Abdomen/Pelvis		1 (0.7%)	0 (0.0%)	1 (0.9%)	1.00
Skin		17 (12.1%)	4 (12.5%)	13 (11.9%)	0.93
Location at the time of the blast					
Distance from the blast (km, mean ± SD)		1.7 ± 1.2	1.7 ± 1.2	1.7 ± 1.2	0.89
Zones	< 1 km	56 (38.6%)	11 (33.3%)	45 (40.2%)	
	1 km -3 km	36 (24.8%)	10 (30.3%)	26 (23.2%)	0.66
	> 3 km	53 (36.6%)	12 (36.4%)	41 (36.6%)	

*Patients were considered to have comorbidity if they had at least one of the following: chronic obstructive pulmonary disease; hypertension; diabetes; coronary artery disease; hyperlipidemia; or history of neurological disease.
PCS, post-concussion syndrome; *RPQ,* Rivermead post-concussion questionnaire; *IQR, i*nterquartile range.

of headaches (21.2%), fatigue (18.2%), and frustration (15.2%) (Table 2).

The multivariate logistic regression assessing the association between PCS and participants' characteristics showed that age and sex were independent predictors of PCS. Younger people (adjusted odds ratio [aOR] 0.972, p=0.04, 95% confidence interval [CI] 0.947-0.998) were at higher risk of having PCS. Similarly, females were more likely to meet the criteria for PCS (aOR 2.884, p=0.03, 95% CI 1.133-7.340) (Table 3).

DISCUSSION

Traumatic brain injury poses a socioeconomic burden on both the affected patients and society, for the patients' decreased quality of life, more frequent hospitalizations, and lower rates of returning to work.[25] Our study showed a high prevalence of PCS following the Port of Beirut blast. More than three-quarters of the study participants met the criteria for PCS three months later. This prevalence is considerably higher than reported in other disaster settings, where rates typically range from 10-40%.[30-33] This could be attributed to the scale of the blast that detonated in a densely populated area of the Lebanese capital and to the type of injuries resulting from combined primary, secondary, and tertiary mechanisms and requiring urgent medical presentations to the ED. Notably, females were significantly more likely to experience PCS overall and had a higher proportion of severe cases. These findings highlight this specific blast event's profound and lasting impact on its survivors, particularly women.

Unlike most studies on PCS resulting from accidents or falls, we examined the aftermath of a singular, non-natural event. The Beirut blast's unique combination of a high-pressure wave injury,[2] physical debris impact, and psychological trauma presents a distinct set of challenges and potential long-term consequences.[2,5,34] While many studies in the literature have extensively investigated bTBIs and their prognosis in military settings, research on civilian bTBIs remains scarce. Of interest, our study participants were all civilian victims who sustained physical injuries beyond head trauma, which will offer valuable and unique insights into the broader public health implications of such catastrophic events.

Table 2. Rivermead post-concussion syndrome questionnaire symptoms experienced by patients at least three months after the Beirut blast.

RPQ Symptoms		Total (145)	No PCS (33)	PCS (112)
Somatic symptoms	Headaches	71 (49.0%)	7 (21.2%)	64 (57.1%)
	Dizziness	55 (37.9%)	2 (6.1%)	53 (47.3%)
	Nausea/vomiting	37 (25.5%)	1 (3.0%)	36 (32.1%)
	Fatigue	97 (66.9%)	6 (18.2%)	91 (81.3%)
	Noise sensitivity	90 (62.1%)	2 (6.1%)	88 (78.6%)
	Light sensitivity	19 (13.1%)	0 (0.0%)	19 (17.0%)
	Blurred vision	64 (44.1%)	1 (3.0%)	63 (56.3%)
	Double vision	64 (44.1%)	4 (12.1%)	60 (53.6%)
	Sleep disturbance	87 (60.0%)	4 (12.1%)	83 (74.1%)
Cognitive symptoms	Forgetfulness	54 (37.2%)	0 (0.0%)	54 (48.2%)
	Poor concentration	35 (24.1%)	0 (0.0%)	35 (31.3%)
	Longer to think	72 (49.7%)	3 (9.1%)	69 (61.6%)
	Being irritable	40 (27.6%)	0 (0.0%)	40 (35.7%)
Emotional symptoms	Feeling depressed	86 (59.3%)	4 (12.1%)	82 (73.2%)
	Feeling frustrated	82 (56.6%)	5 (15.2%)	77 (68.8%)
	Restlessness	89 (61.4%)	2 (6.1%)	87 (77.7%)
RPQ score (median (IQR))		20 (21)	2.0 (6.0)	25 (18.75)

PCS, post-concussion syndrome; *RPQ*, Rivermead post-concussion questionnaire; *IQR,* interquartile range.

Additionally, existing military bTBI research focused typically on the development of PCS, altered mental health outcomes, and neuropsychological symptoms resulting from repetitive low-level or high-level blast exposures.[35] In fact, it was shown that the severity of PCS cumulatively increases as a function of a number of blast exposures.[35] In contrast, in our study the Beirut blast constitutes a single, high-level blast exposure that was found to be associated with altered neuropsychological changes represented by PCS.

Our finding that younger individuals were at higher risk of developing PCS aligns with prior research on TBI. A study by Ponsford et al found that younger mTBI patients were more associated with higher reporting of PCS symptoms on follow-up.[36] Additionally, Mearse et al reported a trend for an association between younger age and PCS, although this trend did not reach statistical significance.[31] This trend aligns with the developing brain's heightened vulnerability to injury and suggests that younger individuals may require targeted interventions and support following blast events. Nevertheless, some reports highlighted that older age is an independent risk factor for unfavorable outcomes at follow-up for PCS patients.[19,20,37] Moreover, Garza et al showed that with every year of age, there was a 2.6% increase in the odds of an unfavorable outcome.[18] Further research with larger and more diverse samples is needed to clarify the relationship between age and PCS risk in the context of blast injuries.

The increased risk of PCS among women in our study aligns with some existing research, indicating a potential sex-based vulnerability to TBI complications. Multiple studies reported that females were more likely to experience PCS compared to males.[36,38,39] Additionally, females were more likely to report higher symptom severity in total score and all somatosensory, vestibular, affective, and cognitive symptom clusters than males.[20-22,40] This disparity may be attributed to hormonal differences, pre-existing conditions, or variations in pain processing between the sexes.[36,38] Further research is needed to understand the biological and social factors contributing to this sex-based disparity in PCS outcomes and develop sex-specific management strategies.

While previous studies have linked closer proximity to the blast with increased blast-related injury severity,[23,41] our study did not find a significant association between distance from the blast and PCS diagnosis. It is possible that this is due to the fact that the majority of our cohort was within 3 km of the blast center.[5] Our study enrolled patients seeking medical attention at the ED, potentially excluding individuals with milder injuries who resided further from the blast site and preferred to present to other medical centers since our institution was among the centers that sustained damage from the blast.[42] Additionally, we calculated the radius distance from the center of the blast not taking into consideration barriers that reflect blast wave. Future investigations with larger and geographically diverse samples are needed to clarify the relationship between distance and PCS occurrence in blast events.

Finally, PCS remains a subject of ongoing debate in the scientific community. While the ICD-10 still recognizes PCS as a distinct clinical entity,[43] it has been removed from the

Table 3. Logistic regression analysis assessing the association between the characteristics of patients and injury types with the likelihood of developing post-concussion syndrome following the Beirut blast.

Variable	aOR	p-value	95% CI
Age (Continuous)	0.972	0.04	(0.947-0.998)
Gender (Ref: Male)	2.836	0.03	(1.114-7.220)
Injury other than head (Ref: No)	1.104	0.82	(0.468-2.604)
Head trauma (Ref: No)	0.769	0.53	(0.339-1.744)
Distance from the blast (Continuous)	1.000	0.89	(1.000-1.000)

aOR, adjusted odds ratio; *95% CI*, confidence interval; *Ref*, reference.

Diagnostic and Statistical Manual of Mental Disorders, 5th edition, and reclassified under "neurocognitive disorder due to traumatic brain injury."[44] Some argue that PCS symptoms do not meet the criteria for a "syndrome"[45] and instead use the term "persistent post-concussive symptoms" (PPCS).[46] Recent efforts have been aimed at redefining PCS and PPCS as persisting symptoms after concussion, emphasizing that not all symptoms occurring after a concussion are necessarily caused by the concussion.[47] This controversy underscores the complex nature of PCS and highlights the need for multidisciplinary approaches to its study and treatment. Continued research is essential to clarify its diagnostic criteria and improve patient outcomes.

LIMITATIONS

Our study was conducted in an ED in the setting of a catastrophic, unexpected event. This led to a substantial number of patients with missing or incomplete medical charts and contact information. As a result, a significant number of the patients who initially presented to our ED were not included in the study. However, data on symptoms and location at time of injury were comprehensively confirmed on follow-up phone calls. Furthermore, the single-center nature of the study, located near the blast site, may limit generalizability. Most of our cohort was within 3 km of the blast, potentially excluding those with milder injuries who sought care elsewhere.

It is also important to note that symptoms of PCS are not encountered exclusively in patients with TBI and may overlap with other disorders.[22,30] This study was further limited by the scientific controversy surrounding PCS[47] as a distinct clinical entity. While our findings depict the prevalence of PCS symptoms following the blast, they cannot conclusively attribute PCS to bTBI. Additionally, we were unable to specifically classify patients as having primary, secondary, or tertiary bTBIs, as they may have suffered from one or a combination of any of these subtypes for determing the severity of the bTBI.

CONCLUSION

This study highlights the significant prevalence and enduring impact of post-concussive syndrome symptoms following the catastrophic explosion in the Port of Beirut, particularly among women and younger individuals. These findings underscore the need for tailored rehabilitation and support programs for blast survivors, considering age- and sex-specific vulnerabilities. Additionally, our investigation emphasizes the importance of studying civilian blast events to inform comprehensive public health preparedness plans and disaster response strategies. Investing in robust mental health resources and specialized care pathways for blast-related traumatic brain injury should be a priority in building resilience against future large-scale catastrophes.

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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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Field vs. Emergency Department Intubation: A Retrospective Review of Hospital Outcomes of Trauma Patients

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Introduction: Definitive airway management is crucial for severely injured trauma patients when basic pre-hospital interventions fail to provide adequate oxygenation and ventilation. Endotracheal intubation by emergency medical service (EMS) personnel is often necessary before reaching the emergency department (ED). While some studies suggest that advanced airway protocols in the pre-hospital setting improve survival in patients with severe head injuries, others indicate potential complications and adverse outcomes associated with pre-hospital intubation. In this study we aimed to evaluate whether trauma patients who underwent intubation by EMS in the field experienced different hospital outcomes compared to those intubated by physicians in the ED. Specifically, it assessed the impact of pre-hospital intubation on the number of days requiring mechanical ventilation, intensive care unit length of stay (ICU LOS), and overall hospital LOS.

Methods: We conducted a retrospective chart review at a single, level II trauma center from January 1, 2019–December 31, 2023, involving trauma patients requiring intubation. Patients were divided into two groups: 608 patients ED department (ED ETT). Primary outcomes included days on mechanical ventilation, while secondary outcomes included ICU and hospital LOS. An independent *t*-test was performed to compare the differences in mean ventilator days, ICU LOS, and hospital LOS between the two groups, accepting *P*-value of <0.10 as significant.

Results: The study included 1,010 patients, with a mean age of 55.5 years in the ED group and 52.5 years in the pre-hospital group. No statistically significant differences were found in mean ventilator days (4.1 ± 4.6 days for the ED group and 4.1 ± 5.7 days for the pre-hospital group), ICU LOS (5.8 ± 6.1 days in the ED ETT group vs 5.6 ± 7.4 days in the pre-hospital ETT group), or overall hospital LOS (10.1 ± 13.6 days in the ED group vs 10.2 ± 17.5 days in the pre-hospital group).

Conclusion: These findings indicate no significant differences in patient outcomes between those intubated pre-hospital and those intubated in the ED. Further research is needed to make modifications to airway management protocols in the pre-hospital setting. [West J Emerg Med. 2025;26(3)751–757.]

INTRODUCTION

Definitive airway placement is commonly required in severely injured trauma patients when basic pre-hospital airway interventions are inadequate or ineffective at providing oxygenation and ventilation. Endotracheal intubation by paramedics or emergency medical service (EMS) responders is often required prior to arriving at the emergency department (ED) for a variety of reasons. Implementation of advanced airway protocols in the pre-hospital setting has been associated with improved survival in patients with severe head injuries leading some to suggest benefits in broadening indications for intubation by pre-hospital personnel.[1]

However, given the challenge of the procedure itself and potential complications, an argument could be made that more conservative pre-hospital airway measures and intubation in the ED could be a safer alternative. There is also evidence that pre-hospital intubation can be associated with higher rates of adverse outcomes and that replacement of bag-valve-mask ventilation with endotracheal intubation in the pre-hospital setting does not result in improved survival or improved neurologic outcomes.[2,3,4]

There are several challenges associated with pre-hospital intubation that could theoretically lead to higher rates of complications and poor patient outcomes. These include environmental hazards, limited equipment, suboptimal patient positioning, variations in skill levels among first responders, and limited ability to manage complications. Some studies have reported endotracheal tube (ET) misplacement rates by EMS personnel from 9% to as high as 25%.[M]isplacement of an ET tube carries significant risk of iatrogenic injury, and lack of first-pass success is likely to result in worse patient outcomes by prolonging periods without adequate oxygenation. Although the reported overall success rates of pre-hospital intubation have improved over time, there is still a significant difference in first-pass success and overall intubation success rate between pre-hospital, non-physician personnel and physicians, which can result in prolonged transport times and a potential delay in receiving definitive care in the ED.[6,7] For this reason, advanced airway management by non-physicians remain somewhat controversial.

There are several advantages to performing endotracheal intubation in the ED including availability of adjunctive medications, advanced monitoring equipment, additional support staff, and airway specialist oversight, among others. Multiple studies have reported increased mortality when patients were intubated in the pre-hospital setting.[8,9,10] There is a considerable amount of conflicting data regarding the outcomes of patients intubated in the pre-hospital setting compared to those intubated in the ED. Most of the existing literature comparing outcomes between these two patient populations analyze mortality rate and neurologic function as the primary outcomes. Few studies have compared the differences in number of days requiring mechanical ventilation, intensive care unit length of stay (ICU LOS), and hospital LOS. Understanding these additional metrics is important since they can significantly impact overall healthcare costs and resource utilization. Additional research into these outcomes may provide a more comprehensive understanding of the implications of pre-hospital vs in-hospital intubation.

Population Health Research Capsule

What do we already know about this issue?
It is unknown whether performing intubation of trauma patients in the pre-hospital setting vs. in the emergency department leads to better outcomes.

What was the research question?
Is there a difference between patient outcomes for trauma patients intubated pre-hospital vs. in the ED? Does the location of intubation affect the hospital course of trauma patients?

What was the major finding of the study?
We found no difference between pre-hospital and in-hospital intubation groups by ventilator days (mean 4.1 days for each, p = 0.87), intensive care unit length of stay (LOS) (mean 5.8 vs. 5.6 days, p = 0.62), and hospital LOS (10.1 vs. 10.2 days, p = 0.98).

How does this improve population health?
Pre-hospital and in-hospital intubation showed similar critical care outcomes for trauma patients, supporting pre-hospital intubation by Emergency Medical Services. This is important, particularly in rural areas with long transport times.

OBJECTIVES

We conducted this study to understand whether the hospital course of trauma patients requiring intubation differs if the intubation is performed by EMS personnel in the field vs by physicians in the ED. Identification of worse or improved outcomes could potentially lead to modification of existing airway intervention protocols for EMS. In this study we aied to evaluate the impact of pre-hospital intubation on the number of days requiring mechanical ventilation, ICU LOS, and hospital LOS.

METHODS

We adhered to several criteria proposed by Worster et al to ensure optimal retrospective chart review and study. These include using trained abstractors, finding clear inclusion and exclusion criteria, using clearly defined variables, discussing interobserver reliability, identifying and abstracting from one health record database, performing simple random sampling, agreeing upon management of missing data, and receiving institutional review board approval.[11] The data from this retrospective chart review was collected from health records from Sarasota Memorial Hospital Trauma Department from January1, 2019– December 31, 2023. This is a level II trauma center in Sarasota, FL. The patients were transported to this

hospital by several EMS agencies including Sarasota County, Manatee County, Bayfront Medical Center, Tampa General Healthcare System, and North Port Fire Rescue, with the vast majority being Sarasota County EMS services. The study population was trauma patients who were brought to the ED and required endotracheal intubation. The patients were divided into two groups, group 1—patients intubated in a pre-hospital setting (pre-hospital ETT); and group 2—patients intubated in the (ED ETT).

The primary outcome measures included the number of days requiring mechanical ventilation (with one ventilator day being counted if the patient remained intubated at any point within a 24-hour period). Secondary outcome measures consisted of LOS in the ICU and the overall hospital LOS. The inclusion criteria were trauma patients requiring intubation, intubation occurring prior to arrival or while in the ED, and patients ≥18 years of age. The exclusion criteria were patients who expired pre-hospital or while in the ED, and the patients who were intubated after being transferred out of the ED. The details retrieved were age, sex, any comorbidities (alcoholism, substance use disorder, chronic obstructive pulmonary disease (COPD), smoker, congestive heart failure (CHF), renal failure, and dementia); whether the patients had pre-hospital intubation and ED intubation; number of ventilator days; ICU LOS; hospital LOS, Injury Severity Score (ISS), mechanism of injury (MOI), ED or hospital disposition (ED Dispo or Hospital DC Dispo), transport method (air/ground/private) and transport agency (EMS organization).

The original dataset included patients who were intubated in the pre-hospital setting using a supraglottic airway device (not a definitive endotracheal airway) and subsequently had the supraglottic device removed and replaced by an endotracheal tube in the ED. These patients were listed in both the pre-hospital ETT and ED ETT groups in the original dataset. These patients were considered to be intubated in the ED. They were removed from the pre-hospital ETT group and remained in the ED ETT group. This decreased the pr-hospital ETT total from 672 to 608 patients. The injuries were categorized into various MOI by using keyword search from the *International Classification of Diseases*, 10th Rev (ICD-10) E-code Injury Descriptor Text provided. An independent *t*-test was performed to determine whether there was any statistically significant difference between mean ventilator days, ICU LOS, and hospital LOS of the two groups, accepting *P*-value of <0.05 as significant.

RESULTS

In the study there were a total 1,010 patients: pre-hospital, l,608; and ED, 402).

Descriptive Statistics (Table 1)

The mean age in the ED ETT group was 55.5 ± 21 years (range 18 to 96 years), while in the Pre-hospital ETT group, it was 52.5 ± 20.5 years (range 18 to 103 years). The mean Injury Severity Score (ISS) was 17.8 ± 13.4 in the ED ETT group (range 1 to 75) and 20 ± 15.4 in the Pre-hospital ETT group (range 1 to 75). The ED ETT group had a mean of 4.1 ± 4.6 ventilator days (range 0 to 40), and the Pre-hospital ETT group had a mean of 4.1 ± 5.7 ventilator days (range 0 to 78). ICU length of stay (LOS) was 5.8 ± 6.1 days for the ED ETT group (range 0 to 48) and 5.6 ± 7.4 days for the Pre-hospital ETT group (range 0 to 87). The hospital length of stay (LOS) was 10.1 ± 13.6 days for the ED ETT group (range 0 to 129) and 10.2 ± 17.5 days for the Pre-hospital ETT group (range 0

Table 1. The descriptive statistics of the following variables of the two groups, emergency department intubation group (ED ETT) and pre-hospital intubation group (Pre-hospital ETT), are displayed here. Age is displayed in years. Injury severity score (ISS) and Glasgow coma scale (GCS) are on a numerical scale. Ventilator days (vent days), intensive care unit length of stay (ICU LOS), and hospital length of stay (hospital LOS) are in number of days. The total number (count), mean, standard deviation (std), minimum (min), first quartile (25%), median (50%), third quartile (75%), and maximum (max) values for each variable are listed.

	Age		ISS		Ventilator Days		ICU LOS		Hospital LOS		Initial GCS	
	ED ETT	Pre-hospital ETT	ED ETT	Pre-hospital ETT	ED ETT	Pre-hospital ETT	ED ETT	Pre-hospital ETT	ED ETT	Pre-hospital ETT	ED ETT	Pre-hospital ETT
count	391	594	394	587	402	608	402	608	402	608	402	608
mean	55.5	52.5	17.8	20	4.1	4.1	5.8	5.6	10.1	10.2	10.7	4.4
std	21	20.5	13.4	15.4	4.6	5.7	6.1	7.4	13.6	17.5	4.7	2.6
min	18	18	1	1	0	0	0	0	0	0	3	3
25%	36	34	6.5	8	2	1	2	1	2	1	7	3
50%	58	53	17	19	2	2	4	3	6	4	13	3
75%	73	68	26	27	5	5	8	7	14	11	15	6
max	96	103	75	75	40	78	48	87	129	147	15	15

to 147). At the time of intubation, Glasgow Coma Scale (GCS) scores were 10.7 ± 4.7 for the ED ETT group (range 3 to 15) and 4.4 ± 2.6 for the Pre-hospital ETT group (range 3 to 15). There is a difference in the total count of patients reported in age and ISS categories. This is due to a small number of patients in each group not having an age or ISS included in the data set and is not expected to significantly affect the primary outcomes examined.

Age Distribution

The majority of the patients were young adults, particularly in the 19-30 age group, with 58 cases in ED ETT group and 101 in Pre-hospital ETT group. This was followed by 31-40 age group 53 cases in ED ETT and 95 in Pre-hospital ETT.

Sex Distribution

In the ED ETT group, there were 128 (31.8%) females and 274 (68.2%) males. In the Pre-hospital ETT category, there were 165 (27.1%) females and 443 (72.9%) males.

Mechanism of Injuries

Patients were categorized into various mechanisms of injury (MOI) by using keyword search from the ICD-10 E-code Injury Descriptor Text provided in the original dataset. The categories include motor vehicle collision (MVC), fall, assault, intentional self-harm, gunshot wound (GSW), burn, unspecifiedunintentional trauma, unspecified penetrating trauma, submersion injury, animal bite, and electric injury. The number of patients presenting for each type of injury was compared based on which group they were included in, those intubated in the emergency department (ED ETT) and those intubated in the pre-hospital setting by emergency medical services personnel (pre-hospital ETT). The number of each patient and percentage of the group that each category represents was included. In the ED ETT group, motor vehicle collisions (MVC) were the most prevalent mechanism of injuries 183 cases (52.0%) followed by falls 83 cases (23.6%) and assaults 32 cases. Similarly, in the pre-hospital ETT group, motor vehicle collisions (MVC) were the most common with 295 cases (53.2%) followed by falls 138 cases (24.9%) and assaults 32 cases (5.8%).

Details of Co-Morbidities

Co-morbidities in each group, those intubated in the emergency department (ED ETT) and those intubated in the pre-hospital setting (Pre-hospital ETT), included tobacco smoking history (smoker), patients with a documented history of alcoholism (alcoholism), chronic obstructive pulmonary disease (COPD), documented history of substance abuse (substance abuse), congestive heart failure (CHF), dementia, and renal failure. In the Emergency Department (ED) ETT, the most common co-morbidities were smoker—64 cases (30.9%), followed by alcoholism with 46 cases (22.2%), and

Table 2. R-values of correlation matrix for the following variables of the two groups, emergency department intubation group (ED ETT) and pre-hospital intubation group (Pre-hospital ETT) are listed in the table below. Variables of the two groups that were analyzed include: age, injury severity score (ISS), ventilator days (vent days), intensive care unit length of stay (ICU LOS), hospital length of stay (hospital LOS), and initial Glasgow coma scale score (initial GCS). Age is in years. ISS and GCS are on a numerical scale. Vent days, ICU LOS, and hospital LOS are in number of days. The total number (count), mean, standard deviation (std), minimum (min), first quartile (25%), median (50%), third quartile (75%), and maximum (max) values for each variable are listed.

Correlation Matrix for ED ETT						
	Age	**ISS**	**Vent Days**	**ICU LOS**	**Hospital LOS**	**Initial GCS**
Age	1	-0.0142	0.119555	0.154048	-0.05381	0.072941
ISS	-0.0142	1	0.266635	0.265233	0.158705	-0.14235
Vent days	0.119555	0.266635	1	0.830989	0.523683	0.023537
ICU LOS (days)	0.154048	0.265233	0.830989	1	0.655022	0.037941
Hospital LOS (days)	-0.05381	0.158705	0.523683	0.655022	1	0.015997
Initial GCS	0.072941	-0.14235	0.023537	0.037941	0.015997	1
Correlation Matrix for Pre-hospital ETT						
	Age	**ISS**	**Vent Days**	**ICU LOS**	**Hospital LOS**	**Initial GCS**
Age	1	-0.11417	0.018234	0.013062	-0.08269	0.066854
ISS	-0.11417	1	0.166451	0.16036	0.121373	-0.2159
Vent days	0.018234	0.166451	1	0.909962	0.628391	-0.04413
ICU LOS (days)	0.013062	0.16036	0.909962	1	0.731803	-0.0368
Hospital LOS (days)	-0.08269	0.121373	0.628391	0.731803	1	-0.04758
Initial GCS	0.066854	-0.2159	-0.04413	-0.0368	-0.04758	1

chronic obstructive pulmonary disease (COPD) with 29 cases (14.0%), respectively. Other co-morbidities were congestive heart failure (CHF) and substance abuse in 25 cases (12.1%) and 26 cases (12.6%), respectively. Dementia and renal failure were in 12 cases (5.8%) and 5 cases (2.4%), respectively. The Pre-hospital ETT group also had a higher prevalence of smokers with 91 cases (35.1%), followed by alcoholism with 62 cases (23.9%) and COPD with 27 cases (10.4%), respectively. Dementia and CHF were present in 16 cases (6.2%) and 24 cases (9.3%), respectively. Substance abuse was reported in 34 cases (13.1%), and renal failure was reported in 5 cases (1.9%).

Correlation Analysis

The correlation matrices among clinical factors within each group are shown in Table-2. In the ED ETT group, Ventilator Days and ICU LOS were positively correlated ($r = 0.831$), indicating that patients needing prolonged ventilation also had extended ICU stays. Similarly, in the Pre-hospital ETT group, Ventilator Days correlated strongly with ICU LOS ($r = 0.910$), reflecting a pattern comparable with ED ETT group. Initial GCS was negatively correlated with ISS in both the ED ETT ($r = -0.142$) and Pre-hospital ETT groups ($r = -0.216$), suggesting that more severely injured patients presented with lower GCS scores. Mean values and standard deviations of the selected variables are shown in Table 3. ED ETT patients had a mean age of 55.41 years, compared to 52.53 years for pre-hospital ETT patients. Initial GCS scores were significantly different between the two settings (ED: 10.67 ± 4.68 vs. Pre-hospital: 4.41 ± 2.64). Age ($t = 2.16$, $P < .05$) and ISS ($t = -2.23$, $P < .05$) differed significantly. Ventilator Days ($t = -0.15$, $P > .05$), ICU LOS ($t = 0.48$, $P > .05$), and hospital LOS ($t = -0.02$, $P > .05$), did not show significant differences between the two groups. Initial GCS was notably different ($t = 27.07$, $P < .05$), with patients intubated pre-hospital having poorer GCS scores than those intubated in the ED.

DISCUSSION

There are areas of debate regarding whether pre-hospital intubation is beneficial or whether intubation should be delayed and performed in the ED.[13-17] Although guidelines exist,[18,19] there is ongoing research and discussion to optimize protocols.[20-26] Our goal in this study was to examine the outcomes of trauma patients who required endotracheal intubation, either in the pre-hospital setting or while in the ED. The goal ws to identify any significant differences in ICU LOS, and overall hospital LOS. Understanding these additional metrics is important since they can significantly impact overall healthcare costs and resource utilization.

These findings suggest that there were no significant differences in the outcomes examined. The lack of statistically significant differences implies that, in the study population, intubation in the pre-hospital setting did not worsen or improve patient outcomes when compared to patients who were intubated in the ED setting. Compared to patients who were intubated in the ED, those who were intubated in the pre-hospital setting were more severely injured, with higher ISS and lower GCS scores. Patients who were more severely injured and intubated in the pre-hospital setting, which presents several unique challenges, would be expected to have longer, more protracted hospital courses and poorer outcomes. Patients in the ED ETT group also had a significant difference in age, having a higher average age compared to the pre-hospital ETT group, which may make patients more likely to experience a longer, more complicated hospital course. Despite this, there were no notable differences between the two groups. The lack of a noticeable difference in hospital course may lend some evidence in support of pre-hospital intubation in severely injured trauma patients.

Many studies have questioned the utility of pre-hospital endotracheal intubation, and there are several that may even indicate a potential for worse outcomes after pre-

Table 3. T-Test results of the following variables of the two groups, emergency department intubation group (ED ETT) and pre-hospital intubation group (pre-hospital ETT) are listed in the table below. Variables of the two groups that were analyzed include: age, injury severity score (ISS), ventilator days (vent days), intensive care unit length of stay (ICU LOS), hospital length of stay (hospital LOS), and initial Glasgow coma scale score (initial GCS). Age is in years. ISS and GCS are on a numerical scale. Vent days, ICU LOS, and hospital LOS are in number of days

Variable	ED ETT (Mean ± SD)	Pre-hospital ETT (Mean ± SD)	t-statistic	*P*-value
Age	55.41 ± 20.97	52.53 ± 20.53	2.16	0.031
ISS	17.82 ± 13.30	19.90 ± 15.34	-2.23	0.026
Vent days	4.08 ± 4.59	4.13 ± 5.73	-0.15	0.88
ICU LOS (days)	5.82 ± 6.13	5.60 ± 7.44	0.48	0.63
Hospital LOS (days)	10.15 ± 13.56	10.17 ± 17.48	-0.02	0.98
Initial GCS	10.67 ± 4.68	4.41 ± 2.64	27.07	0

hospital endotracheal intubation vs basic pre-hospital airway management.[6, 26] There are higher rates of failed intubation when performed in the pre-hospital setting with a number of possible complications, and most studies show no improvement in neurologic outcomes or long-term survival rates.[1,5,8] There is also the problem of intubation attempts detracting from other critical resuscitative efforts, such as high-quality chest compressions, defibrillation, medication administration, and non-invasive ventilation. Despite these challenges and the multiple studies calling into question the utility of pre-hospital intubation, there are a great deal of confounding variables in these studies. There is still a need for more evidence before more definitive conclusions can be made.

LIMITATIONS

The retrospective nature of the study limits its broader applicability. Additionally, to increase the generalizability of the findings, data from a larger number of institutions and peripheral settings with varying complexities and geographical differences are needed in a prospective manner. This study design lacks external validity due to being conducted in a single center in a small, isolated geographic region and would not be generalizable to the larger population. It was performed retrospectively over a five-year period, which introduces the possibility of selection bias, mis-classification bias, information bias, observer bias, and recall bias. The study period did overlap with the COVID-19 pandemic. It is possible that some EMS agencies may have altered their airway management protocols to minimize exposure to EMS personnel. However, recommendations for pre-hospital airway management in patients with suspected COVID-19 infection focused primarily on proper personal protective equipment (PPE) use and utilization of high efficiency particle arresting filters following endotracheal intubation or supraglottic airway (SGA) placement.

Indications for advanced airway placement were not changed. Video assisted laryngoscopy (VL) was recommended over direct visualization, if available, and placement of a SGA was advised if VL was unavailable.[28] This may have led to a larger number of patients who would have traditionally been intubated in the pre-hospital setting, being intubated in the ED. This could have resulted in more severely injured, critically ill patients being included in the ED ETT group; however, this outcome was not seen, suggesting the EMS agencies involved in this study did not significantly alter their protocols, focused on proper PPE use, or had access to VL. There are several additional considerations that need to be made when interpreting these findings.

Although the majority of the patients in the pre-hospital ETT group were treated by one EMS agency, there were several other EMS agencies included in the study. There is a great deal of variation in intubation success rates by EMS companies.[5] We did not have access to the field airway management protocols, but this variation may be due to differences in airway assessment, management, and responder skill level among the various agencies. Level of EMS personnel training and experience is also variable. If the patient was brought to the hospital via ground transport, the paramedic or, in rare cases, the EMS physician, who is an emergency medicine resident or attending physician assigned to work with the crew, was the clinician performing the intubation. Patients transported by flight teams were intubated by flight paramedics, but the majority of patients in each group were transported by ground teams. Details of the pre-hospital management including the level of training for the personnel performing intubation and transport time, among others, were not obtainable. All these factors have potential to affect intubation success rate, hospital course, and patient outcome.

In addition to variations in pre-hospital personnel training, the experience level of those performing intubation in the ED also varied. At this institution, there is an emergency medicine residency. It is protocol for residents to perform the first intubation attempt, followed by the attending emergency physician, and finally by the anesthesia attending, if all other attempts are unsuccessful. There were several situations in which the number of ventilator days, length of ICU stay, and length of hospital stay were reported to be much less than one would expect. This includes patients who expired in the inpatient setting, patients who were transferred to an outside facility requiring higher level of care, patients who were discharged from the hospital to hospice care, and patients who left the hospital against medical advice.

CONCLUSIONS

Currently, there is insufficient evidence to justify any changes to pre-hospital advanced airway management protocols. Additional research is needed in this area. We did not find any significant differences in terms of reliance on mechanical ventilation or length of hospital stay between the two groups. Given these findings, it is essential to conduct larger, multicenter studies to evaluate patient outcomes comprehensively and to explore additional factors that may influence the effectiveness of pre-hospital intubation. By doing so, we can better understand the nuances of airway management in trauma care and develop evidence-based guidelines that optimize patient safety and outcomes. Collaborative efforts between EMS responders and hospital systems will be vital in addressing these questions and improving overall care for trauma patients. Additional research into these outcomes may provide a more comprehensive understanding of the implications of pre-hospital versus in-hospital intubation.

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Caught Unprepared: The Urgent Need for Reproductive Health Training in Emergency Medicine

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"I'm not sure I want to keep the baby."

She looked at me, eyes full of fear and sorrow yet also glazed over—thought-frozen by all the potential choices and futures ahead of her. I reached out and held her hand, giving her the time and space she needed while processing the news, despite the incessant beeping and noises that the flimsy blue curtain barely shielded us from.

"What are my next steps if I don't want to keep the baby?"

My hand suddenly pulled away from hers—not because of judgment or contempt, but because I was unprepared. I withdrew my hand because I had never been asked that question in my entire residency training. I was in new territory and unsure how to proceed.

I graduated from my emergency medicine residency in Texas this past year and moved cross-country to pursue a fellowship in Washington, DC. The patient in front of me was one of the many I had seen in the first month as an attending. During that month, I managed difficult airways, placed central lines, and ran a cardiac arrest with confidence rooted in my training. Yet, in front of a tearful young woman, I felt utterly useless and stuck.

During my residency in Texas, when the Dobbs decision was announced on June 24, 2022, we were instructed to escalate any concerning pregnancy or miscarriage issues to OB/GYN. That was that. But here, in my low-access community hospital in DC, I didn't have in-house OB/GYN support. I asked a colleague what to do and was shocked to find that emergency physicians in the DC area weren't paralyzed by the words "fetal demise," "miscarriage," or "abortion" due to fear of litigation, as they were in Texas. They knew the potential options and were significantly more comfortable counseling patients on reproductive health options.

As a physician, I believe my duty is to follow the law in the state in which I am practicing, while providing the best, safest care within those legal boundaries. But there I was, in a new state with different laws, suddenly overwhelmed by my lack of knowledge and experience. I was afraid to speak, worried that I might misinform the patient. Fortunately, this patient was stable. But what if she had been actively decompensating? My lack of training, awareness of care options, and potential legal ramifications could have had disastrous consequences for both mother and child.

My experience reflects a larger concern for the practice of emergency medicine (EM). Since Dobbs, many hospitals have closed their labor and delivery units because physicians have left these areas.[1] As a result, more than three million women (or 5.7% of women of reproductive age) live in areas without maternity services.[2] Without other options, these patients sometimes have no choice but to come to the emergency department for care.

A year ago, following the Dobbs decision, a group of emergency physicians put out a call for EM residencies to continue teaching and educating residents on reproductive health for the sake of patient care despite the constantly shifting political landscape:

> The Dobbs decision will exacerbate existing disparities in maternal health and likely drive related pregnancy and miscarriage care to the perennial health system safety net, the ED. As a result, EM education will necessarily expand to include contraception screening and provision, manual uterine evacuation, and the provision of medication abortions in the ED. There is precedent for [emergency] physicians performing these functions, but they need to be further developed and more widely incorporated into residency training.[3]

Now, after the most recent election and an uncertain medical landscape, the need for updated and thorough training is even more urgent. Regardless of political affiliation or beliefs, physicians must stay informed and prepared. The call to action and proposed solutions by physicians were made over a year ago, yet more physicians graduate every year without this crucial education in an uncertain political and legal landscape. Some organizations, such as Access Bridge, are working to provide clinical guidelines for emergency physicians on reproductive health, but it is not enough.

After nearly a year and the unnecessary deaths of young women such as Amber Thurman,[4] some lawmakers and members of Congress are finally taking action. Just recently, the US Senate Finance Committee, chaired by Sen. Ron Wyden, released a 29-page report titled, Practicing Amid "A Minefield": Emergency Reproductive Health Care Post-*Dobbs*. The report reviews recent investigations regarding the delivery and practice of reproductive healthcare and the confusing and challenging legal landscape state abortion bans create through EMTALA without clear hospital legal guidance—a situation emergency physicians had predicted nearly a year ago.[5] Most importantly, it lays out recommendations specifically for hospitals, physician groups, and medical organizations to "work together to provide training, guidance and resources on the interplay between EMTALA and abortion bans." The report further recommends that medical organizations should issue guidance and publish standards that define appropriate clinical care in obstetrics emergencies.[6]

With these recommendations in play, EM residency programs and national practice organizations now must step up to provide consistent, state-specific guidance so that all emergency physicians can maintain the national standard of care expected by our patients. Delaying action only risks creating a generation of emergency physicians who lack the knowledge and confidence to treat women with reproductive health emergencies. Physician leaders must engage with their states, determine effective, legal ways to educate residents, and implement these changes before a generation of emergency physicians graduate with inadequate training and fear regarding reproductive health.

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Response to the Letter to the Editor Regarding "Bicarbonate and Serum Lab Markers as Predictors of Mortality in the Trauma Patient"

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Dear Authors:

We sincerely appreciate your thoughtful comments on our article, "Bicarbonate and Serum Lab Markers as Predictors of Mortality in the Trauma Patient." Your detailed analysis and enthusiasm regarding our study are highly valued and encourage further exploration of the topics we addressed.

We agree with the points raised regarding more narrowly stratifying the observations by trauma types and anatomical locations, as well as the nuanced approach to interpreting serum marker levels like lactate, are insightful and align with our intentions to promote more precise clinical applications of such markers.

It is appropriate to acknowledge that this database lacks the granularity necessary to differentiate between bicarbonate or lactate values obtained within the same day. This limitation inherently restricts our ability to explore the temporal progression of these markers and their association with patient outcomes, such as lactate clearance or persistence, which are indeed important prognostic factors. Your replication of our analysis with a narrower focus on anatomical injuries and lactate stratification further substantiates the value of specificity in trauma research. We are encouraged by your findings and agree that refining study cohorts could yield even more clinically relevant insights.

Thank you again for engaging with our work and for contributing to the ongoing dialogue in trauma care research. Your feedback will undoubtedly inspire future investigations aimed at improving patient outcomes.

Sincerely,
Dr. Matt Talbott, Krishna Paul, and Dr. Dietrich Jehle

Link to Letter to the Editor: https://westjem.com/articles/comments-on-bicarbonate-and-serum-lab-markers-as-predictors-of-mortality-in-the-trauma-patient.html

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Beyond Efficiency: Considering the Benefits of Residents in the Emergency Department

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Determining the productivity and efficiency that emergency medicine (EM) residents add to an emergency department (ED) is an important undertaking. In "Impact of Medical Trainees on Efficiency and Productivity in the Emergency Department: Systematic Review and Narrative Synthesis," Valentine et al found that residents moderately increase ED productivity while mildly decreasing the efficiency of departments.[1] As a medical education fellow at Washington University in St. Louis, I have benefitted from the ways institutions value trainees and their educational journey.

The work by Valentine et al underscores the difficulty of balancing educating residents with the reality of ED flow, especially for hospitals considering adding EM rotators or starting a residency. I would add that there are many benefits of having an academic emergency department that go beyond efficiency, including improving patient experience and career satisfaction. For example, Lang et al demonstrated that residents at their institution scored higher on Press Ganey surveys than attendings.[2] Clinical teaching is linked to ED attendings' having higher satisfaction with their career ,which may prevent burnout.[3] Let us continue to appreciate the numerous less-tangible ways trainees benefit the department, the hospital system, and patient care that go beyond efficiency and productivity.

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Beyond Efficiency: Considering the Benefits of Residents in the Emergency Department

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Dear Dr. Armstrong:

Thank you for your thoughtful comments and interest in our article: "Impact of Medical Trainees on Efficiency and Productivity in the Emergency Department: Systematic Review and Narrative Synthesis."

We appreciate your perspective on the benefits that emergency medicine residents bring to the ED. In our review, we deliberately excluded papers on the impact of trainees on patient satisfaction and patient outcomes. We screened many interesting articles that addressed these topics and believe they merit their own separate systematic reviews.

We agree that there are numerous considerations when starting or hosting a residency program within an ED. One of the core tenets of competency-based medical education is aligning educational outputs with community needs. Ideally, this would involve demonstrating a need for more emergency physicians in the geographic area of the proposed residency and showing that graduates are staying to provide care in these underserved communities. Unfortunately, there is currently no accrediting body that considers this alignment. The Accreditation Council for Graduate Medical Education's scope is limited to ensuring the adequacy of training rather than assessing the necessity of a program based on community needs.

Finally, we would also caution against relying on "intangible" measures of trainee value. As researchers, we are tasked with exploring these variables to provide evidence-based insights. Our concern is that accepting the benefits of academia as "intangible" may contribute to continued non-competitive compensation practices by academic institutions. As highlighted recently, the market often undervalues additional credentials and fellowship training, leading to large pay disparities between academic and community physicians.[1]

Once again, thank you for your engaging comments. We value the opportunity to discuss these important issues further.

Sincerely,

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