WestJEM

Volume 24, Number 5, September 2023 Open Access at WestJEM.com ISSN 1936-900X

Western Journal of Emergency Medicine:

Integrating Emergency Care with Population Health

Indexed in MEDLINE

Contents continued on page iii

CALIFORNIA ACEP
AMERICAN COLLEGE OF EMERGENCY PHYSICIANS

ACOEP
The American College of Osteopathic Emergency Physicians

UC Irvine Health

CALAAEM
CALIFORNIA CHAPTER DIVISION OF THE AMERICAN ACADEMY OF EMERGENCY MEDICINE

A Peer-Reviewed, International Professional Journal

VOLUME 24, NUMBER 5, September 2023

PAGES 823-1004

ACOEP stands with all emergency physicians and providers on the front line. We thank you for your tireless work and effort.

ACOEP
The American College of Orthopaedic Emergency Physicians

www.acoep.org

Penn State Health Emergency Medicine

About Us:

Penn State Health is a multi-hospital health system serving patients and communities across central Pennsylvania. We are the only medical facility in Pennsylvania to be accredited as a Level I pediatric trauma center and Level I adult trauma center. The system includes Penn State Health Milton S. Hershey Medical Center, Penn State Health Children's Hospital, and Penn State Cancer Institute based in Hershey, Pa.; Penn State Health Hampden Medical Center in Enola, Pa.; Penn State Health Holy Spirit Medical Center in Camp Hill, Pa.; Penn State Health St. Joseph Medical Center in Reading, Pa.; Penn State Health Lancaster Pediatric Center in Lancaster, Pa.; Penn State Health Lancaster Medical Center (opening fall 2022); and more than 3,000 physicians and direct care providers at more than 126 outpatient practices in 94 locations. Additionally, the system jointly operates various health care providers, including Penn State Health Rehabilitation Hospital, Hershey Outpatient Surgery Center, Hershey Endoscopy Center, Horizon Home Healthcare and the Pennsylvania Psychiatric Institute.

We foster a collaborative environment rich with diversity, share a passion for patient care, and have a space for those who share our spark of innovative research interests. Our health system is expanding and we have opportunities in both academic hospital as well community hospital settings.

Benefit highlights include:

- Competitive salary with sign-on bonus
- Comprehensive benefits and retirement package
- Relocation assistance & CME allowance
- Attractive neighborhoods in scenic central Pa.

PennState Health

FOR MORE INFORMATION PLEASE CONTACT:

Heather Peffley, PHR CPRP - Penn State Health Lead Physician Recruiter
hpeffley@pennstatehealth.psu.edu

Western Journal of *Emergency Medicine*:

Integrating Emergency Care with Population Health

Indexed in **MEDLINE, PubMed, and Clarivate Web of Science, Science Citation Index Expanded**

Official Journal of the California Chapter of the American College of Emergency Physicians, the America College of Osteopathic Emergency Physicians, and the California Chapter of the American Academy of Emergency Medicine

Available in MEDLINE, PubMed, PubMed Central, CINAHL, SCOPUS, Google Scholar, eScholarship, Melvyl, DOAJ, EBSCO, EMBASE, Medscape, HINARI, and MDLinx Emergency Med. Members of OASPA.

Editorial and Publishing Office: *West*JEM/Depatment of Emergency Medicine, UC Irvine Health, 3800 W. Chapman Ave. Suite 3200, Orange, CA 92868, USA
Office: 1-714-456-6389; Email: Editor@westjem.org

Western Journal of *Emergency Medicine*:

Integrating Emergency Care with Population Health

Indexed in **MEDLINE, PubMed, and Clarivate Web of Science, Science Citation Index Expanded**

Official Journal of the California Chapter of the American College of Emergency Physicians, the America College of Osteopathic Emergency Physicians, and the California Chapter of the American Academy of Emergency Medicine

Available in MEDLINE, PubMed, PubMed Central, Europe PubMed Central, PubMed Central Canada, CINAHL, SCOPUS, Google Scholar, eScholarship, Melvyl, DOAJ, EBSCO, EMBASE, Medscape, HINARI, and MDLinx Emergency Med. Members of OASPA.

Editorial and Publishing Office: *West*JEM/Depatment of Emergency Medicine, UC Irvine Health, 3800 W. Chapman Ave. Suite 3200, Orange, CA 92868, USA
Office: 1-714-456-6389; Email: Editor@westjem.org

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

JOURNAL FOCUS

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

Policies for peer review, author instructions, conflicts of interest and human and animal subjects protections can be found online at www.westjem.com.

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*

Western Journal of *Emergency Medicine*:

Integrating Emergency Care with Population Health

Indexed in **MEDLINE, PubMed, and Clarivate Web of Science, Science Citation Index Expanded**

Western Journal of *Emergency Medicine*:

Integrating Emergency Care with Population Health

Indexed in **MEDLINE, PubMed, and Clarivate Web of Science, Science Citation Index Expanded**

EISENHOWER HEALTH

Education Fellowship at Eisenhower Medical Center, Rancho Mirage, CA

ABOUT THE PROGRAM

- SAEM-approved Education Fellowship
- Opportunities to learn in both Graduate and Undergraduate Medical Education
- Offer "Training to Teach in Medicine" certificate program from Harvard Medical School
- One- or two-year fellowship
- Competitive salary with full-benefits from Eisenhower Health

ABOUT EISENHOWER MEDICAL CENTER

- Rated among the region's Best Hospitals by *U.S. News & World Report*
- More than 85,000 visits per year
- Advanced Primary Stroke Center, STEMI Center, Accredited Geriatric Emergency Department and Level Four Trauma Center
- State-of-art medical center
- 50 private patient rooms
- Best EMR: Epic
- Three-year Emergency Medicine residency program

LIVING IN THE DESERT

- Affordable cost of living
- Variety of activities: hiking, shopping, dining, golfing, etc.
- Within two hours from many big cities (L.A. and San Diego)

CONTACT

Wirachin Hoonpongsimanont, MD, MS
Call: 862-216-0466 ■ Email: wirachin@gmail.com
website: gme.eisenhowerhealth.org

LIVE. WORK. PLAY. PROSPER.

Save the Date

Spring Seminar 2024 | April 27 – May 1

Signia Orlando Bonnet Creek • Orlando, Florida

#ACOEP24

ACOEP
The American College of
Osteopathic Emergency Physicians

Call for Section Editors

- Behavioral Emergencies
- Emergency Cardiac Care
- International Medicine
- Pediatric Emergencies
- Public Health
- Trauma Care
- Ultrasound

WestJEM Integrating Emergency Care with Population Health

Send CV and letter of interest to Editor@WestJEM.org

WestJEM Integrating Emergency Care with Population Health

NEW: HEALTH EQUITY SECTION

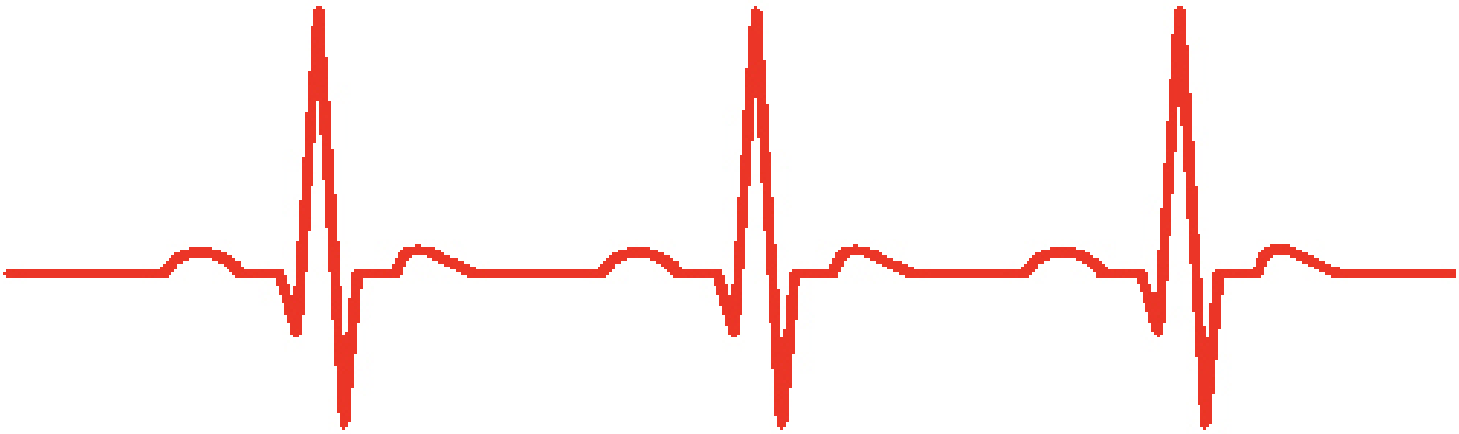
Call for

Reviewers and Manuscripts

Send CV and letter of interest to Editor@WestJEM.org

WestJEM Integrating Emergency Care with Population Health

Call for Reviewers!



Please send your CV and letter of interest to
editor@westjem.org

CPCEM Clinical Practice & Cases

Optimizing a Drone Network to Respond to Opioid Overdoses

Daniel J. Cox, MD, MEng* [*]Duke University, Department of Emergency Medicine, Durham, North Carolina
Jinny J. Ye, MD* [†]Duke University, Department of Electrical and Computer Engineering, Durham, North Carolina
Chixiang Zhang, MS† [‡]Durham County Emergency Medical Services, Durham, North Carolina
Lee Van Vleet, MHS, NREMT-P‡ [§]Global Health Institute, Duke University, Durham, North Carolina
João R. Nickenig Vissoci, PhD*§ [‖]Duke University, Department of Mechanical Engineering and Materials Science, Durham, North Carolina
Daniel M. Buckland, MD, PhD*‖

Section Editors: Shira Schlesinger, MD, MPH, and Gayle Galletta, MD
Submission history: Submitted December 14, 2022; Revision received March 30, 2023; Accepted May 24, 2023
Electronically published August 30, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59609

Introduction: Effective out-of-hospital administration of naloxone in opioid overdoses is dependent on timely arrival of naloxone. Delays in emergency medical services (EMS) response time could potentially be overcome with drones to deliver naloxone efficiently to the scene for bystander use. Our objective was to evaluate a mathematical optimization simulation for geographical placement of drone bases in reducing response time to opioid overdose.

Methods: Using retrospective data from a single EMS system from January 2016–February 2019, we created a geospatial drone-network model based on current technological specifications and potential base locations. Genetic optimization was then used to maximize county coverage by drones and the number of overdoses covered per drone base. From this model, we identified base locations that minimize response time and the number of drone bases required.

Results: In a drone network model with 2,327 opioid overdoses, as the number of modeled drone bases increased the calculated response time decreased. In a geospatially optimized drone network with four drone bases, response time compared to ambulance arrival was reduced by 4 minutes 38 seconds and covered 64.2% of the county.

Conclusion: In our analysis we found that in a mathematical model for geospatial optimization, implementing four drone bases could reduce response time of 9–1–1 calls for opioid overdoses. Therefore, drones could theoretically improve time to naloxone delivery. [West J Emerg Med. 2023;24(5)823–830.]

INTRODUCTION

In 2021 over 100,000 people died from opioid overdoses in the United States.[1] Opioid death rates also increased 10-fold from 2013 to 2019.[2] Although death from an opioid typically occurs over a few hours,[3] there may be bystander delays in calling 9–1–1.[4–6] The reduction of deaths from opioid overdoses often depends on prompt 9–1–1 response and use of the reversal medication naloxone.

Naloxone is currently available without a prescription in intranasal and intramuscular forms that lay-users can safely administer with little skill. Because of this, bystanders can play a vital role in preventing deaths from opioid overdoses through the administration of naloxone. Despite expanded access and education on naloxone, people who use opioids may not carry this life-saving medication.[7] Furthermore, time to ambulance arrival, which can impede the provision of naloxone, ranges from 1.7–51 minutes (median 6.9 minutes).[8] National Fire Protection Agency Standard 1710 establishes target response times for EMS personnel. It states that the goal for response times is five minutes for 90% of

dispatched incidents.[9] Analysis from 2017 suggested that EMS response times averaged 7 minutes in the US, two minutes longer than NFPA 1710.[10]

Unmanned aerial vehicles, or drones, may offer a bridge for faster naloxone delivery while awaiting trained first responders (firefighters, police, or paramedics). Drones have previously been used for medication delivery in rural areas,[7] disease surveillance and collection of biosamples,[11] and they have been investigated for use in automatic external defibrillators delivery in cardiac arrest.[12] Recently, a study by Tukel et al demonstrated that drones have the ability to travel straight-line distances carrying life-saving opioid reversal medications faster than ambulances.[13] Additionally, a pre-print by Lejune and Ma describes use of a stochastic method to improve response times by 78% in Virginia Beach.[14]

Our objective in this study was to determine whether a mathematical model could be used to optimize the placement of drone bases to reduce response time to opioid overdoses. Given the locations of opioid overdoses, this mathematical model determines the number and location of drone bases to meet any specified reduction in response time. When compared to observed ambulance response times, our optimized network was found to reduce response times to opioid reversal medication delivery by over four minutes.

METHODS

Study Setting

The study was conducted in a county in North Carolina with a population of over 300,000 people in 2019 on ≈750 square kilometers of land with an average population density of 434 per square kilometer.[15] A single EMS agency responds to medical emergencies for this area. In all suspected opioid overdose calls, firefighters and sheriff's deputies are dispatched along with EMS. However, we only had access to the EMS data for this study. Note that the data does not include response times for law enforcement, firefighters, or other emergency medical responders.

Dispatching ambulances use a hybrid system status management (SSM). The hybrid SSM coordinates responding units based in stations and automatic vehicle location (AVL) to guide dispatch. The AVL ensures that the unit closest to the call is assigned to the response based on GPS. The paramedic service also strategically posts units based on call volume. For example, if all responding units are busy, outlying units will be sent to general geographic areas to provide coverage in uncovered areas during a high-volume period. General study setting information (eg, county demographics, response times) are shown in Table 1. We defined "dispatch time" as the time between when the call came in and when a unit or drone was assigned to that particular incident.

Table 1. Summary statistics for Durham County, North Carolina.

County Demographic and Historical Response Data	
Characteristics	
Population (2017)	311,640
Population density (2017), km^2	935.7
Average annual number of opioid overdoses	743.1
Female gender in overdoses	43%
Average patient age, years	41
Number of paramedic and fire stations	29
Dispatch time, minutes/seconds	
Average	03:01
90th percentile	05:00
Response time, minutes/seconds	
Average	10:46
90th percentile	17:00

Study Design

Using a retrospective cross-sectional design, we used data in prospectively collected electronic health records as part of routine care. Our overall design was inspired by Boutilier et al,[16] which mathematically optimized drone networks for automatic external defibrillators (AED) for out-of-hospital cardiac arrest in Toronto, Canada. Their method optimized by a threshold response time, determining how many drones at each prospective base would be required to reduce response times by one, two, and three minutes. We furthered this analysis method by not holding the number of bases constant and optimized the number of drones and bases needed to produce the greatest coverage area and produce the greatest decrease in response time per drone.

DATA SOURCES

Opioid Overdose Episodes

We included in this study all dispatches for suspected opioid overdoses in the service area from January 1, 2016–February 17, 2019 (Emergency Medical Dispatch card number 23 or naloxone administration during the call) regardless of call priority). Locations of these dispatches were automatically geocoded (converting a text-based address to geographic coordinates) based on addresses obtained during dispatch calls.

Candidate Base Locations

For the drone network, all fire, paramedic, and EMS administrative buildings were considered potential drone bases. The addresses of each station were obtained from the local paramedic service and geocoded into Universal Transverse Mercator (GIS Geography, Redlands, CA)

coordinates. We used 29 such candidate stations in our analysis. Drone bases were selected among these candidate stations.

Drone Specifications

Drone parameters for our model were chosen to reflect current, cost-effective drone capabilities. We set the maximum speed as 18 kilometers per hour and a maximum distance of 7 kilometers on one battery life. We chose more conservative metrics than Boutilier et al because naloxone will require less power to transport compared to an AED. However, Tukel et al used drones that could reach speeds of 94 kilometers per hour, which would likely further improve results from this study. These drones had the ability to carry up to 1.4 kilograms in payload, which should easily allow for naloxone to be transported. Because there is no previously standardized launch time, we assumed drone lift off and landing would each take 60 seconds. We did not account for time for lay-users to reach the drone, remove the medication, and return to the patient's side, as these calculations have not been established. Ambulance response time also does not account for the time interval between EMS arrival on scene to arrival to patient.

Each drone's geographical catchment area was set to a 3.2 kilometer-(two mile) radius for the drone's ability to fly to and from the scene. We also accounted for wind speed and rain on the days of overdose incidents using hourly North Carolina climate data in the service area.[17] Assuming the drone could withstand a level 5 wind (wind speeds of 19–24 miles per hour), we set 19 miles per hour as the threshold speed for drones to work normally. For most drones, it is not recommended to operate in rainy conditions. We assumed that drone service would pause during these times (precipitation >0).

ANALYSIS

Measurements

Our primary outcomes were ambulance and drone response times as depicted in Figure 1. For our dataset, we defined ambulance response time as the duration between EMS assignment and arrival at scene as documented in EMS records. Drone response time was considered time between drone assignment and arrival at scene. These definitions were equivalent to those used by Boutilier et al. Drones would be collected from the scene when an ambulance arrives. Time between arrival on scene and arrival to the patient was not calculated for either drone or ambulance response times. We calculated drone response times using a genetic optimization model and technological specifications of current drones as described above. Additional time was added to the calculated flight time to account for dispatching the drone and allowing it to land after arriving on the field site. This additional time produced a very conservative estimate of the total response time for each drone flight. We excluded incidents with missing data on scene location and response time.

Genetic Optimization

Genetic optimization is an iterative process inspired by natural selection in which the properties of a potential solution to a problem are changed with each iteration. After each iteration (generation), the performance (fitness) is assessed for each potential solution. The subsequent generation of solutions is then determined based on the composition of the current highest performing solutions. In biological terms, the best solutions in each generation serve as the parents for the next set of potential solutions. This process continues until a solution meets a set of minimum criteria.[18,19]

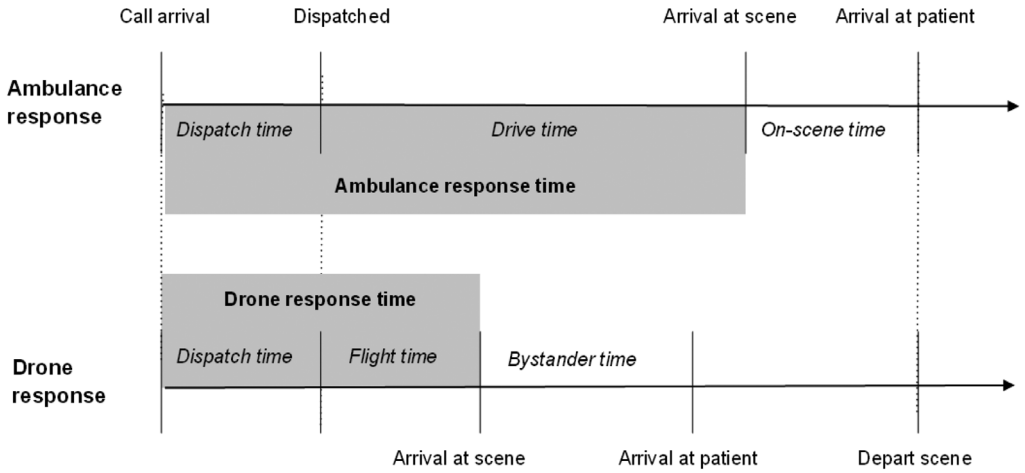


Figure 1. Ambulance and drone timelines adapted from Boutilier et al 2017.[16] The objective of the drone is to get naloxone to the patient as early as possible. If the ambulance arrives first, the drone on-scene time will be zero. If the drone arrives first, naloxone can be given while the ambulance is in route.

Our goal was to determine the optimal number and spatial geographic distribution of drone bases that would reduce naloxone distribution times to opioid overdoses. To accomplish this, we first used locations of overdose incidents, number of drone bases, and locations of drone bases to create drone base networks. These networks each had a unique combination of base locations, number of bases, coverage rate (percentage of incidents covered by drone bases), and coverage density (number of incidents covered by a drone base). Given the prespecified number of bases from 0–29, the genetic optimization model determines the geographical locations of drones that maximizes coverage rate and density (in mathematical terms, if entropy converged). Maximizing coverage rate and density did not account for rural and urban differences in response times. Our algorithm sought to improve the overall distribution of response times, regardless of location. For example, base locations for a two-drone network may be completely different than a three-drone network rather than simply adding another drone location. The genetic optimizer was considered successful for drone network optimization if entropy converged. We conducted analyses with Python 3.6.8 (Python Software Foundation, Wilmington, DE) on Jupyter Notebook and ArcGIS Desktop 10.5.1 (Esri).

Observed and Estimated Response Time

We found that the drone networks improved average response time for each added drone base. For each reduction in response time, we identified the locations of these drone bases chosen from candidate EMS/fire stations. We calculated the distributions of the observed response times and estimated drone response times for each incident. A graph of response time and number of drone bases were plotted. We chose the operating point, or the point closest to the graph origin, as the optimum number of drone bases that would minimizs the response time and number of bases.

We performed the test of significance with a Student *t*-test by proposing the null hypothesis H_0: the average (or expected) response time of historical, optimized, and fully deployed delivery network is different from each other. We calculated the *P*-value for each paired combination of historical, optimized and fully deployed delivery networks. *P*-values less than 0.05 were considered significant.

Ethics Statement

The Duke University Institutional Review Board determined this study to be exempt (Pro00101461).

RESULTS

Characteristics of Study Subjects and Climate

From 2016 to early 2019, 2,634 calls were dispatched for suspected opioid overdose/poisoning. After eliminating duplicate incidents with unique responding units, we found 2,327 distinct incidents of suspected overdose/poisoning or dispatch calls in which naloxone was used. We excluded 303 cases in which response time data were missing, three cases in which response times were greater than 40 minutes and assumed to be inaccurate documentation, and one case that was geocoded incorrectly, resulting in a total of 2020 final encounters. Summary characteristics for opioid overdoses are shown in Table 1. Of the included cases of opioid overdoses 43% involved females, and the average age was 41 years old. Dispatch time took an average of 3 minutes 1 second, and response time took an average of 10 minutes 46 seconds. Regarding climate, no overdoses occurred when winds exceeded 19 miles per hour, while 147 incidents occurred during rain. We did not exclude in the genetic algorithm the incidents that occurred in the rain.

Main Results

The entropy of the genetic optimization converged after 60 generations, meaning the drone base network was able to be optimized. The change in response time and coverage rate with each added drone base is shown in Table 2. Response time and coverage rate consistently improved with increasing number of drone bases up to the 29 available locations. For example, having only one drone base reduced response time by 2 minutes 24 seconds with a 36% coverage rate. But at full deployment of 29 bases, response time was reduced by 8 minutes 12 seconds and covered 97.8% of incidents.

Table 2. Drone network characteristics for the response time improvement in opioid overdoses.

Number of drone bases	Improvement in response time, mm:ss	Coverage rate %
0	00:00	0.0
1	02:24	35.8
2	03:28	50.5
3	03:57	56.3
4	04:38	64.2
5	05:03	70.9
6	05:24	73.0
7	05:47	76.8
8	06:05	79.9
9	06:19	82.1
10	06:38	86.5
11	06:51	86.9
12	07:02	90.3
13	07:08	91.3
14	07:18	91.4
15	07:25	91.3
16	07:31	92.7
17	07:34	92.7

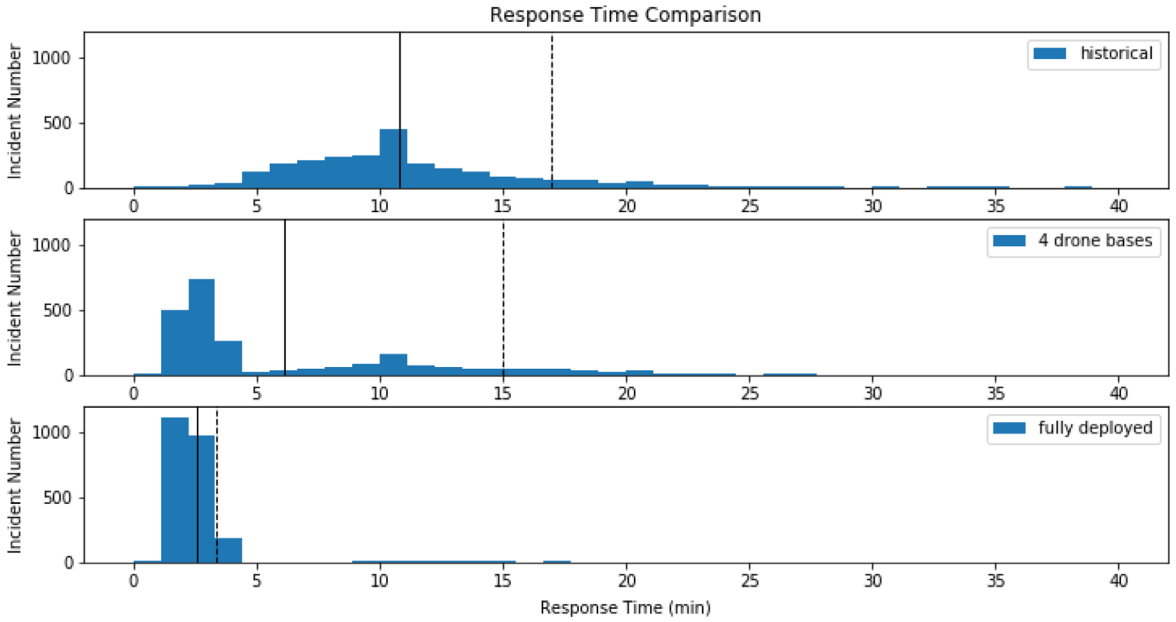


Figure 2. Comparison of response time distributions. The top row demonstrates the distribution of historical ambulance response times. The second row shows the distribution of estimated response time corresponding to the four-base drone network. The third row shows the distribution of estimated response time if all candidate bases were chosen as the part of the drone network. (Drone bases are fully deployed.) Solid vertical lines demonstrate the mean response time. Dashed vertical lines represent the 90th percentile in response time.

The distribution of response times also narrowed with an increase in drone bases (Figure 2). As more drone bases were introduced into the network, the average and range of estimated response times are markedly decreased compared to historical ambulance response times. Because response time cannot be improved without increasing the number of drone bases, we chose a drone network that minimized response time and number of bases, thereby maximizing resource utilization. This ideal network, shown as the point closest to origin (Figure 3), was four drone bases. These optimal candidate bases improved average response time by 4 minutes and 38 seconds with a coverage rate of 64.2%. These bases are in areas with more opioid overdoses (ie, urban areas), leaving rural areas largely uncovered by drones due to constraints on flight time and distance (Figure 4).

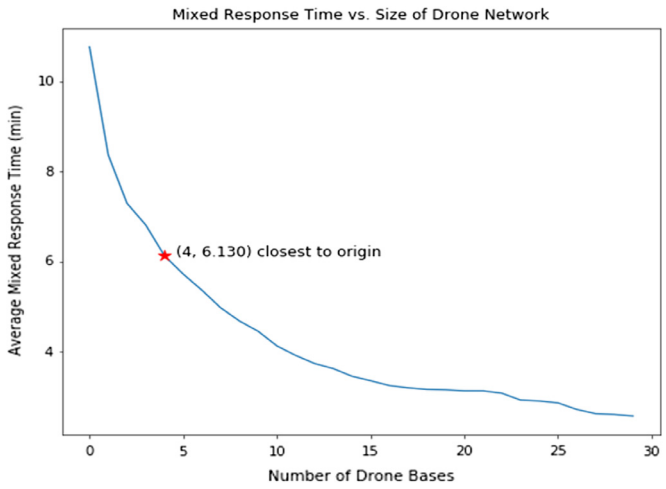


Figure 3. Average response time given number of drone bases. This figure demonstrates the relationship between the number of drone bases and response time. The red star represents the point closest to the origin (x-axis must be a whole number). This point corresponds to the most efficient use of drone resources.

DISCUSSION

In this study we evaluated the potential benefit of using drones to improve time to naloxone delivery in suspected opioid overdoses. Our analysis found that a mathematical model can optimize the location and number of bases to reduce naloxone delivery time compared to historical ambulance response times. We found that drones not only improve the average time of naloxone delivery on scene (Table 2), but also reduce the entire response time distribution (Figure 2).

Drone delivery of naloxone has the potential to reduce the time to naloxone administration and theoretically reduce mortality from opioid overdoses. Our conservative model demonstrates that drones could be used to deliver naloxone ahead of ambulances. Compared to ambulances, drones may overcome challenges and delays in reaching private locations.[8] In simulated out-of-hospital cardiac arrests, drones have reduced response time by 16 minutes compared to EMS.[12]

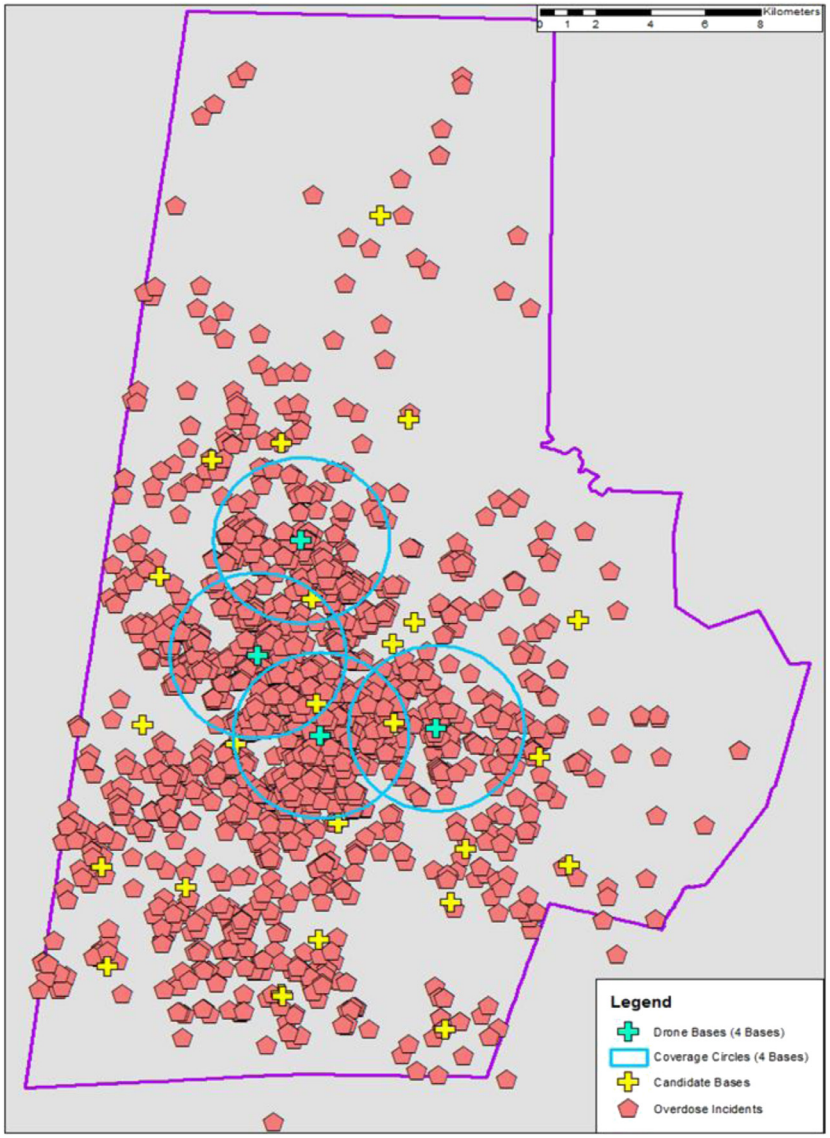


Figure 4. Historical opioid overdoses, paramedic station locations, and optimal drone network. This county map demonstrates locations of historical opioid overdoses (red pentagons). Additionally, it shows the locations of all candidate drone bases (+ signs) and the optimized drone network (blue + signs) and its coverage area (area inside blue circles).

In our optimized model, the locations of our drone bases leave the most rural locations to be covered only by ambulances. Drone networks can cover rural areas. However, the number of drones needed to cover rural areas would likely not be economical at the current range of Federal Aviation Administration (FAA)-rated commercial drones unless there was a cluster of opioid overdoses where drones could be stationed nearby. The genetic algorithm did not directly account for rural/urban differences. Instead, it focused on covering the maximum number of overdoses, of which the vast majority occur in urban areas. Thus, our drone network maximizes our chances of reducing mortality in opioid overdoses, especially during times of increased traffic and call volume which can prolong ambulance response times.

Although all states currently have some form of naloxone access laws, studies suggest that Blacks are less likely to have access to naloxone.[20–22] With Blacks making up 36.9% of the population in the service area, a drone network has the potential to provide this lifesaving treatment to those who may not have equitable access.

LIMITATIONS

Because the model depended on the estimated incidence of opioid overdoses in each catchment area, bases in high-call volume areas will have more drone busy time and require more drones. However, the remaining parameters were more conservative, likely leading to an overestimate in drone network size. We assumed only one drone per base, whereas in reality multiple drones could be deployed from one base,

decreasing drone busy time. Drone resources may also be overestimated because we included dispatches for opioid overdoses that did not receive naloxone. This small fraction of cases may be ruled out for future drone deployment. Additionally, drone technology is progressing rapidly. With our conservative drone specifications, response times are likely an overestimate. Furthermore, potential candidate bases locations such as hospitals and clinics were not included in the model. Having these additional locations could further reduce drone response times.

We additionally used Euclidean distance to set our coverage area and did not account for FAA regulations on drone flight paths, which may require a slightly more circuitous path to bystanders than anticipated by this model. Further, difficult weather conditions (eg, wind and rain) may limit the ability to fly drones based on technological capabilities. Reassuringly, the number of overdose incidents during these conditions were minimal. Thus, we expect real-life implementation of drones to not be majorly impacted by weather.

Lastly, the data we used was incomplete because we did not have access to data from law enforcement or fire departments. This may have led to an overestimation of historical ambulance response times. In addition, data was based on emergency medical dispatch (EMD) impression of the chief complaint as a drug overdose. Calls in which EMS impression was opioid overdose, but EMD impression was not, may have been missed. We attempted to account for this difference by including all calls in which naloxone was administered, regardless of impression. Other opioid overdose cases may have been unaccounted for due to data exclusion based on incomplete or suspected inaccurate documentation on response times. However, because we excluded only 11.5% of cases based on documentation, the impact of missing data is likely small.

CONCLUSION

We have established that a drone network mathematically optimized in location and number of drone bases would potentially reduce time to naloxone delivery in opioid overdoses compared to historical ambulance response times. Our next steps will be to closely examine the feasibility of implementing such a drone network by measuring GPS signals, confirming flight paths, and completing live drone tests. As drone technology improves and cost decreases, future utilization of drone networks could help temporize many emergency medical situations until EMS arrives.

Address for Correspondence: Daniel Buckland, MD, PhD, Duke University, Department of Emergency Medicine, Department of Mechanical Engineering and Material Sciences, Duke University Medical Center 3096, Durham, NC, USA 27710. Email: dan.buckland@duke.edu

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.

REFERENCES

1. Spencer MR, Miniño AM, Warner M. Drug Overdose Deaths in the United States, 2001–2021. *NCHS data brief*, 2022(457):1–8.
2. Mattson CL, Tanz LJ, Quinn K, et al. Trends and Geographic Patterns in drug and synthetic opioid overdose deaths - United States, 2013-2019. *MMWR*, 2021;70(6):202–7.
3. Sporer KA. Acute heroin overdose. *Ann Intern Med*, 1999;(7):584–90.
4. Sherman SG, Gann DS, Scott G, et al. A qualitative study of overdose responses among Chicago IDUs. *Harm Reduct J*, 2008;5(1):1–5.
5. Tobin KE, Davey MA, Latkin CA. Calling emergency medical services during drug overdose: an examination of individual, social and setting correlates. *Addiction*, 2005;100(3):397–404.
6. Tracy M, Piper TM, Ompad D, et al. Circumstances of witnessed drug overdose in New York City: implications for intervention. *Drug Alcohol Depend*, 2005;79(2):181–90.
7. Heavey SC, Chang Y-P, Vest BM, et al. *'I have it just in case' - Naloxone access and changes in opioid use behaviours. Int J Drug Policy*, 2018;51:27–35.
8. Madah-Amiri D, Clause T, Myrmel L, et al. Circumstances surrounding non-fatal opioid overdoses attended by ambulance services. *Drug Alcohol Rev*, 2017;36(3):288–94.
9. Sanchez TM, Changes to NFPA 1710 and Impacts to BNA. 2017, Sandia National Lab. (SNL-NM), Albuquerque, NM.
10. Mell H.K, Mumma SN, Hiestand B, et al. Emergency medical services response times in rural, suburban, and urban areas. *JAMA Surgery*, 2017;152(10):983–4.
11. Rosser JC.Jr, Vudatha V, Terwilliger BA. Surgical and medical applications of drones: a comprehensive review. *J Leadersh Organ Stud*, 2018;22(3).
12. Claesson A., Fredman DM, Svensson L, et al. Unmanned aerial vehicles (drones) in out-of-hospital-cardiac-arrest. *Scand J Trauma Resusc Emerg Med*, 2016;24(1):124.
13. Tukel CA, et al. Time-to-scene for opioid overdoses: are unmanned aerial drones faster than traditional first responders in an urban environment? *BMJ Innovations*, 2020:bmjinnov-2019-000357.
14. Lejeune M., 1074208 and Ma W. Drone-delivery network for opioid overdose–nonlinear integer queueing-optimization models and methods. arXiv preprint arXiv:2206.14340, 2022.

15. US Census Bureau.*QuickFacts: Durham County, North Carolina*. 2010–2019 July 1, 2019 [cited 2021 July 15]; Available at: https://www.census.gov/quickfacts/durhamcountynorthcarolina. Accessed August 15, 2021.
16. Boutilier JJ, Brooks SC, Janmohamad A, et al. Optimizing a drone network to deliver automated external defibrillators. *Circulation*, 2017;135(25):2454–65.
17. North Carolina Climate Office. Weather And Climate Database 1/1/16 0:00-2/18/19 23:00. [cited 2021 July 15]; Available at: https://products.climate.ncsu.edu/cardinal/scout/?station=DURH&temporal=hourly. Accessed August 15, 2021.
18. Fuertes G., Vargas M, Alfaro M, et al. Chaotic genetic algorithm and the effects of entropy in performance optimization. *Chaos*, 2019;29(1):013132.
19. Smit S.K., Eiben A.. Parameter tuning of evolutionary algorithms: generalist vs. specialist. in *European Conference on the Applications of Evolutionary Computation.* 2010. NewYork, NY:Springer.
20. Dayton L, Tobin K, Oluwaseun NF, et al. Racial disparities in overdose prevention among people who inject drugs. *J Urban Health-Bulletin of Y Academy of Medicine*, 2020;97(6):823–30.
21. Ong AR, Lee S, Bonar EE. Understanding disparities in access to naloxone among people who inject drugs in Southeast Michigan using respondent driven sampling. *Drug Alcohol Depend*, 2020;206:107743.
22. Abbas B, Marotta P, Goddard-Eckrich D, et al. Socio-ecological and pharmacy-level factors associated with naloxone stocking at standing-order naloxone pharmacies in New York City. *Drug Alcohol Depend*, 2021;218:108388.

Does Housing Status Matter in Emergency Medical Services Administration of Naloxone? A Prehospital Cross-sectional Study

Tiffany M. Abramson, MD*
Corey M. Abramson, PhD†
Elizabeth Burner, MD, MPH, MSc, PhD*
Marc Eckstein, MD, MPH*
Stephen Sanko, MD*
Suzanne Wenzel, PhD‡

*University of Southern California, Keck School of Medicine, Department of Emergency Medicine, Divisions of Emergency Medical Services and Research, Los Angeles, California
†University of Arizona, School of Sociology, Tucson, Arizona
‡University of Southern California, Suzanne Dworak-Peck School of Social Work, Los Angeles, California

Section Editors: Marc Martel, MD, and Patrick Maher, MD, MS
Submission history: Submitted February 19, 2023; Revision received July 10, 2023; Accepted July 19, 2023
Electronically published August 28, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.60237

Introduction: Persons experiencing homelessness (PEH) use emergency medical services (EMS) at disproportionately high rates relative to housed individuals due to several factors including disparate access to healthcare. Limited access to care is compounded by higher rates of substance use in PEH. Despite growing attention to the opioid epidemic and housing crisis, differences in EMS naloxone administration by housing status has not been systematically examined. Our objective in this study was to describe EMS administration of naloxone by housing status in the City of Los Angeles.

Methods: This was a 12-month retrospective, cross-sectional analysis of electronic patient care reports (ePCRs) for all 9–1–1 EMS incidents attended by the Los Angeles Fire Department (LAFD), the sole EMS agency for the City of Los Angeles during the study period, January-December 2018. During this time, the City had a population of 3,949,776 with an estimated 31,825 (0.8%) PEH. We included in the study individuals to whom LAFD responders had administered naloxone. Housing status is a mandatory field on ePCRs. The primary study outcome was the incidence of EMS naloxone administration by housing status. We used descriptive statistics and logistic regression models to examine patterns by key covariates.

Results: There were 345,190 EMS incidents during the study period. Naloxone was administered during 2,428 incidents. Of those incidents 608 (25%) involved PEH, and 1,820 (75%) involved housed individuals. Naloxone administration occurred at a rate of 19 per 1,000 PEH, roughly 44 times the rate of housed individuals. A logistic regression model showed that PEH remained 2.38 times more likely to receive naloxone than their housed counterparts, after adjusting for gender, age, and respiratory depression (odds ratio 2.38, 95% confidence interval 2.15–2.64). The most common impressions recorded by the EMS responders who administered naloxone were the same for both groups: overdose; altered level of consciousness; and cardiac arrest. Persons experiencing homelessness who received naloxone were more likely to be male (82% vs 67%) and younger (41.4 vs 46.2 years) than housed individuals.

Conclusion: In the City of Los Angeles, PEH are more likely to receive EMS-administered naloxone than their housed peers even after adjusting for other factors. Future research is needed to understand outcomes and improve care pathways for patients confronting homelessness and opioid use. [West J Emerg Med. 2023;24(5)831–838.]

INTRODUCTION

Background

Opioid overdoses have reached epidemic proportions in the United States (US), and overdose deaths continue to increase.[1,2] Opioid overdose is now among the leading causes of accidental deaths.[3] The incidence of overdose deaths has increased with the introduction of fentanyl and other synthetic opioids and the aftermath of the COVID-19 pandemic.[1,2,4–6] Although opioid use disorders (OUD) and other substance use disorders (SUD) affect individuals of all socioeconomic statuses, persons experiencing homelessness (PEH) are at particular risk.[7–9] In 2021, 9% of all opioid overdose-related deaths were among PEH.[10]

The housing crisis is another public health epidemic facing the US; it has contributed to a rapidly growing population of PEH with more than 1.5 million individuals experiencing homelessness each year.[11,12] Los Angeles County, which has one of the highest housing costs and the second largest population of PEH nationally, is no exception.

Persons experiencing homelessness have higher rates of chronic medical conditions, substance abuse, and psychiatric diagnoses, as well as an overall increase in morbidity and mortality.[13–16] Drug overdoses, specifically those associated with opioids, are a common cause of death in PEH.[16–18] In one Boston-based study, drug overdose was the leading cause of death and was responsible for one in three deaths in adults experiencing homelessness under the age of 45.[17] Further, PEH are less likely to have a regular source of medical care and have increased emergency department (ED) utilization and engagement with emergency medical services (EMS).[19]

Persons experiencing homelessness use EMS at disproportionally high rates compared to their housed counterparts. Prior research found that PEH call EMS at a rate 14 times that of their housed counterparts.[20] At the same time, EMS calls for opioid overdose appear to be on the rise with naloxone administration occurring on almost half a million EMS runs over a two-year period.[21] As the housing crisis and opioid epidemic collide, it is important to describe how housing status affects EMS utilization and prehospital care for presumed opioid overdose. These findings may lead to recognition of bias in care, identification of opportunities for interventions for those with OUD and limited access to care, and improvement in EMS responders' education.

Importance

Despite growing attention to the opioid epidemic and housing crisis, differences in use of 9–1–1 EMS resources for treatment of presumed opioid overdose by PEH and subsequent treatment by EMS has not been described.

Goals of this Investigation

The primary outcome of interest in this study was how the prevalence of EMS administration of naloxone varies by housing status in the City of Los Angeles. This has important implications for understanding and addressing public health disparities at the intersection of housing, opioids, and poverty.

Population Health Research Capsule

What do we already know about this issue?
Persons experiencing homelessness (PEH) have higher rates of chronic medical conditions and are disproportionately represented among opioid overdose deaths.

What was the research question?
Does the prevalence of naloxone administration by emergency medical services (EMS) vary by housing status?

What was the major finding of the study?
Naloxone was administered at a higher rate to PEH (19 vs 0.4/1000). The adjusted OR of naloxone administration was 2.38 times than that of housed peers (95% CI 2.15–2.64).

How does this improve population health?
These findings can help drive EMS education and field interventions and identify a target for community risk reduction in this vulnerable population.

METHODS

Study Design

This was a 12-month retrospective, cross-sectional analysis of electronic health records (EHR) for all 9–1–1 EMS incidents attended by the Los Angeles Fire Department (LAFD) from January 1–December 31, 2018. Study design and reporting adhered to best practices per Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) and Reporting of Studies Conducted using observational routinely collected health data (RECORD) statements.[22,23]

Study Setting

The LAFD is the sole entity providing 9–1–1 EMS responses for the City of Los Angeles, the second most populous city in the US. The LAFD receives more than one million 9–1–1 calls and responds to almost 400,000 EMS incidents annually. The City of Los Angeles spans 480 square miles and has 3,949,776 inhabitants, with a homeless population of 31,285 (0.8%).[24,25]

The LAFD provides EMS care under the guidance of the LA County EMS Agency and its treatment protocols. At the

time of the study, the treatment protocol for "overdose/poisoning/ingestion" included intranasal, intramuscular or intravenous naloxone administration for suspected opioid overdose with altered mental status and hypoventilation/apnea.[26]

Selection Criteria

We included all 9–1–1 EMS calls that resulted in a unique incident number and a completed electronic patient care report (ePCR) with documentation of EMS-administered naloxone during the study period. The LAFD has been using the same ePCR and EHR system (HealthEMS, Stryker, Redmond, WA) since 2011. The EHR includes information from dispatch, the ePCR, and billing information. Responder impressions consist of 64 standardized options, which remained stable over the study period.[27] Housing status is a mandatory field on ePCRs. Prehospital EMS responders are trained to assess the question "Is the patient homeless?" (yes vs no) on every LAFD-attended 9–1–1 EMS incident by asking the patient or, if the patient is unable or unwilling to respond, by applying their best judgment.

Data Extraction

Data was extracted electronically from HealthEMS. We merged clinical data and EMS responder data using call number and booklet number, which are unique identifiers. Cases in which both the service date and call number were identical were dropped beyond the first instance. A sample of these cases were checked to ensure they were truly duplicates. We included cases in which "Narcan" or "Narcan nasal spray" were listed as medication that was administered during the incident. We stored all data was stored in a password-protected electronic spreadsheet (Microsoft Excel; Microsoft Corporation, Redmond, WA). The authors did not have access to the study population.

Variable Definition and Modeling

To assess housing status, EMS responders asked each patient whether they were currently experiencing homelessness. If the patient was unable to answer, the EMS responder was instructed to use their best judgment based on their training.

We chose to define respiratory depression *a priori* as bradypnea with a respiratory rate of less than 12 breaths per minute, based on the LA County EMS Agency protocol and prior work evaluating prehospital naloxone administration.[28,29] Although respiratory depression may also present as hypopnea, it is subjective and not reliably documented in the prehospital care report.

We extracted transport status from the disposition field on the ePCR. No transport was defined as an entry of "no transport/refused care," "treated/no transport," or "treated/no transport (AMA)." Transport was defined as an entry of "treated/transported."

We modeled these variables as binary: housing status (currently unhoused yes/no, per EMS responder), identified as female (yes/no per EMS responder), respiratory depression (<12 breaths per minutes: yes/no) and transported (yes/no). The EMS responder's impression and patient's age were modeled as categorical.

The primary outcome was the prevalence of EMS administration of naloxone by housing status. Secondary outcomes included incidence of naloxone by patient characteristics, EMS responder's impression, and transport status. We also examined whether disparate rates of naloxone administration remained robust after controlling for patient demographic and clinical characteristics in a regression model.

Analysis

Our analyses used standard procedures for calculating descriptive statistics for the population of incidents. As our descriptive analyses were drawn from a complete compilation of calls rather than a sample, we followed the standard practice of excluding *P*-values for evaluating inferences about whether the sample statistics (eg, sample means) provided a reasonable estimate of the corresponding population parameters.

To understand whether the observed effect was explainable by core clinical or demographic factors, we performed a logistic regression analysis. Our model included age categories, gender, and clinical indication of respiratory depression because these factors were shown to have an effect in prior literature.[20,29] The logistic regression formalized this, allowing us to test whether observed differences by PEH status were 1) reducible to clinical need or 2) reducible to other demographics. The logistic regressions do not provide a complete model of all possible explanations or establish causality, but rather help rule out alternative explanations of scientific and policy significance and to quantify important effects.

The descriptive statistics used the set of data for cases where naloxone was administered and for which we had data on housing status. Regression models provided information on the magnitude and direction of demographics and clinical effects on naloxone administration for the full population of EMS incidents. These models were used to describe associations in our data, not imply causality. Missing values were accounted for by list-wise deletion– a common strategy for large datasets without high levels of missing data. All data were assembled, cleaned and modeled in STATA 14 (Stata Corp, College Station, TX). We produced figures using the ggplot2 package in R (The R Project for Statistical Computing, Vienna, Austria).

The study was reviewed and approved as exempt by the Institutional Review Board of the University of Southern California (HS-19-00472).

RESULTS

Of the 345,190 unique, recorded 9–1–1 EMS incidents during the study period, 2,428 incidents met inclusion criteria (Figure 1). In the 2,428 incidents in which EMS administered naloxone, 608 (25%) incidents involved PEH, and 1,830 (75%) involved housed individuals. Incidents that resulted in naloxone administration occurred at a rate of 19 per 1,000 PEH compared to 0.4 per 1,000 housed individuals, or roughly 44 times the rate of housed individuals (Figure 2).

The study population had a mean age of 45 years (SD 19.4) and was 70.7% male. Of the patients who received EMS-administered naloxone, PEH were younger (mean 41.4 years [SD 14.1] vs 46.2 years [SD 20.7]) and more often male (81.9 vs 66.9%). The prevalence of patients who declined transport was higher for PEH than for housed individuals (17.3 vs 7.2%). The top three most common EMS responder impressions for which naloxone was administered were the same in both PEH and housed groups: overdose/poisoning/ingestion, altered level of consciousness and cardiac arrest (Table 1). Among those patients who received naloxone, a slightly greater proportion of the housed individuals were in cardiac arrest when compared to those experiencing homelessness (6.9 vs 4.3%). This does not change the primary finding or account for a substantial portion of the effect. Introducing the cardiac arrest variable in the model decreases the odds ratio [OR] from 2.38 to 2.35.

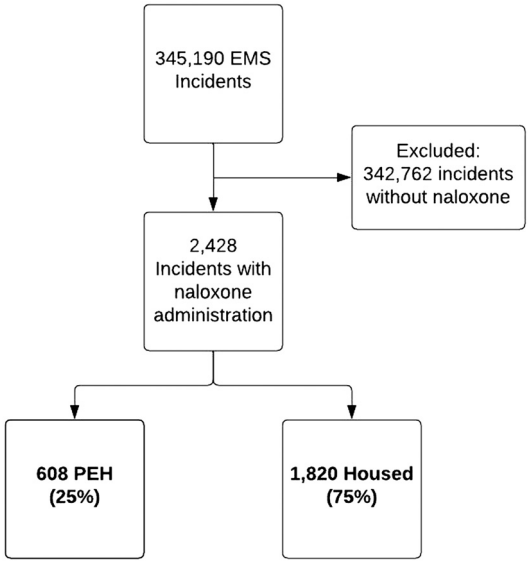


Figure 1. Study flow diagram.
EMS, emergency medical services; *PEH*, persons experiencing homelessness.

The logistic regression shown in Table 2 demonstrates that even after accounting for key covariates (ie, age, respiratory depression, and gender), the odds of PEH being administered naloxone was 2.38 that of housed peers (95% confidence interval [CI] 2.15–2.64). This is visualized in Figure 3, which shows the post-adjustment odds of naloxone administration by group.

This data shows that even after adjusting for gender, age, and respiratory depression, 1) respiratory depression had the largest effect on whether naloxone was administered (OR 49.32, 95% CI 45.17–53.873) and 2) PEH had 2.38 higher odds of receiving EMS-administered naloxone relative to housed peers. This suggests that while administration mapped on to clinical factors on average, EMS responders administered naloxone at higher rates to PEH than to their housed counterparts irrespective of condition.

DISCUSSION

In this study, PEH in the City of Los Angeles received EMS-administered naloxone at substantially higher rates than the housed population. While some of this may reflect need, PEH were still over two times more likely to receive the drug when all else was equal.

Secondarily, PEH who received naloxone tended to be younger and more often male when compared to their housed counterparts, although this did not explain the effect. This is consistent with prior studies documenting EMS utilization by PEH and the general differences in demographics between

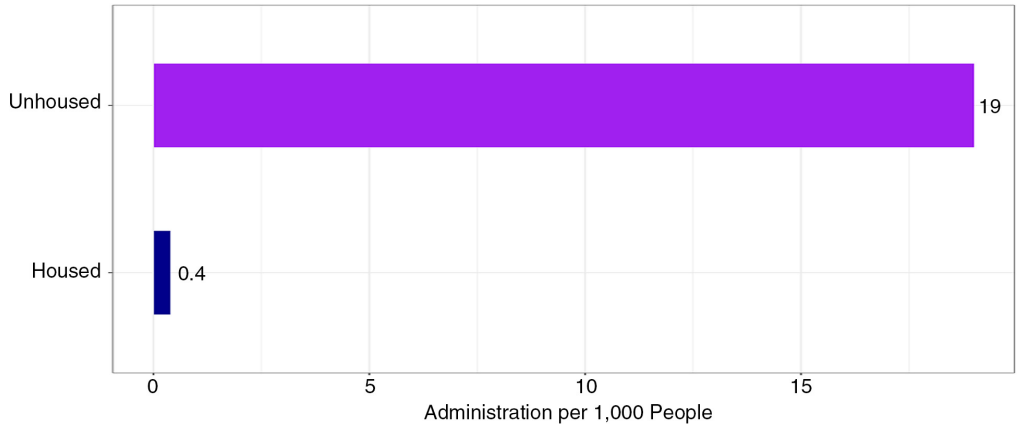


Figure 2. Naloxone administration rate by population.

Table 1. Patient characteristics by housing status.

	All (N = 2,428)		PEH (n = 608)		Housed (n = 1,820)	
Mean age (years)	45 (SD 19.4)		41.4 (SD 14.1)		46.2 (SD 20.7)	
Median age (years)	53 (IQR 37)		47 (IQR 23)		54 (IQR 40)	
	n	%	n	%	N	%
Gender						
Female	712	29.3	110	18.1	602	33.1
Male	1,716	70.7	498	81.9	1218	66.9
Respiratory depression (RR < 12)	1,136	46.8	302	49.7%	834	45.8
Not transported	236	9.7	105	17.3%	131	7.2%
EMS professional impression[1]						
Overdose/poisoning/ingestion	1,373	56.3	399	66.2%	974	53.6%
Altered level of consciousness	695	28.5	153	25.4%	542	29.8%
Cardiac arrest	154	6.3	27	4.5%	127	7.0%

[1]For EMS impression, eight charts were missing values (n = 2,420). There were no missing values for gender, respiratory depression, nor transport status.
PEH, persons experience homelessness; *IQR*, interquartile range; *RR*, respiratory rate.

Table 2. Odds ratios for selected associations with naloxone administration.

Variable	OR (95% CI)	Adjusted OR (95% CI)
Homeless	2.61* (2.38, 2.88)	2.38* (2.15, 2.64)
Female		0.65* (0.59, 0.71)
Respiratory depression		49.32* (15.16, 53.87)
Age		
0–24		–
25–49		1.11 (0.98, 1.27)
50–74		0.54* (0.47, 0/62)
>75		0.28* (0.23, 0.33)

*P < .01.
OR, odds ratio; *CI*, confidence interval.

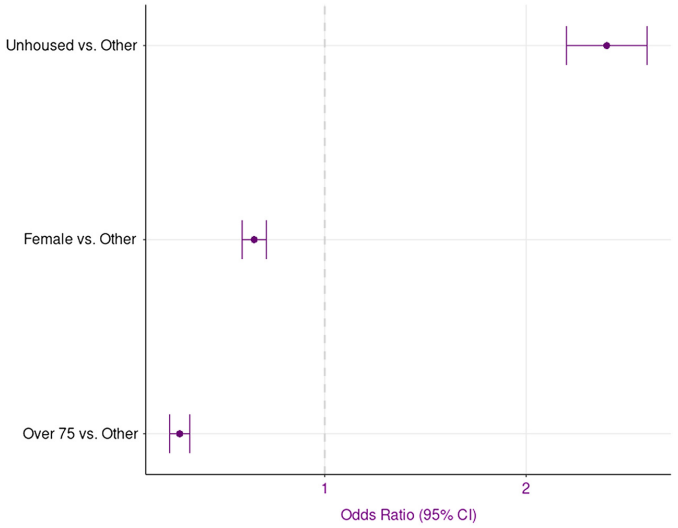


Figure 3. Adjusted odds of naloxone administration.
CI, confidence interval.

homeless and housed communites.[19,20,30,31] However, it is notable that the mean age of our study population was younger than the average EMS user in the City of Los Angeles (45 vs 52 years). This difference is maintained for both the PEH and housed groups, 46.2 vs 52.6 years and 41.4 vs 46.1 years, respectively, suggesting that those receiving naloxone may be younger than the general population.[20]

Persons experiencing homelessness were more than two times as likely to refuse transport than their housed counterpart who received EMS-administered naloxone. However, prior studies in Los Angeles have demonstrated that overall, PEH were less likely to refuse transport against medical advice.[20] Further, independent of housing status, refusal of transport was higher in patients receiving EMS-administered naloxone than overall refusal of treatment and/or transport against medical advice rate in Los Angeles during this study period.[20] This highlights that there may be differences in clinical presentation, EMS care, patient-EMS interaction, and social situations associated with the management of presumed opioid overdose and OUD.

Our findings describe disproportionately high rates of administration of naloxone to PEH compared with their housed counterparts. The logistic regression suggests that experiencing homelessness is a predictor of naloxone administration net of other factors. This data highlights the discrepancy that persists even after controlling for age, gender, and respiratory status. However, this model does not

distinguish whether this difference is due to a variation in clinical presentations or another factor that is leading EMS responders to administer naloxone when the patient's medical emergency is related to an etiology other than opioid overdose. Future studies are needed to understand the differences in care provided by EMS to PEH vs housed individuals and to evaluate patient outcome data. These findings can help drive future EMS education and field interventions, and potentially help develop specialized prehospital programs that focus on opioid overdose and risk reduction in this vulnerable population.

Although this study does not address patient outcomes, we must discuss the potential clinical impact of higher rates of naloxone administration on patient outcomes. Naloxone is a relatively safe drug. However, there are risks associated with administering high doses of naloxone given the dose-dependent relationship between naloxone and pulmonary edema. A recent prehospital study demonstrated higher rates of pulmonary complications, such as pulmonary edema and need for ventilatory support, in cases in which higher doses of out-of-hospital naloxone were administered.[32] Further, administering naloxone in cases where patients have OUD, but opioid overdose is not the etiology of their symptoms, may unnecessarily precipitate acute opioid withdrawal, vomiting, and aspiration. Finally, administering excessive or unnecessary naloxone detracts from EMS responders' ability to critically assess the situation and treat the primary medical emergency. Thus, PEH are at potentially higher risk for poor outcomes given the higher rates of EMS-administered naloxone. Further studies are needed that incorporate patient outcome as well as patient and EMS responders' experiences to elucidate potential biases in care.

Further, this study identifies a potential target for patient-centered interventions. Prior studies have suggested that by increasing access to naloxone, opioid overdose mortality can be decreased.[33–35] However, in California only 6% of local EMS agencies had EMS-based outreach programs and 9% oversaw naloxone distribution.[36] Given that EMS may be the first, or only, medical care that an individual receives, this interaction provides the potential for OUD-related care, medication-assisted therapy, naloxone administration, and/or linkage to care. The EMS agency is in a unique position of having situational awareness and regular contact with PEH, which can be leveraged to address the needs of this at-risk population. Through prehospital interventions and novel care pathways, there may be opportunities to improve patient outcomes in a more cost-effective and culturally acceptable manner.

Finally, this study is the first step in describing the disparities of EMS-administered naloxone by housing status. Persons experiencing homelessness were administered naloxone at a substantially higher rate than the population as a whole (19 vs 0.4 per 1,000 members of the population). Much of this reflects differences in need. However, our analyses show that unhoused individuals remained more than twice as likely as housed peers to be administered naloxone even after adjusting for clinical and demographic factors. Future research will be necessary to determine the cause and scope of these patterns.

LIMITATIONS

Because this was a retrospective observational study it has limitations inherent to study design and clinical documentation. The available data is subject to reporting errors and missing data points. Nor were we able to assess temporality of the respiratory rate in relation to the patient receiving naloxone, since the timing of vitals and interventions were documented by the EMS responders in retrospect and, therefore, were not precise enough. Additionally, it is possible that additional clinical characteristics other than bradypnea impact an EMS responder's decision to administer naloxone. Given the variability in documentation, assessment of neurologic status and airway compromise were not included in this analysis but may have impacted whether a patient received naloxone. Further, this study relies upon observation data and was not designed to establish causality. While the effect of homelessness was not eliminated in models adjusting for core clinical indications or demographics (age, gender), it is possible that the effect is reducible to latent variables or confounders that are absent from our data.

Further, homelessness is a complex and sometimes transient issue. The EMS responders were responsible for documenting the patients' housing status. Given the binary option in the ePCR and the training provided, it is possible that patients' housing status could potentially have been inaccurately coded in either direction. The decision to document housing status as homeless may be biased by appearance, environment, presence of paraphernalia, and even the use of naloxone itself.

Additionally, this study only accounts for naloxone administration by EMS and does not include naloxone administered by bystanders or other first responders, such as law enforcement or street medicine teams. Further, although this study captures all patients who were administered naloxone by EMS, it does not capture all patients who may have had opioid or substance use disorders. Given the existing body of literature that suggests a high incidence of SUD, including OUD, in the unhoused population, it is likely that an even larger number of EMS patients who are homeless may be experiencing an emergency related to OUD/SUD even when not explicitly labeled with an EMS responder's impression related to overdose or intoxication or administered naloxone. While this cannot be further extrapolated due to limitations in the ePCR data, this relationship has previously been described in the emergency medicine literature.[30] Thus, an even larger number of

patients could potentially benefit from outreach programs or other interventions.

Finally, the study was conducted in a single city. As a city with one of the largest populations of PEH, Los Angeles was used as a lens to evaluate the evolving situation at the intersection of the opioid epidemic, the housing crisis, and EMS. While Los Angeles may have unique characteristics, prior studies suggest that the demographics of its homeless population are similar to other major US cities.[31] Given national trends, Los Angeles may serve as a bellwether for other metropolitan areas in the US.

CONCLUSION

Persons experiencing homelessness in the City of Los Angeles received EMS-administered naloxone at higher rates than their housed counterparts, even when accounting for differences in age, gender, and respiratory depression. Future research is needed to validate these findings in other settings and to understand this difference in administration rates, characterize patient outcomes, and identify potential targets for alternative care pathways for patients confronting homelessness and opioid use disorder.

Address for Correspondence: Tiffany M. Abramson, MD, University of Southern California, Keck School of Medicine, 1200 N. State Street, Rm 1011, Los Angeles, California 90033. Email: tiffany.abramson@med.usc.edu

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.

REFERENCES

1. O'Donnell J, Tanz LJ, Gladden RM, et al. Trends in and characteristics of drug overdose deaths involving illicitly manufactured fentanyls — United States, 2019–2020. *Morb Mortal Wkly Rep*. 2021;70(50):1740–6.
2. Wilson N, Kariisa M, Seth P, et al. Drug and opioid-involved overdose deaths—United States, 2017–2018. *Morb Mortal Wkly Rep*. 2020;69(11):290–7.
3. Ahmad FB, Cisewski JA, Rossen LM, et al. Provisional drug overdose death counts. *Natl Cent Heal Stat*. 2022. Available at: https://www.cdc.gov/nchs/nvss/vsrr/drug-overdose-data.htm. Accessed December 7, 2022.
4. Glober N, Mohler G, Huynh P, et al. Impact of COVID-19 pandemic on drug overdoses in Indianapolis. *J Urban Health*. 2020;97(6):802–7.
5. Gladden RM, O'Donnell J, Mattson CL, et al. Changes in opioid-involved overdose deaths by opioid type and presence of benzodiazepines, cocaine, and methamphetamine — 25 States, July–December 2017 to January–June 2018. *Morb Mortal Wkly Rep*. 2019;68(34):737–44.
6. Centers for Disease Control and Prevention. Death rate maps & graphs. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control. 2022. Available at: https://www.cdc.gov/drugoverdose/deaths/index.html. Accessed December 7, 2022.
7. Doran KM, Rahai N, McCormack RP, et al. Substance use and homelessness among emergency department patients. *Drug Alcohol Depend*. 2018;188:328–33.
8. Marshall JR, Gassner SF, Anderson CL, et al. Socioeconomic and geographical disparities in prescription and illicit opioid-related overdose deaths in Orange County, California, from 2010–2014. *Subst Abus*. 2019;40(1):80–6.
9. Yamamoto A, Needleman J, Gelberg L, et al. Association between homelessness and opioid overdose and opioid-related hospital admissions/emergency department visits. *Soc Sci Med*. 2019;242:112585.
10. Centers for Disease Control and Prevention. State Unintentional Drug Overdose Reporting System (SUDORS). Atlanta, GA: US Department of Health and Human Services, CDC. Available at: https://www.cdc.gov/drugoverdose/fatal/dashboard. Accessed December 8, 2022.
11. Henry M, Shivji A, de Sousa T, et al. The 2015 Annual Homeless Assessment Report (AHAR) to Congress Part 1: Point-in-Time Estimates of Homelessness; 2015.
12. Henry M, de Sousa T, Roddey C, et al. The 2020 Annual Homeless Assessment Report (AHAR) to Congress; 2020.
13. Kushel MB, Perry S, Bangsberg D, et al. Emergency department use among the homeless and marginally housed: Results from a community-based study. *Am J Public Health*. 2002;92(5):778–84.
14. Han B, Wells BL. Inappropriate emergency department visits and use of the health care for the homeless. *J Public Heal Manag Pract*. 2003;9(6):530–7.
15. Brown RT, Kiely DK, Bharel M, et al. Geriatric syndromes in older homeless adults. *J Gen Intern Med*. 2012;27(1):16–22.
16. Gambatese M, Marder D, Begier E, et al. Programmatic impact of 5 years of mortaliy surveillance of New York City homeless populations. *Am J Public Health*. 2013;103(Suppl 2):S193–8.
17. Baggett TP, Hwang SW, O'Connell JJ, et al. Mortality among homeless adults in Boston: shifts in causes of death over a 15-year period. *JAMA Intern Med*. 2013;173(3):189–95.
18. Baggett TP, Chang Y, Singer DE, et al. Tobacco-, alcohol-, and drug-attributable deaths and their contribution to mortality disparities in a cohort of homeless adults in Boston. *Am J Public Health*. 2015;105(6):1189–97.
19. Gallagher TC, Andersen RM, Koegel P, et al. Determinants of regular source of care among homeless adults in Los Angeles. *Med Care*. 1997;35(8):814–30.

20. Abramson TM, Sanko S, Eckstein M. Emergency medical services utilization by homeless patients. *Prehosp Emerg Care*. 2020;25(3):1–8.
21. Glober NK, Govindarajana P. Population-based estimates of ambulance utilization and treatment patterns for opioid-related overdose in a national sample. *Prehosp Emerg Care*. 2018;21(10):97–152.
22. Von Elm E, Altman DG, Egger M, et al; STROBE Initiative. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ*. 2007;335(7624):806–8.
23. Benchimol EI, Smeeth L, Guttmann A, et al. The reporting of studies conducted using observational routinely collected health data (RECORD) Statement. *PLoS Med*. 2015;12(10):e1001885.
24. 2003–2018 Greater Los Angeles Homeless Count - City Of Los Angeles. Available at: https://www.lahsa.org/documents?id=2003-2018-greater-los-angeles-homeless-count-city-of-los-angeles. Accessed March 4, 2020.
25. American Community Survey. Available at: https://data.census.gov/table?q=DP05&g=160XX00US0644000&tid=ACSDP1Y2018.DP05. Accessed July 10, 2023.
26. Prehospital Care Manual. Reference 1317.29. Available at: https://dhs.lacounty.gov/emergency-medical-services-agency/home/resources-ems/prehospital-care-manual/. Accessed December 8, 2022.
27. Prehospital Care Manual. Reference 1200.3. Available at: https://dhs.lacounty.gov/emergency-medical-services-agency/home/resources-ems/prehospital-care-manual/. Accessed December 8, 2022.
28. Prehospital Care Manual. Reference 1380. Available at: https://dhs.lacounty.gov/emergency-medical-services-agency/home/resources-ems/prehospital-care-manual/. Accessed December 8, 2022.
29. Jenkins C, Levine M, Sanko S, et al. Use of naloxone in 9–1–1 patients without respiratory depression in Los Angeles County, California (USA). *Prehosp Disaster Med*. 2021;36(5):543–6.
30. Salhi BA, White MH, Pitts SR, et al. Homelessness and emergency medicine: a review of the literature. *Acad Emerg Med*. 2018;25(5):577–93.
31. Ropers RH, Boyer R. Perceived health status among the new urban homeless. *Soc Sci Med*. 1987;24(8):669–78.
32. Farkas A, Lynch MJ, Westover R, et al. Pulmonary complications of opioid overdose treated with naloxone. *Ann Emerg Med*. 2020;75(1):39–48.
33. Keane C, Egan JE, Hawk M. Effects of naloxone distribution to likely bystanders: results of an agent-based model. *Int J Drug Policy*. 2018;55:61–9.
34. Walley AY, Xuan Z, Hackman HH, et al. Opioid overdose rates and implementation of overdose education and nasal naloxone distribution in Massachusetts: interrupted time series analysis. *BMJ*. 2013;346(7894):1–13.
35. Abouk R, Pacula RL, Powell D. Association between state laws facilitating pharmacy distribution of naloxone and risk of fatal overdose. *JAMA Intern Med*. 2019;179(6):805–11.
36. Glober NK, Hern G, McBride O, et al. Variations in the California emergency medical services response to opioid use disorder. *West J Emerg Med*. 2020;21(3):671–6.

Application of a Low-cost, High-fidelity Proximal Phalangeal Dislocation Reduction Model for Clinician Training

Spencer Lord, MD[*†]
Sean Geary, MD[*]
Garrett Lord, AIA[‡]

[*]Albany Medical Center, Department of Surgery and Department of Emergency Medicine, Albany, New York
[†]Massachusetts General Hospital, Department of Surgery, Boston, Massachusetts
[‡]Dattner Associates, New York, New York

Section Editor: Juan Acosta, DO, MS
Submission history: Submitted November 20, 2022; Revision received April 19, 2023; Accepted April 16, 2023
Electronically published August 25, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59471

Introduction: Patients present to the emergency department (ED) relatively commonly with traumatic closed proximal interphalangeal joint (PIPJ) dislocations, an orthopedic emergency. There is a paucity of teaching models and training simulations for clinicians to learn either the closed dislocated dorsal or volar interphalangeal joint reduction technique. We implemented a teaching model to demonstrate the utility of a novel reduction model designed from three-dimensional (3D) printable components that are easy to connect and do not require further machining or resin models to complete.

Methods: Students watched a two-minute video and a model demonstration by the authors. Learners including emergency medicine (EM) residents and physician assistant fellows assessed model fidelity, convenience, perceived competency, and observed competency.

Results: Seventeen of 21 (81%) participants agreed the model mimicked dorsal and volar PIPJ dislocations. Nineteen of 21 (90%) agreed the model was easy to use, 21/21 (100%) agreed the dorsal PIPJ model and 20/21 (95%) agreed the volar PIPJ model improved their competency.

Conclusion: Our 3D-printed, dorsal and volar dislocation reduction model is easy to use and affordable, and it improved perceived competency among EM learners at an academic ED. [West J Emerg Med. 2023;24(5)839–846.]

INTRODUCTION

Traumatic dislocations of the proximal interphalangeal joint (PIPJ) are among the most common types of finger dislocation. Dorsal dislocation is due to a lateral loading force with hyperextension leading to disruption of the volar plate, joint capsule, and composite ligaments leading to a dorsal dislocation.[1–3] Volar dislocations, although much rarer, do occur and are often caused by compression and rotation with concomitant PIPJ flexion.[4] Despite the prevalence of this injury within the trauma population, there are few teaching models available with no published practice assessment of the model trainers for clinicians.[5,6]

We provide a simple to print, assemble, and replace dorsal and volar reduction model created from three-dimensional (3D) printed components without requiring machining (Figure 1).[7] Our model follows the principle of simple dorsal and volar dislocation that requires management using the exaggeration by deformity described by Roberts and Hedges et al in 1998.[8] We developed a workshop to assess the model by evaluating model fidelity, model convenience, and clinician competency during a training module.

METHODS

Model Design

We developed a unique, interchangeable PIPJ model to practice reducing non-fractured PIPJ dorsal and volar dislocations. Specific details regarding model function and joint articulation are fully described within Lord 2022 et al.[7] We developed a 3D-printed hand model using a palm base from the open-source Flexy-Hand prosthetic (e-NABLE

global online community).[9] We modified the second and third fingers to function as a dislocated PIPJ in closed complex dorsal dislocation (Figure 2.1–3) with reduction achieved by the exaggeration of deformity method, and the fourth and fifth fingers to function as a dislocated PIPJ in closed volar dislocation (Figure 2.4–6). The fingers are also detachable for reconfiguration and easy replacement (Figure 3).

Population Health Research Capsule

What do we already know about this issue?
Dorsal joint reductions are common orthopedic emergencies, yet there are few training models for clinicians.

What was the research question?
Does a novel low-cost, high-fidelity model dorsal joint reduction model improve competency?

What was the major finding of the study?
100% of participants agreed the dorsal proximal interphalangeal joint model (PIPJ) and 95% agreed the volar PIPJ model improved competency.

How does this improve population health?
An affordable education model enables medical trainees to learn the PIPJ dislocation reduction technique and, therefore, provide better patient care.

Supplies

For model design we used Rhinoceros V6 software (McNeel and Associates, Seattle, WA), Ultimaker Cura version 4.9.0 G-CODE software (Ultimaker, Utrecht, Netherlands), a Creality Ender 3 3D printer (Creality, Schenzhen, China), and 1.75mm PLA filament (Hatchbox, Pomona, CA). Specifically for the joint apparatus we used a single #6–32 × 1–1/2in machine screw, two #6 flat washers, and four 5/32 neoprene washers from a hardware store, which we cut to size with a razor blade (Figure 4). The apparatus was hand tightened for added stability. Table 1 provides a breakdown of costs.

Print Configuration

The entire print takes 33 hours and 25 minutes if each part is printed separately, with each finger taking 3 hours and 28 minutes (proximal, middle, distal, pin, and hinge). An entire hand requires the production of four proximal, four middle, and four distal finger components, along with eight pins and four hinge connectors along with a single palm and single thumb. The properties of all printed components are included in Table 2. The.stl print is available, open source, at https://grabcad.com/library/proximal-phalanx-traction-model-1. We provide a step-by-step assembly of the dorsal dislocation and volar dislocation. Supplemental file 4 includes how to use Cura Ultimaker software to upload your.stl file and assign your printer.

Model Assembly

The following figures show the stepwise assembly of both the dorsal dislocation and volar dislocation (Figure 3). A step-by-step video assembly of the dorsal PIPJ reduction is

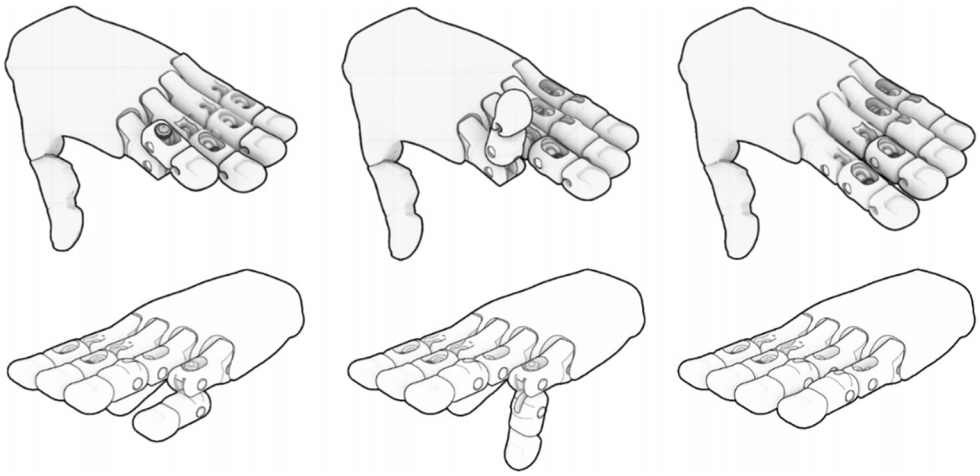


Figure 1. Proximal interphalangeal joint (PIPJ) complex dorsal dislocation with "exaggeration of deformity" method of the second finger (1A), hyperextension of the PIPJ (1B), and reduction back to the neutral position (1C). PIPJ volar dislocation of the fifth finger (1D), flexion reduction position of the PIPJ (1E), and reduction back to the neutral position (1F).

Figure 2. Proximal interphalangeal joint (PIPJ) complex dorsal dislocation with exaggeration of deformity method of the second finger (2.1), hyperextension of the PIPJ (2.2), and reduction back to the neutral position (2.3). PIPJ volar dislocation of the fourth finger (2.4), hyperflexion reduction position of the PIPJ (2.5), and reduction back to the neutral position (2.6).

available at (https://youtu.be/TkEyc3R2p9s) and volar PIPJ reduction (https://youtu.be/_MCwHHbP-Sk). An exploded assembly model is described in Lord et al 2022.[7]

Study Design

This was a prospective observational study performed at a single, Level I trauma center emergency medicine (EM) residency program during the months of November 2021 and March 2022. All study participants were current EM residents and physician assistants, who were given a live demonstration of how to perform a volar and dorsal reduction by the exaggeration method on the provided teaching model [https://www.youtube.com/watch?v=i1XPiA3GYmQ]. Participants were assessed for observed competency using a stepwise assessment, and they in turn assessed the model's fidelity and convenience, as well as their perceived competency. (See supplemental 1, supplemental 2, and supplemental 3.)[10,11] Participants were not assessed for previous competency. Institutional review board approval was granted for an anonymous survey of an educational experience with dissemination of survey results for publication.

Workshop

Following the demonstration, participants were assessed for observed competency. The total teaching section took place during a 90-minute scheduled period within residents' protected educational time. Participants were given two attempts to practice both the volar and dorsal dislocation model before assessment attempt. Procedural steps were scored based on whether the task was completed or there was hesitancy or omission/failure. We determined that hesitancy would be defined as a pause >3 seconds. Omission was defined as skipping a step, and we defined failure as inappropriately deforming or breaking the model. Following the workshop, participants were asked to complete a short survey using a six-point Likert scale (5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly disagree, non-applicable) pertaining to questions regarding model fidelity, convenience, and competency.[11] The workshop director was available for questions after the participants attempted the model and completed the questionnaire and was available to rebuild the model if participants could not do so themselves.

RESULTS

During the study period a total of 21 participants comprising 19 residents (six postgraduate year [PGY] 1,

Table 1. Itemized list of model components including cost.

Item	Brand	Size	Unit cost ($)	Total cost
Machine screw	Everbilt	#6–32 × 1–1/2 in	0.42	4.98
Flat washer	Everbilt	#6	0.36	4.36
Machine screw nut	Everbilt	#6–32	0.11	1.28
Neoprene washer	Everbilt	5/32in	0.24	0.98
Razor blade	Stanley	n/a	1.97	1.97
1.75mm filament 1kg	Hatchbox	n/a	22.99	22.99
Rhinoceros V6 software	McNeel and Associates	n/a	195.00	195.00
Ultimaker Cura software	Ultimaker	n/a	Free	Free
G-CODE software	Ultimaker	n/a	Free	Free
Creality Ender 3 3D printer	Creality	n/a	179.99	179.99
Total Costs				411.55

Table 2. Properties of all printed components.

Item	Print time	Filament weight (g)	Filament length (m)	Wall thickness (mm)	Top/bottom thickness (mm)	Infill%/type	Layer height (mm)
Palm	18 hours 42 min	(134g)	45m	0.8mm	1.0mm	50%/Cubic	0.2mm
Proximal	1 hour 23 min	8g	2.81m	0.8mm	1.0mm	50%/Cubic	0.2mm
Middle	1 hour 5 min	6g	2.01m	0.8mm	1.0mm	50%/Cubic	0.2mm
Distal	33 min	4g	1.36m	0.8mm	1.0mm	50%/Cubic	0.2mm
Pin	6 min	<1g	0.13m	0.8mm	1.0mm	50%/Cubic	0.2mm
Hinge	15 min	1g	0.27m	0.8mm	1.0mm	50%/Cubic	0.2mm
Thumb	1 hour 51 min	11g	3.74m	0.8mm	1.0mm	50%/Cubic	0.2mm

g, gram; *m*, meter; *mm*, millimeter.

seven PGY 2, and six PGY 3) and two physician assistant fellows completed both the dorsal and volar PIPJ reduction model. All participants consented to allow use of their data for research purposes. Data analysis was performed with Excel 2006 (Microsoft Corp, Redmond, WA). Figure 4 provides a graphical representation of model feasibility, convenience, and perceived competency.

Model Feasibility

All 21 participants were included in the feasibility portion. Nineteen of 21 (95%) agreed the joints were palpable on exam; 2/21 (5%) did not answer the question. Seventeen of 21 (81%) participants either agreed or strongly agreed that the model mimicked a dorsal proximal interphalangeal joint (dPIPJ) dislocation, and 17/21 (81%) agreed or strongly agreed it mimicked a volar proximal interphalangeal joint (vPIPJ) dislocation. Also, 13/21 (62%) and 12/21 (57%) agreed or strongly agreed that tension required for successful joint reduction of the dPIPJ and vPIPJ was realistic. Seventeen of 21 (81%) participants agreed the model mimicked a dorsal and volar PIPJ dislocation. Nineteen of 21 (90%) agreed the model was

Figure 3. 3.1. Shows all component parts of the dorsally dislocated finger (lateral view). **3.2**. Dorsal view. **3.3**. Place pin and align the central opening with openings in the middle and proximal finger portions. **3.4**. Modified neoprene washer cut ¼ in x ¼ in. **3.5**. Load two neoprene washers and a machine screw nut. **3.6.** Load the screw dorsally through the pin. **3.7**. pass screw through pin in proximal phalanges as shown and attach screw nuts in this position. **3.8**. Place in the reduced position to check resistance. **3.9**. Shows all component parts of the volar dislocated finger (lateral view). **3.10**. Dorsal view. **3.11**. Modified neoprene washer cut ¼ in x ¼. **3.12**. Load two neoprene washers and machine screw nut. **3.13**. Load the screw ventrally through the pin. **3.14**. Pass screw through pin in proximal phalanges as shown and **3.15**. attach screw nuts in this position. **3.16**. Place in the reduced position to check resistance.

Figure 4. A graphical representation providing interpretation of model convenience, feasibility, and perceived training competency. *vPIPJ*, volar proximal interphalangeal joint; *dPIPJ*, dorsal proximal interphalangeal joint.

easy to use, and 100% agreed the model improved their competency.

Convenience

All 21/21 participants were included in the convenience portion. Nineteen (90%) agreed or strongly agreed that the model was easy to use. Of the participants who had practiced on a finger reduction model before, 6/10 (60%) agreed or strongly agreed this model was easier to use, 4/21 (19%) thought the model was neutral or no different in use compared to other models, and 11/21 (52%) selected "non-applicable" as they had no model to compare. Six of the 21 participants (29%) did not have to replace components during their testing and, thus, they responded "non-applicable" to the question.

Perceived Competency

All 21/21 participants were included in the perceived competency portion. Twenty-one (100%) agreed the dPIPJ model improved their competency in dPIPJ reduction technique. Nineteen (95%) agreed the vPIPJ model improved their competency in vPIPJ reduction technique. Nineteen (95%) agreed the model is adequate for training EM staff.

Observed Competency

All 21 participants were included in the observed competency portion (Figure 5). In both the volar and dorsal reduction groups, all participants placed the hand in a prone position, palpated the deformity and stabilized the joint prior to reduction using the correct practice without hesitation. Fifteen of 21 (71%) performed correct hyperextension and hyperflexion without hesitation, and 6/21 (29%) performed hyperextension and hyperflexion but with hesitancy. In the dPIPJ dislocation, 17/21 (81%) performed traction/countertraction correctly and without hesitation, 2/21 (10%) performed traction/counter traction correctly but with hesitancy, and 2/21 (10%) performed traction/countertraction incorrectly resulting in detachment of the metacarpal-phalangeal joint from the hand model. In the vPIPJ dislocation, 19/21 (90%) performed traction/countertraction correctly without hesitancy. Two of 21 (10%) performed traction/countertraction correctly but with hesitation.

DISCUSSION

This is the first low-cost, high-fidelity PIPJ reduction model published in the medical literature describing a reproducible fidelity study. The model has removable and replaceable components without the requirement of resin mold production or machining. This model also provides appropriate competency training in a low-stress, teaching environment for learners. The model provides convenience regarding assembly, replacement, and use. The model mimics real-life dPIPJ and vPIPJ simple dislocations and shows both perceived and observed competency with practice. With few misapplications/omissions noted during the observed performance, our model avoids the

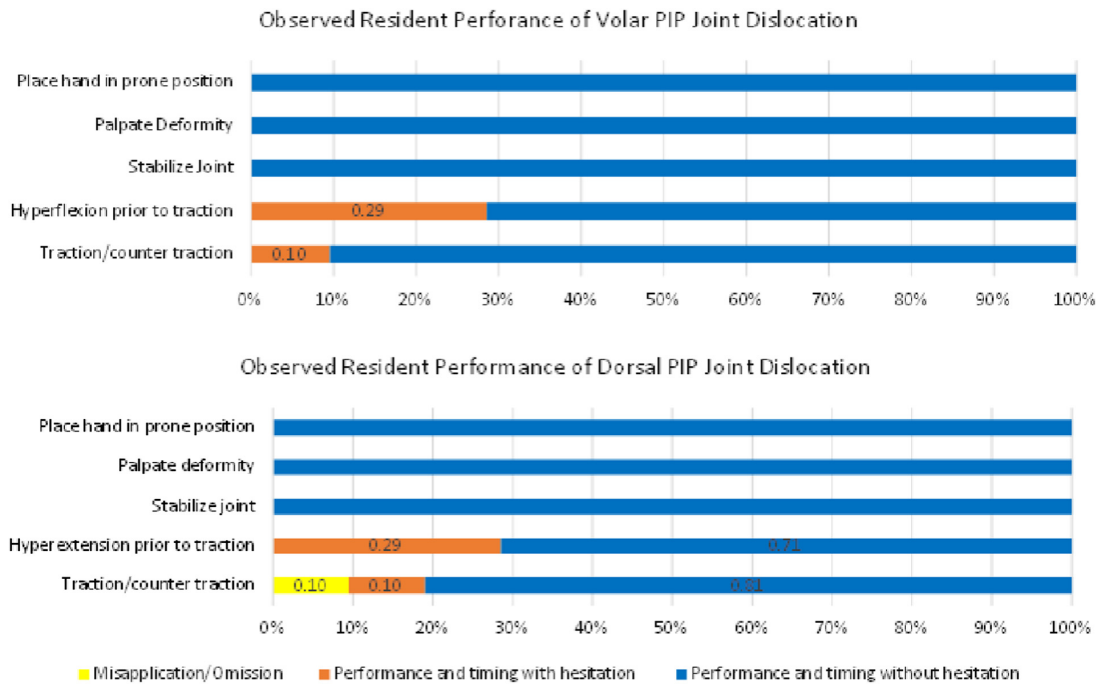


Figure 5. Observed competency of the volar proximal interphalangeal joint (PIPJ) reduction model and dorsal PIPJ reduction model.

"fidelity trap" (assuming participants "learn in proportion to the level of realism") that can occur with high-fidelity teaching models.[12,13]

Our design not only depicts a dislocation, but it also requires anatomically correct motions to successfully reduce the joint into the correct position. The unique articulation surfaces prevent "cheating," enable learners to experience the significant tension and pressure needed to successfully reduce the joint and allow for an easy reset to the dislocated position for the next participant. Our model provides improvement over currently available products due to tested repeatability, relative affordability, and a unique joint apparatus to prevent incorrect technique. It is the first model of its kind made from reusable, replaceable 3D-printed components from a personal 3D printer and easily available components from a hardware store.

Future studies will focus on addressing limitations, specifically creating a more realistic finger cover to better replicate the procedure or trialing different silicone thicknesses without adding significantly more construction requirements for the trainee. While the silicone covering we chose was an affordable option, it often caught itself in the joint making the reduction attempt impossible. Other anticipated model innovations include testing and refining appropriate force requirements during reduction, ideally using a quantitative force transducer. Further studies are needed to assess different clinician groups who perform this procedure including prehospital medical services, military personnel, more senior emergency clinicians, and non-emergency clinicians including orthopedic and plastic surgeons.

Three-dimensional anatomical learning has been shown to be a more effective studying tool compared to 2D technologies.[14] Further, 3D teaching models are noninferior to cadaveric teaching, are often cheaper, and potentially more accessible.[15–17] Simple and even complex joint reductions can be performed out of hospital, and studies have shown the relative ease and safety of prehospital joint reductions.[18–20] Procedural training using high-fidelity teaching models provides trainees with non-inferior procedural training in the absence of expensive mannequins. A recent meta-analysis found that operative time and complication rates improved when using 3D models for surgical planning, and a large multispecialty review highlighting the role of 3D printing in complex medical procedural planning and training showed improved competency.[21,22] There is a growing field in preoperative planning in orthopedic oncology, and orthopedic trauma surgery.[23–25]

LIMITATIONS

The model does have limitations. Namely, there are no models available for purchase nor are there published training models to compare.[5,6] Therefore, while participants deemed the model easy to use, we could not objectively compare feasibility, competency, and convenience to other models. The model also takes time to assemble due to the intentional metacarpophalangeal joint dislocation mechanism and assembly by non-machined parts. While most participants believed the model represented a realistic PIPJ dislocation, to maintain stability we reduced the degree of rotational displacement of the dislocated joint, therefore

reducing model fidelity. Furthermore, our dorsal dislocation model is more applicable when there is a bayonet deformity (ie, when the condyle of the proximal phalanx is no longer in contact with the base of the middle phalanx). In the absence of bayonetting, the degree of hyperextension that the model requires is not always needed in the clinical setting.

While the joint apparatus was functional it was difficult to use and articulate with the purchased silicone coverings; half the participants asked to remove the silicone finger cover prior to participating in the evaluation; thus, learners were unable to practice in the environment of a truly closed dislocation. While we attempted to assess observed competency, we did not compare outcomes between those who had reported performing a dorsal dislocation reduction (7/21) (33%) or volar dislocation reduction (2/21) (10%). Due to the relatively small sample size of this study, we did not ask about total number of attempted live reductions or success rate of attempted live procedures. Further, with the small sample size and with most participants being residents, this study lacks generalizability.

While printing of the model was replicable, a general knowledge of Cura Ultimaker software is needed to complete the print, which for the non-engineers among the authors, took two hours of online tutorial instruction to understand and be self-sufficient. This may not be an accurate length of time required to learn the software as we did not assess this in our study.

Of the participants who did not agree or strongly agree that the traction was realistic, 40% attributed this to believing the tension was too tight. We did not confirm whether this was the reason two participants did not agree the model was easy to use, nor whether the reason four participants did not agree or strongly agree the model mimicked vPIPJ and dPIPJ dislocations.

We did not use a quantitative force transducer as we could not find a simple way to incorporate it into the study model. It would be extremely beneficial to further refine the device to achieve more accurate representation for forces required for reduction. Also, it should be noted that 8/21 (38%) documented "non-applicable" for the convenience question—"The PIPJ model is easy to assemble"—even though each participant had to attach the fingers to the hand model prior to use.

CONCLUSION

Our unique proximal interphalangeal joint dislocation model provides a reproducible, easy-to-print product that can be used within the learning environment to train practitioners. The model is easy to assemble and provides a joint articulation to train learners for both dorsal and volar PIPJ dislocations.

Address for Correspondence: Spencer Lord, MD, Massachusetts General Hospital, Department of Surgery, 55 Fruit St. Boston Massachusetts, 02114. Email: slord1@mgb.org

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.

REFERENCES

1. Vicar A. Proximal interphalangeal joint dislocations without fractures. *Hand Clin*. 1988;4(1):5–13.
2. Golan E, Kang K, Culbertson M, et al. The epidemiology of finger dislocations presenting for emergency care with the United States. *Hand* 2016;11(2):192–6.
3. Prucz R, Friedrich J. Finger joint injuries. *Clin. Sports Med* 2015;34(1):99–16.
4. Jerome T. Volar dislocation of the proximal interphalangeal joint. *J. Orthoplastic Surg* 2021;5:6–8.
5. Luna (website). Available at: https://lunainc.com/blog/athletic-training-students-learn-technique-using-lunas-joint-reductiontrainer. Accessed June 22, 2021.
6. Polanksy R and Kwon N. Reduction of finger dislocation. *Medscape*. Available at: https://emedicine.medscap e.com/article/109206-overview (embedded in youtube: https://youtu.be/tJjerc616rM). Accessed June 22, 2021.
7. Lord G, Lord S, Geary S. Phalangeal Dislocation Reduction Model. US Patent No. 63/396,914. US Patent and Trademark Office.
8. Roberts J, Hedges J, eds. *Clinical Procedures in Emergency Medicine*. Philadelphia: Elsevier Science 1998:838.
9. Adlughmin. 2014. The FLexy-Hand – The Most Innovative, Useful, Realistic Looking 3D Printed Prosthetic Hand Yet. Available at: https://3dprint.com/1500/the-flexy-hand-3d-printed-prosthetic. Accessed June 22, 2021.
10. Senuren C, Yaylaci S, Kayayurt K, et al. Developing cricothyroidotomy skills using a biomaterial-covered model. *Wilderness Environ Med* 2020; 31(3):291–7.
11. Sullivan A, Khait L, Favot. A novel low-cost ultrasound-guided pericardiocentesis simulation model: demonstration of feasibility. *J Ultrasound Med*. 2018;37(2):493–500.
12. Carey J and Rossler K. The how when why of high-fidelity simulation. [Updated 2022 May 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing 2022 Jan-. Available at: https://www.ncbi-nlm-nih-gov.elibrary.amc.edu/books/NBK559313/. Accessed June 21, 2022.

13. Helyer R, Dickens P. Progress in the utilization of high-fidelity simulation in basic science education. *Adv Physiol Educ*. 2016;40(2):143–4.
14. Zilverschoon M, Custers E, Cate O, et al. Support for using a 3D anatomy application over anatomical atlases in a randomized comparison. *Anat Sci Educ*. 2022;15(1):178–86.
15. Lim K, Loo Z, Goldie S, et al. Use of 3D printed models in medication: a randomized control trial comparing 3D prints versus cadaveric materials for learning external cardiac anatomy. *Anat Sci Educ* 2016;9:213–21.
16. Ye Z, Jiang H, Nie C, et al. The role of 3D printed models in the teaching of human anatomy: a systematic review and meta-analysis. *BMC Med. Educ*. 2020;20(1):335.
17. Cai B, Kanagasuntheram R, Bay B, et al. The effects of a functional three-dimensional (3D) printed knee joint simulator in improving anatomical spatial knowledge. *Anat Sci Educ* 2019;12(6):610–8.
18. Wright C, Brandon B, Reisman E. Closed-reduction techniques for glenohumeral-, patellofemoral-, and interphalangeal-joint dislocations. *J. of Athl. Train*. 2020; 55(8):757–67.
19. Lord S, Brodell J, Lenhardt H, et al. Implementation of a prehospital patella dislocation reduction protocol. *Prehosp Emerg Care* 2020;24(6):800–3.
20. Fennelly J, Gourbault L, Neal-Smith , et al. A systematic review of pre-hospital shoulder reduction techniques for anterior shoulder dislocation and the effect on patient return to function. *Chin. J. of Traumatol*. 2020;23(5):295–301.21.
21. Yammine K, Karbala J, Maalouf A, Daher J, Assi C. Clinical outcomes of the use of 3D printing models in fracture management: a meta-analysis of randomized studies. *Eur J Trauma Emerg Surg*. 2022;48(5):3479–91.
22. Meyer-Szary J, Luis M, Mikulski S, et al. The role of 3D printing in planning complex medical procedures and training of medical professionals—cross-sectional multispecialty review. *IJERPH*. 2022;19(6):3331.
23. Punyaratabandhu T, Liacouras P, Pairojboriboon S. Using 3D models in orthopedic oncology: presenting personalized advantages in surgical planning and intraoperative outcomes. *3D Print Med* 2018;4(1):12.
24. Zhang M, Guo J, Li H, et al. Comparing the effectiveness of 3D printing technology in the treatment of clavicular fracture between surgeons with different experiences. *BMC Musculoskelet Disord*. 2022;23(1):1003.
25. Wang J, Wang X, Wang B, et al. Comparison of the feasibility of 3D printing technology in the treatment of pelvic fractures: a systemic review and metanalysis of randomized controlled trials and prospective comparative studies. *Eur J Trauma Emerg Surg* 2021;47(6):1699–12.

Gender and Inconsistent Evaluations: A Mixed-methods Analysis of Feedback for Emergency Medicine Residents

Alexandra Brewer, MA, PhD* [*]University of Southern California: Los Angeles, Department of Sociology, Los Angeles, California
Laura Nelson, MA, PhD[†] [†]University of British Columbia, Department of Sociology, Vancouver, British Columbia, Canada
Anna S. Mueller, MA, PhD[‡] [‡]Indiana University, Department of Sociology, Bloomington, Indiana
Rebecca Ewert, MA, PhD[§] [§]Northwestern University, Chicago, Illinois
Daniel M. O'Connor, MD[‖] [‖]Massachusetts General Brigham Wentworth-Douglass Hospital, Dermatology and Skin Health, Dover, New Hampshire
Arjun Dayal, MD[¶] [¶]Rush Copley Medical Group, Aurora, Illinois
Vineet M. Arora, MD, MAPP[#] [#]University of Chicago, Pritzker School of Medicine, Chicago, Illinois

Section Editors: Jeffrey Druck, MD, and Yanina Purim-Shem-Tov, MD, MS
Submission history: Submitted July 25, 2023; Revision received April 23, 2023; Accepted May 25, 2023
Electronically published August 22, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.58153

Objectives: Prior research has demonstrated that men and women emergency medicine (EM) residents receive similar numerical evaluations at the beginning of residency, but that women receive significantly lower scores than men in their final year. To better understand the emergence of this gender gap in evaluations we examined discrepancies between numerical scores and the sentiment of attached textual comments.

Methods: This multicenter, longitudinal, retrospective cohort study took place at four geographically diverse academic EM training programs across the United States from July 1, 2013–July 1, 2015 using a real-time, mobile-based, direct-observation evaluation tool. We used complementary quantitative and qualitative methods to analyze 11,845 combined numerical and textual evaluations made by 151 attending physicians (94 men and 57 women) during real-time, direct observations of 202 residents (135 men and 67 women).

Results: Numerical scores were more strongly positively correlated with positive sentiment of the textual comment for men ($r = 0.38$, $P < 0.001$) compared to women ($r = -0.26$, $P < 0.04$); more strongly negatively correlated with mixed ($r = -0.39$, $P < 0.001$) and negative ($r = -0.46$, $P < 0.001$) sentiment for men compared to women ($r = -0.13$, $P < 0.28$) for mixed sentiment ($r = -0.22$, $P < 0.08$) for negative; and women were around 11% more likely to receive positive comments alongside lower scores, and negative or mixed comments alongside higher scores. Additionally, on average, men received slightly more positive comments in postgraduate year (PGY)-3 than in PGY-1 and fewer mixed and negative comments, while women received fewer positive and negative comments in PGY-3 than PGY-1 and almost the same number of mixed comments.

Conclusion: Women EM residents received more inconsistent evaluations than men EM residents at two levels: 1) inconsistency between numerical scores and sentiment of textual comments; and 2) inconsistency in the expected career trajectory of improvement over time. These findings reveal gender inequality in how attendings evaluate residents and suggest that attendings should be trained to provide all residents with feedback that is clear, consistent, and helpful, regardless of resident gender. [West J Emerg Med. 2023;24(5)847–854.]

INTRODUCTION

Although women now graduate from medical school at the same rate as men,[1] they remain underrepresented in academic medicine.[2] The greatest attrition of women from academic medicine occurs directly after residency,[1] pointing to the importance of gender dynamics taking place within graduate medical education to the production of long-term inequality in men's and women's medical careers. Several recent studies have examined how gender bias in residency may have consequences for women's pursuit of academic careers and persistence in academic medicine.[3–6] Medicine is a male-typed field[3,7]: even as women are increasingly represented among physicians, there are still strong cultural associations between men and the role of doctor, which can lead to implicit bias against women physicians.[8] Associations between men and doctoring may be particularly strong in emergency medicine (EM), which is among the most male-dominated medical specialties.[9,10]

A recent study from our group found that a gender gap in Accreditation Council for Graduate Medical Education (ACGME) milestone attainment appears to emerge over the course of EM residency, with attendings scoring male residents higher than female residents.[5] This attainment gap was not dependent on the gender of the attending physician doing the evaluation, or the gender pairing between the attending and resident.[5] Research building on this study has used the textual comments attached to numerical scores to unpack how gender bias may have influenced attendings' numerical scores. Qualitative studies analyzing the textual comments attached to attendings' numerical scores of resident performance have found that EM faculty give women residents less consistent feedback,[6] feedback that is more focused on personality than clinical competence,[6] harsher criticism,[3] and less helpful and reassuring feedback[3] than to males.

While our prior work focused on either numerical or textual evaluations, with this study our goal was to examine concordance between numerical scores and textual comments to better understand gender gaps in resident evaluations in the emergency department. Does gender bias influence how attendings physicians assign residents numerical scores? Greater discordance between textual comments and numerical scores for women than men suggest gender bias may shape the way feedback is provided, which in turn may contribute to the established gender gap in evaluations and may harm resident education.

METHODS

We conducted a mixed methods analysis of textual and numerical ACGME milestone-based evaluations of EM residents by attending physicians.

Population Health Research Capsule

What do we already know about this issue?
A gender gap in ACGME milestone attainment emerges over the course of Emergency Medicine (EM) residency, such that women receive significantly lower scores than men in their final year.

What was the research question?
Does resident gender influence how attending physicians score residents on ACGME milestone-based evaluations?

What was the major finding of the study?
Male residents received more evaluations where the numerical score and sentiment of the textual comment matched than female residents.

How does this improve population health?
This study identifies biases and gender inequalities in EM workforce training. A representative and well-trained EM workforce likely improves patient care and outcomes.

Data Collection

We collected study data from four geographically diverse, three-year ACGME-accredited, EM training programs at university hospitals between July 1, 2013–July 1, 2015. Training programs were included in this study if they had adopted InstantEval V2.0 (Monte Carlo Software LLC, Annandale VA), a direct-observation mobile app for collecting ACGME milestone evaluations, and if they enabled faculty to leave both numerical and textual evaluations.

We analyzed a total of 11,845 evaluations by 151 attendings (94 men and 57 women) of 202 residents (135 men and 67 women) across all three years of residency. Each evaluation consisted of a numerical ACGME Emergency Medicine Milestone Project-based performance level (1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, or 5) on 1 of 23 possible individual EM subcompetencies,[11] along with an optional text comment (limited to 1,000 characters). The application presented faculty members with descriptors of individual milestones and the meaning of numerical performance levels as they performed the evaluation. Faculty were supposed to assess one milestone per evaluation. A score of 1 was to be assigned in cases where the resident performed at the skill level expected of an incoming resident; 2 when the resident

was improving but not yet performing at mid-residency level; 3 when the resident had mastered most of the skills expected of a graduating resident; 4 when the resident was performing at the skill level expected of a graduating resident; and 5 when the resident was performing beyond the level expected of a graduating resident.[11] Most programs encouraged 1–3 evaluations per shift, but faculty could choose when to complete evaluations, whom to evaluate, and how many evaluations to complete.

Data Analysis

Our analytic strategy combined complementary quantitative and qualitative methods.[12] Quantitative methods allowed us to identify broad patterns in comment type and scores across our data, while we used qualitative methods to confirm that the mechanisms suggested by the quantitative methods (ie, inconsistent evaluations) were explicitly apparent in the comments received by the actual residents in our data.

First, all textual comments from all four hospitals were qualitatively coded in NVivo 12 (QST International, Burlington, MA), a qualitative analysis software package. Four team members conducted focused coding of comments for positive (containing only praise), negative (containing only criticism), mixed (both positive and negative), or neutral (containing neither praise nor criticism) tone and content. See examples in Table 1. To ensure consistency, at least two of four team members coded every comment, and any discrepancies between codes were discussed by all four team members until a consensus was reached. Information about residents' and faculty members' gender was hidden during qualitative coding to prevent confirmation bias. This process was imperfect since some comments included gendered pronouns or names of residents. While we tried using sentiment analysis techniques to identify valence, we found that the standard techniques did not capture the true valence of the words in our data. For example, *patient* is considered a positive word (as in the adjective related to patience) in most sentiment dictionaries, but it is a neutral word in our data (noun *patients*). We thus found hand-coding the most reliable and accurate method to identify comment valence.

In our second, quantitative step, we calculated the total number of comments for each valence type and the overall average score across all comments for each resident in all four hospitals. To measure the relationship between comment valence and numerical score, we correlated the total number of positive, mixed, and negative comments with average score by resident gender, reporting the Pearson correlation coefficient and its associated *P*-value as an indication of the magnitude and significance of the correlation. To measure comment type over the course of residency training, we counted the number of positive, mixed, and negative comments by resident gender and by their year in the program and tabulated the average counts by resident gender in all four hospitals.

Third, we conducted a final round of detailed qualitative coding to assess whether patterns in the quantitative results were likely to be meaningful to residents. During this stage, we focused on a single hospital site chosen because it was the largest (in terms of number of attendings, residents, and evaluations) of the four sites in our dataset. All examples of comments in the text come from this single site. Three team members coded all 3,120 text comments from this site as either consistent or inconsistent with numerical score. Consistency was defined as a fit in sentiment between textual comments and numerical scores, eg, a positive comment was attached to a higher-than-average numerical score, and inconsistency as a misfit. Three analysts conducted a single round of coding on PGY-3 data from the other three hospitals to ensure this one hospital was not idiosyncratic and found it was not.

All names used in the text are pseudonyms to protect confidentiality. Since numerical scores have different meanings for residents at different stages of training, we present qualitative examples of PGY-1 residents in the results for the sake of simplicity. This study was approved as exempt research by the University of Chicago Institutional Review Board.

Table 1. Definitions of Positive, Negative, Mixed, and Neutral Codes.

Code	Definition	Example
Positive	Comment contains praise of resident and no criticism	Resident is truly above his level of training. He is complete and thoughtful in his treatment of patients and understands the overall goal. Performed very well with a difficult intubation.
Negative	Comment contains criticism of resident and no praise	I hope that this is the first rotation in the ED, otherwise he is cleary runing behind his peers. Needs a lot of prompting, lacks of initiative and insight, looks scared, poor follow up on his own patients. Performance below average.
Mixed	Comment contains both praise and criticism	Good data gathering, but needs to work on diffential diagnosis. Also, instaead of asking questions needs to take some responsability to figure things out, look things up.
Neutral	Comment contains neither praise and criticism	Worked to place ultrasound guided lines this month.

Table 2. Descriptive statistics by postgraduate year and resident gender in four hospitals.

	PGY1				PGY2				PGY3			
	Women		Men		Women		Men		Women		Men	
	34		71		43		79		33		70	
Number of residents evaluated	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Number of Comments per Resident	37	22	36	17	35	21	39	21	32	22	34	19
Positive Comments per Resident	29	18	25	14	27	16	31	18	23	18	27	17
Mixed Commments per Resident	5	5	7	5	5	5	5	5	4	5	3	4
Negative Comments per Resident	3	5	3	4	3	4	2	3	1	3	1	2
Score by Resident	2.3	0.2	2.3	0.2	2.7	0.2	2.7	0.2	2.9	0.3	3.0	0.3

Note: Our unit is resident/year. These numbers include duplicate counts of residents who were evaluated over multiple years. There were 64 residents who were evaluated in both their first and second years of the program, and 64 who were evaluated in both their second and third years, for a total of 330 resident/year units and 202 unique residents.
PGY, postgraduate year.

RESULTS

We found that attendings' assessments of female residents were less consistent than those of male residents. Inconsistency occurred at two levels: 1) inconsistency between numerical scores and textual comments; and 2) inconsistency in the expected career trajectory.

1. Inconsistency between numerical score and textual comment

We found that for both men and women residents, there was a positive correlation between average evaluation score and the number of positive comments the resident received, and a negative correlation between the average score and number of mixed and negative comments. However, this relationship was stronger for comments of all valences for men, with a Pearson correlation coefficient of 0.26 (and a *P*-value < 0.04) for positive comments and score for women compared to 0.38 for men (<0.001), −0.22 (<0.08) for negative comments and score for women and −0.46 (<0.001) for men, and −0.13 (<0.28) for mixed comments and score for women compared to −0.39 (<0.001) for men. For women, the correlation between mixed and negative comments and score was not statistically significant (see Figure 1).

In-depth qualitative analysis from one hospital revealed that textual comments that matched numerical scores provided clarity as to what residents were doing well and where they needed to improve. Consider the following positive comment written by attending Steven for resident

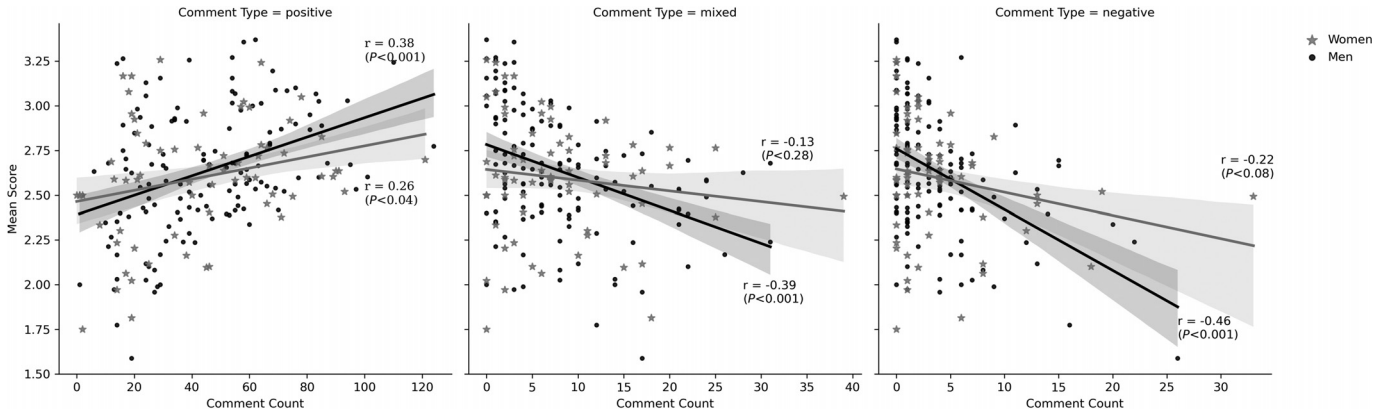


Figure 1. Scatter plot with regression line, correlation coefficient (and *P*-value) for number of comments and mean score, by resident gender and comment type at four hospitals.
Note: r is Pearson correlation coefficient (and *P*-value), by resident gender and comment type. The shaded ribbons represent the 95% confidence interval.

Eugene: "Really continues to come along nicely. Good follow up and follow through for results, status, and disposition." This comment was associated with a numerical score of 3.5 out of 5, indicating that Steven thought that intern Eugene was performing at mid-residency level.

Conversely, men received lower average scores when they received more negative comments compared to women across all four hospitals in our sample (Figure 1), again indicative of greater consistency in their feedback from attendings. In our qualitative analysis of a single site, the following comments made by attendings Michael and Greg for residents Zander and Spencer, both of which were accompanied by a numerical score of 1 of 5 (the lowest possible numerical score, indicating that residents were not yet performing at the level expected of an incoming intern), were typical of consistent negative feedback.

- "As we discussed during and after shift, reviewing the electronic medical record can provide significant useful information to guide your management. Take a few moments to look for discharge summaries or recent ED visits." (Michael for Zander)
- "Continue to work on building a list of differentials for each patient. This will help you not only figure out what studies you want to order but also what questions you need to ask to help narrow it down." (Greg for Spencer)

On the other hand, attendings were more inconsistent in how they assessed women's performances, assigning them a higher number of numerical scores that mismatched their textual comments. Our qualitative analysis showed that when it came to positive comments with low scores, attendings often simultaneously communicated that women were succeeding and failing at the same skill. For instance, attending Harrison wrote about intern Josie, "Managed a patient well with cuts and abrasions, sutures small lac, seemed to have reasonable skills for her level." While this comment contains modest praise for Josie's ability to manage wounds, Harrison assigned Josie a score of 1 of 5 for this comment, a rating meant to indicate a lower-than-intern skill level.

This pattern was similar for positive scores assigned to negative comments. In one typical example, attending Megan gave resident Kendall a score of 3 of 5, indicating that she was performing at mid-residency level in intern year, but criticized her ability to formulate a plan for patient care, stating, "Seems to hesitate with forming final plan/dispo for patient, presents patient knowing the problem but doesn't always have a clear plan of care in mind." Similarly, attending Allison told resident Jade, "Needs to start taking [the] next step forward. 'I'm just an intern' will not play for much longer." Despite this criticism, Allison assigned her a 3.5 of 5, indicating that her abilities were well above intern level.

Our data suggests that ≈11% more women than men (26 of 67 women, and 42 of 135 men) received overall "inconsistent" feedback between textual comments and score, measured by residents receiving a higher-than-average number of comments by comment valence and either a lower-than-average score (for positive comments) or a higher-than-average score (for mixed and negative comments).

2. Inconsistency in expected career trajectory

The ACGME EM guidelines outline a clear trajectory whereby residents are expected to gradually improve over the course of residency through the attainment of skills in 23 subcompetencies. Their recommendations for assigning numerical scores to resident progress reflect this idea of linear progress over time.

Our analysis shows that men and women residents' numerical scores are consistent with this expected pattern. Attendings gave both male and female residents higher numerical scores for their performance in PGY-3 (men received an average score of 3.0 and women 2.9) than in PGY-1 (both men and women received an average score of 2.3). Figure 2 visualizes the different patterns in textual sentiment for men and women residents from PGY-1 to PGY-3. Male residents received more negative and mixed comments in PGY-1 (an average of three negative comments and seven mixed comments) than in PGY-3 (one negative and three mixed), when they received a larger portion of positive comments. (Men received an average of 25 positive

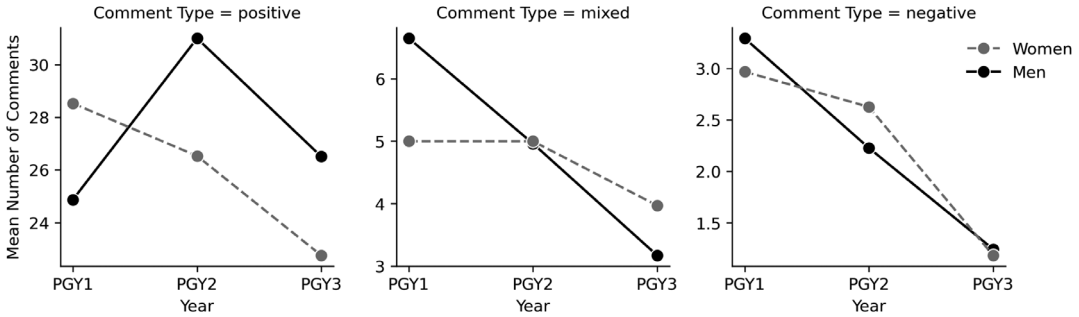


Figure 2. Mean number of comments by resident gender, postgraduate year, and comment type at four hospitals. *PGY*, postgraduate year.

comments in PGY-1 and 27 in PGY-3.) Although male residents appear to be assessed more harshly than their female peers in PGY-1 in that they receive more negative and mixed comments, their trajectory over time is consistent with expectations of improvement as one advances through residency. Female residents, on the other hand, received more positive comments in PGY-1 and fewer in PGY-3 (an average of 29 positive comments in PGY-1 and 23 in PGY-3) while they received almost the same number of mixed comments on average in PGY-1 and PGY-3 (five compared to four). Both men and women received fewer negative comments in PGY-3 (one compared to three in PGY-1), although the number of negative comments overall is low.

DISCUSSION

Our goal for this study was to examine the relationship between numerical and textual performance evaluations for EM residents to shed light on the findings of a prior quantitative study[5] that demonstrated a gender gap in milestone attainment during EM residency. To do this, we used complementary quantitative and qualitative methods to analyze 11,845 numerical and textual evaluations made by 151 attending physicians during real-time direct observations of 202 residents. We identified two forms of inconsistency between numerical scores and textual performance evaluations that may have relevance to women's lagging numerical scores on ACGME milestones and to gender inequality in residency.

First, the data revealed that women's numerical scores were less consistent with the sentiment of their textual comments than those of men. Women residents in our sample were more likely to receive positive comments alongside lower scores, and negative or mixed comments alongside higher scores. Second, the data showed that textual comments for women, but not men, were inconsistent with the expected EM career trajectory of improvement over time. On average, men received slightly more positive comments in PGY-3 than in PGY-1 and fewer mixed and negative comments, while women received fewer positive and negative comments in PGY-3 than PGY-1 and almost the same number of mixed comments.

Inconsistent performance evaluations are worthy of attention for several reasons. First, inconsistent evaluations may harm women residents' development as physicians. Critical feedback, when constructive, can be a source of valuable advice for improving one's performance.[13,14] Our qualitative findings demonstrate that consistency between numerical score and textual comment can offer useful information to residents by providing a clear explanation of why they earned a particular score and, on occasion, actionable feedback about how to improve in the future. Inconsistent feedback could be a barrier to learning from errors and to developing skills as a physician, especially in the earlier stages of residency, and could ultimately contribute to the gender gap in ACGME milestone attainment that emerges over the course of residency.[5]

Additionally, inconsistent evaluations may harm women's confidence in their ability as physicians and/or their commitment to academic medicine. Several studies suggest that women in medicine suffer from imposter syndrome, the psychological phenomenon whereby people doubt their abilities even in the face of evidence of their own success.[15,16] Inconsistent feedback could be a factor that contributes to gender disparities in feelings of imposter syndrome during residency: If women encounter more praise that is combined with criticism, this could foster doubt in their abilities as physicians. Further, prior research from the social sciences shows that confidence in one's skills is critical for the persistence of women in male-typed professions like EM.[17,18]

Inconsistent feedback could be something that contributes to women's attrition from academic EM, which occurs at a higher rate than that of men.[19] The fact that women in our sample received fewer positive textual comments as they progressed from PGY-1 to PGY-3 may also be something that harms their confidence and that could have a broader impact on their careers. Computational simulations have suggested that even very small biases in everyday interactions, such as those we find here, can compound in complex systems to produce much larger patterns of inequality in organizations.[20] Further study is warranted to examine the connection between inconsistent evaluations and attrition from medical careers, whether through imposter syndrome or another mechanism.

This study provides further support for the idea that gender bias contributes to the gender gap in evaluations by showing that attending physicians evaluate residents differently based on gender, with a bias in favor of men, even in the context of objective criteria such as the ACGME milestones. Based on these findings, we caution against the use of competency-based graduation from residency, even when programs rely on clearly articulated standards such as the ACGME milestones. Movement to competency-based graduation would likely disadvantage women residents and deepen inequalities in the medical profession.

LIMITATIONS

There are limitations to our study. First, we did not have information about the broader context in which evaluations were written, including conversations that may have taken place between attendings and residents that could have provided additional information explaining numerical scores and/or textual feedback. Second, we did not have data about the race or ethnicity of the physicians in our sample, which may be a pertinent covariate given evidence of bias against people of color in the medical profession.[21] Third, since our data was collected in 2013-15, it is possible that gender

dynamics in residency programs may have changed in the intervening years, especially as residency programs have invested in reducing biases in training. Fourth, while we took several steps to guard against gender bias in our coding procedures – including using multiple coders, requiring coding consensus, and suppressing attending and resident gender – we did not suppress all gendered language in the textual comments. This may have biased our analysis. Fifth, since we only analyze data from four university hospitals, our findings may not be nationally representative of EM training programs in the US.

Our study also has several strengths. First, faculty did not know that their evaluations would be analyzed for gender bias, diminishing a Hawthorne effect or social desirability bias, and giving us a window into real conditions of gender inequality in medical education. Second, drawing on data from four university hospitals across the US allowed us to be more confident that the inequalities we found were not specific to one hospital environment, but rather may be generalizable across different organizational environments.

Future research is needed to examine the full scope of inconsistent feedback in graduate medical education, including commentary given to residents in person, as well as the consequences of inconsistent feedback for physicians' careers, including attrition from medicine and feelings of burnout and imposter syndrome.

CONCLUSION

By pairing quantitative and qualitative methods, this study contributes to research on gender inequality in graduate medical education by showing multiple levels at which women receive inconsistent feedback in residency. Initiatives to reduce gender inequality in medicine should train faculty to offer all residents clear, consistent, and helpful assessments of their performance, regardless of resident gender.

Address for Correspondence: Alexandra Brewer, MA, PhD, University of Southern California, Department of Sociology, 851 Downey Way, Los Angeles, California 90089.
Email: breweral@usc.edu

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. This project was supported by the National Center for Advancing Translational Sciences of the National Institutes of Health through Grant Number UL1 TR000430. Additional funding was provided by a University of Chicago Diversity Small Grant (awarded to Vineet Arora) and a University of Chicago Gianinno Faculty Research Award (awarded to Anna S. Mueller).

REFERENCES

1. Lautenberger DM, Dandar VM, Raezer CL, et al. The state of women in academic medicine: the pipeline and pathways to leadership, 2013–2014. Available at: https://members.aamc.org/eweb/upload/The%20State%20of%20Women%20in%20Academic%20Medicine%202013-2014%20FINAL.pdf. Accessed December 7, 2020.
2. Freund KM, Raj A, Kaplan SE, et al. Inequities in academic compensation by gender: a follow-up to the national faculty survey cohort study. *Acad Med*. 2016;91(8):1068–73.
3. Brewer AE, Osborne M, Mueller AS, et al. Who gets the benefit of the doubt? Performance evaluations, medical errors, and the production of gender inequality in emergency medical education. *Am Soc Rev*. 2020;85(2):247–70.
4. Edmunds LD, Ovseiko PV, Shepperd S, et al. Why do women choose or reject careers in academic medicine? A narrative review of empirical evidence. *Lancet*. 2016;388(10062):2948–58.
5. Dayal A, O'Connor DM, Qadri U, et al. Comparison of male vs female resident milestone evaluations by faculty during emergency medicine residency training. *JAMA Intern Med*. 2017;177(5):651–7.
6. Mueller AS, Jenkins TM, Osborne M, et al. Gender differences in attending physicians' feedback to residents: a qualitative analysis. *J Grad Med Educ*. 2017;9(5):577–85.
7. Reskin B. Sex segregation in the workplace. *Ann Rev Soc.* 1993;19:241–70.
8. Cooke M. Implicit bias in academic medicine: #WhatADoctorLooksLike. *JAMA Intern Med*. 2017;177(5):657–8.
9. Bennett CL, Raja AS, Kapoorm N, et al. Gender differences in faculty among academic emergency physicians in the United States. 2019. *Acad Emerg Med.* 26(3):281–5.
10. DeFazio CR, Cloud SD, Verni CM, et al. Women in emergency medicine residency programs: an analysis of data from Accreditation Council for Graduate Medical Education-approved residency programs. *AEM Educ Train*. 2017;1(3):175–8.
11. Accreditation Council for Graduate Medical Education and American Board of Emergency Medicine (ACGME and ABEM). 2015. The emergency medicine milestone project." Available at: https://www.acgme.org/Portals/0/PDFs/Milestones/EmergencyMedicineMilestonespdf. Accessed January 25, 2018.
12. Small MS, Pamphile VD, McMahan P. How stable is the core discussion network? *Soc Networks* 2015;40:90–102.
13. Correll S, Simard C. Research: vague feedback is holding women back. *Harv Bus Rev.* April 29, 2016. Available at: https://hbr.org/2016/04/research-vague-feedback-is-holding-women-back. Accessed December 7, 2020.
14. King EB, Botsford W, Hebl MR, et al. Benevolent sexism at work gender differences in the distribution of challenging developmental experiences. *J Manag*. 2012;38:1835–66.

15. Mullangi S, Jagsi R. Imposter syndrome: treat the cause, not the symptom. *JAMA*. 2019;322(5):403–4.
16. Butkus R, Serchen J, Moyer DV, et al. Achieving gender equity in physician compensation and career advancement: a position paper of the American College of Physicians. *Ann Intern Med* 2018;168(10):721–36.
16. Hansen M, Schoonover A., Skarica B, et al. Implicit gender bias among US resident physicians. *BMC Med Educ* 2019;19(1):396.
17. Cech E, Rubineau B, Silbey S, Seron C. Professional role confidence and gendered persistence in engineering. *Am Soc Rev*. 2011;76(5):641–66.
18. Correll S. Gender and the career choice process: the role of biased self-assessment. *Am J Soc.* 2001;106(6):1691–730.
19. Lu DW, Hartman ND, Druck J, et al. Why residents quit: national rates of and reasons for attrition among emergency medicine physicians in training. *West J Emerg Med*. 2022;20(2):351–6.
20. Du Y, Nordell J, Joseph K. Insidious nonetheless: how small effects and hierarchical norms create and maintain gender disparities in organizations. *Socius*. 2022;8.
21. Feagin JR, Bennefield Z. Systemic racism and U.S. healthcare. *Soc Sci Med* 2014;103(1):7–14.

COVID-lateral Damage: Impact of the Post-COVID-19 Era on Procedural Training in Emergency Medicine Residency

Daniel Frank, MD*
Thomas Perera, MD†
Moshe Weizberg, MD‡§

*Zucker Hofstra School of Medicine, Northwell Health, South Shore University Hospital, Bay Shore, New York
†Zucker Hofstra School of Medicine, Northwell Health, North Shore/LIJ, Manhasset, New York
‡Zucker Hofstra School of Medicine, Northwell Health, Staten Island University Hospital, Staten Island, New York
§Maimonides Medical Center/Maimonides Midwood Community Hospital, Brooklyn, New York

Section Editors: Jeffrey Druck, MD, and Wendy Macias-Konstantopoulos, MD, MPH, MBA
Submission history: Submitted December 29, 2022; Revision received May 19, 2023; Accepted July 3, 2023
Electronically published September 1, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59771

Introduction: Hospitalizations during the coronavirus 2019 (COVID-19) pandemic peaked in New York in March–April 2020. In the months following, emergency department (ED) volumes declined. Our objective in this study was to examine the effect of this decline on the procedural experience of emergency medicine (EM) residents compared to the pre-pandemic period.

Methods: We conducted this multicenter, retrospective cohort study of patients seen and key procedures performed by EM residents at hospitals spanning three Accreditation Committee for Graduate Medical Education-approved EM residencies in New York City and Nassau County, NY. We obtained numbers of procedures performed during May–July 2020 and compared them to the same time period for 2019 and 2018. We a priori classified critical care procedures—cardioversion, central lines, chest tubes, procedural sedation, and endotracheal intubation. We also studied "fast-track" procedures—fracture/joint reduction, incision and drainage (I&D), laceration repairs, and splints.

Results: Total number of critical care procedures in the months following the COVID-19 peak decreased from 694 to 606 (−12.7%, 95% confidence interval [CI] 10.3–15.4%), compared to an increase from 642 to 694 (+8.1%, 95% CI 6.1–10.5%) the previous year (difference −9.3%). Total number of fast-track procedures decreased from 5,253 to 3,369 (−35.9%, 95% CI 34.6–37.2%), compared to a decrease from 5,333 to 5,253 (−1.5%, 95% CI 1.2–1.9%) the year before (difference −36.3%). Specific critical care procedures performed in 2020 compared to the mean of 2019 and 2018 as follows: cardioversion −33.3%; central lines +19.0%; chest tubes −27.9%; procedural sedation −30.8%; endotracheal intubation −13.8%. Specific fast-track procedures: reductions +33.3%; I&D −48.6%; laceration repair −17.3%; and splint application −49.8%.

Conclusion: Emergency medicine residents' critical and fast-track procedural experience at five hospitals was reduced during the months following the COVID-19 peak in comparison to a similar period in the two years prior. Training programs may consider increasing simulation-lab and cadaver-lab experiences, as well as ED and critical care rotations for their residents to offset this trend. [West J Emerg Med. 2023;24(5)855–860.]

INTRODUCTION

Graduate medical education (GME) of residents and fellows has been dramatically affected worldwide because of the coronavirus 2019 (COVID-19) pandemic. Similar influences on GME have been described during previous epidemics, natural disasters, and even in zones of war and conflict, although perhaps on a different scale.[1–6] During the severe acute respiratory syndrome (SARS) epidemic of 2003, many educational activities were sacrificed, and outside clinical rotations were delayed due to fear of inter-site contamination when residents changed services.[1,5] The ongoing conflict in Iraq has led to a significant impairment in quality of education, and the majority of trainees felt their safety to be at risk.[3] The majority of trainees also reported their intent to leave Iraq after graduation, further crippling the critical healthcare safety net so many citizens rely on.[3]

When Hurricane Katrina struck Louisiana and Mississippi in 2005, hundreds of residents and fellows had their education disrupted. The Accreditation Council for Graduate Medical Education (ACGME) responded by quickly assisting in placing these trainees, either temporarily or permanently, in other programs that could meet their educational needs. The resulting policies provided the framework for institutions to respond to the needs of their GME programs during Hurricanes Ike in 2008 and Harvey in 2017.[4,6]

Early literature on effects on GME of the COVID-19 pandemic focused on procedure-based specialties, such as surgery, urology, interventional radiology, interventional cardiology, ophthalmology, and urology.[7–11] Cancellation of elective procedures and redeployment of residents and fellows created a dramatic reduction in cases needed for adequate training. Surgical programs especially reported decreased clinical experience, reduced case volume, and disrupted education activities as major concerns.[12] Additionally, the ACGME allowed institutions to apply for "emergency status." This eased some of the mandatory training requirements that were normally in place. To mitigate this problem, the American Board of Surgery announced they would accept a 10% reduction in operative cases from graduating residents, while other specialties suggested training might have to be extended to ensure adequate training, especially in a prolonged epidemic scenario.[10,13,14]

Emergency medicine (EM) trainees were similarly affected by the overall decrease in patient volumes that many emergency departments (ED) experienced throughout the pandemic. Decreased case variety, fewer procedures, and fewer patients with serious diagnoses all negatively impacted resident training during the early pandemic period.[15,16]

Throughout the world, GME programs quickly responded with innovation and utilization of online resources during the pandemic to minimize disruptions in resident education. Most didactics, journal clubs, and case reviews moved online, and large conferences became virtual. Many outpatient encounters were taking place via telemedicine platforms. Some surgical programs even started working with simulators built in house, while others developed virtual reality technology in an effort to maintain technical skills.[8,9,11,14,17,18]

Emergency medicine training programs similarly confronted challenges in resident education since the onset of the pandemic. All resident training depends in large part on patient encounters to gain experience and develop clinical acumen and technical skill. Traditionally, postgraduate year (PGY)-1 EM residents would average 0.7 patient encounters per hour, while PGY-3 residents could see 1.3 patients per hour.[19] The pandemic, however, caused a dramatic reduction in ED patient volumes, especially among pediatric patients.[20] During the early pandemic period, ED visits in the United States were 42% lower than the same period a year earlier, with the largest proportional decline in patients 14 years or younger.[21] As a result of the pandemic, EM residents' critical procedural experiences also decreased.[22] Moreover there was a significant decline in all non-COVID-19 related patient presentations, with significantly less resident exposure to cardiac, psychiatric, surgical, and neurosurgical cases.[23]

Population Health Research Capsule

What do we already know about this issue?
The COVID-19 pandemic had dramatic effects on graduate medical education for procedure-based specialties such as surgery and interventional cardiology.

What was the research question?
What effect did the post-COVID-19 peak period have on the procedural experience in EM residency training?

What was the major finding of the study?
Index procedures decreased 33.2%, critical care procedures 12.7% (10.3–15.4%); and fast-track procedures 35.9% (34.6%–37.2%).

How does this improve population health?
Knowing the impact of COVID-19 on EM procedure training may spur programs to augment resident education impacted by interruptions.

Hospitalizations for COVID-19 peaked in New York City in March and April 2020. In the months following, ED volumes declined. Our objective was to study the effect of this decline on the procedural experience of EM residents compared to the pre-pandemic period. Through a multicenter study, we sought to describe the volume, types, and acuity of cases seen by EM residents during the months following the COVID-19 peak within three separate EM training programs in New York City and Nassau County. Such information can inform decisions on how best to augment resident education and maintain quality of training during program interruptions and times of reduced patient volume, clinical exposure, and procedural experience.

METHODS

Study Design

This was a multicenter, retrospective cohort study of the number of patients seen and number of procedures performed by EM residents during the months following the COVID-19 peak. We compared these numbers to the same period in the two previous years. The study was reviewed by the institutional review board and was deemed to be not human subjects research.

Study Setting and Population

This was a multicenter study at five hospitals spanning two ACGME-approved EM residencies and one combined EM-IM residency in New York City and Nassau County. The hospitals include three tertiary care centers, one community hospital, and one children's hospital. Prior to COVID-19, the four adult EDs ranged in patient volume from 33,000 to 102,000 patients per year, and the pediatric ED had a volume of 60,000 patients per year. The residency programs include two EM programs in the PGY 1–3 format, as well as one combined EM-internal medicine (IM) program. The number of residents at each program are 30 and 68 for the EM programs and 10 for the EM-IM program.

Our study took place from May–July 2020. These dates were chosen because they represented the initial period following the major first wave of COVID-19 patients in New York. As a comparison group, we collected data from the same months in the preceding two years.

Study Protocol

We performed an electronic data query to extract data from our health system's electronic health record (EHR). We used standard record review practices.[24] Variables obtained from the electronic data query included patient demographics, disposition, authorship of physician note, diagnosis, and chief complaint. Deidentified data were stored in an Excel spreadsheet (Microsoft Corp, Redmond, WA) on a secure server. We reviewed the total number of patients seen by EM residents during the study period, as well as the admission percentage. We identified patients seen by residents based on the authorship of the physician note. This was to ensure each record would only be counted once. We omitted patients seen by physician assistants, nurse practitioners, or by attendings primarily.

We reviewed our EHR billing data for the number of predetermined procedures performed by EM residents during this period. Billing data was captured from procedure notes written by the physicians. We studied critical care procedures, specifically electrical cardioversion, central lines, chest tubes, procedural sedation, and endotracheal intubation. These are key procedures required by the Residency Review Committee in Emergency Medicine (RRC-EM). We also studied "fast-track" procedures, including fracture/joint reduction, incision and drainage (I&D), laceration repairs, and splints. We compared the numbers of procedure performed to the same period in the previous two years.

Measurements or Key Outcome Measures

Numbers of patients seen and procedures performed in the months following the COVID-19 peak were compared to the numbers during the same period for 2019 and 2018. The primary outcome was the change in the total number of index procedures during the months following the COVID-19 peak as compared to the mean of the two previous years. Secondary outcomes included total number of patients seen, and changes in the number of critical care and fast-track procedures.

Data Analysis

We calculated statistics using SAS statistical software (SAS Institute Inc, Cary NC). Percentage of admissions was compared using chi-square tests.

RESULTS

Total number of patients seen by residents during the months following the COVID-19 peak was 33,246, compared to 49,316 in 2019 (−32.6%) and 49,748 in 2018 (−0.9%) (Table 1). Admission percentage was 32.0% in the months following the COVID-19 peak compared to 28.5% in 2019 and 28.5% in 2018.

The total number of index procedures decreased from 5,947 in 2019 to 3,975 in 2020 (−33.2%); compared to virtually no change the previous year (5,975 to 5,947). Total critical care procedures in the months following the

Table 1. Comparison of patient volume for the COVID-19 study period and the control period.

	2020	2019	2018	*P*-value
Total # of patients seen by residents	33,246	49,316	49,748	<0.001
Admission percentage	32.0%	28.5%	28.5%	<0.001

Table 2. Comparison of total procedures for the study period and the control period.

	2020	2019	2018	Difference 2020 from mean of 2018/2019
Total critical care procedures	606	694	642	−9.3%
Total fast-track procedures	3,369	5,253	5,333	−36.3%
Total procedures	3,975	5,947	5,975	−33.3%

Table 3. Comparison of critical care procedures for the study period and the control period.

Procedure	2020	2019	2018	Difference 2020 from mean of 2018/2019
Cardioversion	7	11	10	−33.3%
Central line	244	212	198	+19.0%
Chest tube	22	27	34	−27.9%
Procedural sedation	126	190	174	−30.8%
Endotracheal intubation	207	254	226	−13.8%

COVID-19 peak decreased from 694 in 2019 to 606 in 2020 (−12.7%, 95% confidence interval [CI] 10.3–15.4%), compared to an increase from 642 to 694 (+8.1%, 95% CI 6.1–10.5%) the previous year (difference −9.3%). Total fast-track procedures decreased from 5,253 in 2019 to 3,369 in 2020 (−35.9%, 95% CI 34.6–37.2%), compared to a decrease from 5,333 to 5,253 (−1.5%, 95% CI 1.2–1.9%) the year before (difference −36.3%) (Table 2).

The data for the individual critical care and fast-track procedures are presented in Table 3 and Table 4. During the study period, there was a notable decrease in the critical care procedures of cardioversion, chest tube, procedural sedation, and endotracheal intubation. The only critical care procedure that demonstrated an increase was central line placement. There was also a decrease noted in fast-track procedures of I&D, laceration repair, and splint application. The only fast-track procedure that demonstrated an increase was orthopedic reductions.

Table 4. Comparison of fast-track procedures for the study period and the control period.

Procedure	2020	2019	2018	Difference 2020 from mean of 2018/2019
Reductions	36	32	22	+33.3%
Incision and drainage	284	551	553	−48.6%
Laceration repair	1,739	2,090	2,115	−17.3%
Splint application	1,310	2,580	2,643	−49.8%

DISCUSSION

March–April 2020 represented the peak of COVID-19 cases in the first wave in the New York metropolitan area. During this time EDs were flooded with extremely sick patients. Residents in EM were often managing multiple critical patients simultaneously. They were also exposed to large-scale death, likely for the first time in their careers. Residents were performing large numbers of intubations and medical resuscitations. This had a dramatic impact on their training.

The immediate post-COVID-19 era, however, saw a dramatic decline in ED volume. This was likely multifactorial, with patients afraid to come to EDs out of fear of contracting COVID-19, as well as their adherence to stay-at-home orders. This also had an effect on EM residency training. Our study found that numbers of ED patients seen by residents decreased by 32.6%. At the same time, admission percentage increased by 3.5%, suggesting that lower acuity patients were not coming to the ED. The numbers of both critical care procedures and fast-track procedures decreased during this period as compared to the previous year. The most dramatic changes were noted in fast-track procedures, with notable decreases in I&D, laceration repair, and splint application.

These findings can have a significant impact on resident education. If this trend continues, we may see residents graduating from training with significantly less procedural experience, especially in the realm of fast-track procedures. Our study can inform decisions on how best to augment resident education and maintain quality of training during program interruptions and times of reduced patient volume, clinical exposure, and procedural experience.

These results are likely multifactorial. In the immediate post-COVID-19 era, many people were afraid to come to the hospital due to a fear of contracting the disease. Alternative locations for care became available including telemedicine and urgent care centers. Finally, patients may have chosen not to seek care at all.

Residency programs are encouraged to look at the numbers of procedures that their residents are performing, especially fast-track type procedures. As these procedure numbers are not required to be reported to the ACGME, there is a possibility that residency programs will not be aware of the individual numbers in their own programs if not specifically examined. Programs that find their residents have a deficiency in the number of fast-track procedures may wish to supplement their experience with procedural training in the simulation lab or cadaver lab.

LIMITATIONS

The study has several limitations, First, it took place in one region of the country, namely New York. These findings may not be generalizable to the rest of the US. However, we did study three different programs at five different hospitals spanning four different counties in the area. Second, this was a retrospective cohort study and, therefore, our data is somewhat limited. It is possible that if the data would have been collected prospectively, we would have had a more complete and more accurate dataset.

Our results were obtained from billing data, which is captured from procedure notes written by the physicians. It is possible that some procedures were performed without a procedure note being written. In that scenario, the procedure would not have been captured in our dataset. However, our billers carefully review all charts and encourage physicians to complete all procedure notes if they have not been completed. In addition, the same methods for collecting procedure data were used in both the study population and the control population.

Additionally, we only looked at data for three months. It is possible that what we observed was a temporary phenomenon and as volumes in EDs began to return, procedural availability has improved as well. Finally, we did not look at procedure numbers during the actual COVID-19 peak. It is possible that the increase in critical care procedures during this period offset the decrease we saw in the study period. However, this would not account for the decrease in fast-track procedures, which essentially went away during the COVID-19 peak.

CONCLUSION

The post-COVID-19 era resulted in lower patient volume and less availability of certain procedures for EM residents in New York City and Nassau County. This phenomenon should be watched closely to determine whether trends appear. If so, interventions may need to be instituted to supplement resident training.

Address for Correspondence: Moshe Weizberg, MD, Maimonides Midwood Community Hospital, Department of Emergency Medicine, 2525 Kings Highway, Brooklyn, New York 11229. Email: mweizberg@maimonidesmed.org

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.

REFERENCES

1. Pepe D, Martinello RA, Juthani-Mehta M. Involving physicians-in-training in the care of patients during epidemics. *J Grad Med Educ*. 2019;11(6):632–4.
2. Muya I, Garside J, Van-der Plas M, et al. Emergency health education in a conflict stricken environment: a situational analysis. *Afr J Emerg Med*. 2018;8(4):129–33.
3. Barnett-Vanes A, Hassounah S, Shawki M, et al. Impact of conflict on medical education: a cross-sectional survey of students and institutions in Iraq. *BMJ Open*. 2016;6(2):e010460.
4. Newman B, Gallion C. Hurricane Harvey: firsthand perspectives for disaster preparedness in graduate medical education. *Acad Med*. 2019;94(9):1267–9.
5. Sherbino J, Atzema C. "SARS-Ed": severe acute respiratory syndrome and the impact on medical education. *Ann Emerg Med*. 2004;44(3):229–31.
6. Donini-Lenhoff FG, Rockey PH, Surdyk PM, et al. Emergency preparedness for residency/fellowship programs: lessons learned during Hurricane Katrina and applied during Hurricane Ike. *Disaster Med Public Health Prep*. 2010;4 Suppl 1:S71–4.
7. Mishra D, Nair AG, Gandhi RA, et al. The impact of COVID-19 related lockdown on ophthalmology training programs in India—outcomes of a survey. *Indian J Ophthalmol*. 2020;68(6):999–1004.
8. Porpiglia F, Checcucci E, Amparore D, et al. Slowdown of urology residents' learning curve during the COVID-19 emergency. *BJU Int*. 2020;125(6):E15–7.
9. Gabr AM, Li N, Schenning RC, et al. Diagnostic and interventional radiology case volume and education in the age of pandemics: impact analysis and potential future directions. *Acad Radiol*. 2020;27(10):1481–8.
10. Gupta T, Nazif TM, Vahl TP, et al. Impact of the COVID-19 pandemic on interventional cardiology fellowship training in the New York metropolitan area: a perspective from the United States epicenter. *Catheter Cardiovasc Interv*. 2021;97(2):201–5.
11. Schwarzkopf R, Maher NA, Slover JD, et al. the response of an orthopedic department and specialty hospital at the epicenter of a pandemic: the NYU Langone health experience. *J Arthroplasty*. 2020;35(7S):S3–5.
12. Chen SY, Lo HY, Hung SK. What is the impact of the COVID-19 pandemic on residency training: a systematic review and analysis. *BMC Med Educ*. 2021;21(1):618.
13. Fong ZV, Qadan M, McKinney R, et al. Practical implications of novel coronavirus COVID-19 on hospital operations, board certification, and medical education in surgery in the USA. *J Gastrointest Surg*. 2020;24(6):1232–6.
14. James HK, Pattison GTR. Disruption to surgical training during Covid-19 in the United States, United Kingdom, Canada, and Australasia: a rapid review of impact and mitigation efforts. *J Surg Educ*. 2021;78(1):308–14.
15. Stark N, Hayirli T, Bhanja A, et al. Unprecedented training: experience of residents during the COVID-19 pandemic. *Ann Emerg Med*. 2022;79(5):488–94.

16. Kim HS, Cruz DS, Conrardy MJ, et al. Emergency department visits for serious diagnoses during the COVID-19 pandemic. *Acad Emerg Med*. 2020;27(9):910–3.
17. Chiel L, Winthrop Z, Winn AS. The COVID-19 pandemic and pediatric graduate medical education. *Pediatrics*. 2020;146(2):e20201057.
18. Dedeilia A, Sotiropoulos MG, Hanrahan JG, et al. Medical and surgical education challenges and innovations in the COVID-19 era: a systematic review. *In Vivo*. 2020;34(Suppl 3):1603–11.
19. Douglass A, Yip K, Lumanauw D, et al. Resident clinical experience in the emergency department: patient encounters by postgraduate year. *AEM Educ Train*. 2019;3(3):243–50.
20. Lo HY, Lin SC, Chaou CH, et al. What is the impact of the COVID-19 pandemic on emergency medicine residency training: an observational study. *BMC Med Educ*. 2020;20(1):348.
21. Hartnett KP, Kite-Powell A, DeVies J, et al. Impact of the COVID-19 pandemic on emergency department visits—United States, January 1, 2019-May 30, 2020. *Morb Mortal Wkly Rep*. 2020;69(23):699–704.
22. Bruno TW, Janwadkar R, Clayton LM, et al. Impact of COVID-19 on emergency medicine resident procedure performance. *AEM Educ Train*. 2022;6(6):e10832.
23. Baugh JJ, White BA, McEvoy D, et al. The cases not seen: patterns of emergency department visits and procedures in the era of COVID-19. *Am J Emerg Med*. 2021;46:476–81.
24. Worster A, Bledsoe RD, Cleve P, et al. Reassessing the methods of medical record review studies in emergency medicine research. *Ann Emerg Med*. 2005;45(4):448–51.

Improvement in Resident Scholarly Output with Implementation of a Scholarly Activity Guideline and Point System

Lauren Evans, MD
Sarah Greenberger, MD
Rachael Freeze-Ramsey, MD
Amanda Young, MD
Crystal Sparks, MSAM
Rawle Seupaul, MD
Travis Eastin, MD, MS
Carly Eastin, MD

University of Arkansas for Medical Sciences, College of Medicine, Department of Emergency Medicine, Little Rock, Arkansas

Section Editors: Jeffrey Druck, MD, and Yanina Purim-Shem-Tov, MD, MS
Submission history: Submitted March 5, 2023; Revision received June 27, 2023; Accepted July 19, 2023
Electronically published August 15, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.60346

Introduction: Ensuring high-quality scholarly output by graduate medical trainees can be a challenge. Within many specialties, including emergency medicine (EM), it is unclear what constitutes appropriate resident scholarly activity. We hypothesized that the quantity and quality of scholarly activity would improve with a clearer guideline, including a point system for eligible scholarly activities.

Methods: A resident Scholarly Activity Guideline was implemented for EM residents in a university setting. The guideline consists of a point system in which point values, ranging from 1–10, are assigned to various types of scholarly activities. Residents must earn at least 10 points and present their work to meet their scholarly graduation requirement. We tracked scholarly activities for graduates from the classes of 2014–2020, with the guideline being implemented for the class of 2016. In a blind analysis, we compared median total points per resident, mean counts of the Boyer model of scholarship components per resident, and mean counts of significant scholarly output per resident before vs after the guideline was implemented. Significant scholarly output was defined as an implemented protocol, a research project with data collection and analysis, a research abstract presentation, or an oral abstract presentation.

Results: Among 64 residents analyzed, 48 residents used the guideline. We found that median points per resident increased after the guideline was implemented (median, interquartile range: before 7 [7], after 11 [10, 13], $P = 0.002$). Post-guideline scholarly activities were found to represent more of Boyer's components of scholarship [mean before 0.81 [SD 0.40], mean after 1.52 [SD 0.71], mean difference 0.71, 95% confidence interval [CI] 0.332 ± 1.09, $P < 0.001$. There was no difference in the mean significant scholarly output per resident (mean before 1.38 [SD 1.02], mean after 1.02 [SD 1.00], mean difference 0.35, 95% CI 0.93 ± 0.23, $P = 0.23$).

Conclusion: Implementation of a Scholarly Activity Guideline point system significantly increased the quantity and, by one of two measures, increased the quality of scholarly output in our program. Our point-based guideline successfully incorporated traditional and modern forms of scholarship that can be tailored to resident interests. [West J Emerg Med. 2023;24(5)861–867.]

INTRODUCTION

Scholarship has been a fundamental requirement during any residency training since 1994, but executing this requirement can be challenging due to confusion regarding what constitutes scholarship.[1] It is consistently thought that all trainees should be exposed to the four components of the Boyer model for scholarship: discovery; integration; application; and teaching.[2,3] In 2013, the Common Program Requirements for residency programs as published by the Accreditation Council for Graduate Medical Education (ACGME) stated that, "residents must participate in scholarship."[4] While there were more specific faculty scholarship expectations, the emergency medicine (EM) requirements did not dictate the type or extent of this requirement for residents. In July 2022, the ACGME added more detailed language to these broad requirements for EM (Table 1), but they can still be difficult for program leadership to execute.[5]

Not surprisingly, there has been broad and subjective application of this requirement. For example, in 2015 Geyer et al found that within EM, 39% of programs surveyed required an original research project upon graduation while 61% of programs allowed curricular development projects or evidence-based reviews as an alternative to a traditional research project with an associated peer-reviewed manuscript.[1] In an attempt to address this issue, in 2018 representatives from two national EM groups published

Population Health Research Capsule

What do we already know about this issue?
Scholarly activities are a required part of residency training, but defining appropriate scholarship remains a challenge for residency leadership.

What was the research question?
Can a novel scholarly activity guideline and point system improve the quality and quantity of resident scholarship?

What was the major finding of the study?
Implementation of the point system correlated with improved median scholarly points per resident (before 7 [IQR 7], after 11 [IQR 10, 13], $P = 0.002$).

How does this improve population health?
A clear, concise scholarly activity guideline may allow for improved resident scholarly output, which contributes to the advancement of emergency care.

Table 1. Evolution of emergency medicine resident scholarship requirements as designated by the ACGME Residency Review Committee for emergency medicine.[4,5]

2013 Emergency medicine requirements for resident scholarly activities	The curriculum must advance residents' knowledge of the basic principles of research, including how research is conducted, evaluated, explained to patients, and applied to patient care. Residents should participate in scholarly activity. The sponsoring institution and program should allocate adequate educational resources to facilitate resident involvement in scholarly activities.
2022 Emergency medicine requirements for resident scholarly activities	Residents must participate in scholarship. The curriculum must advance the residents' knowledge of the basic principles of research, including how research is conducted, evaluated, explained to patients, and applied to patient care. At the time of graduation, each resident should demonstrate: • active participation in a research project, or formulation and implementation of an original research project, including funded and non-funded basic science or clinical outcomes research, as well as active participation in an Emergency Medicine emergency department quality improvement project; or, • presentation of grand rounds, posters, workshops, quality improvement presentations, podium presentations, webinars; or, • grant leadership, non-peer-reviewed print/electronic resources, articles or publications, book chapters, textbooks, service on professional committees, or serving as a journal reviewer, journal editorial board member, or editor; or • peer-reviewed publications.

ACGME, Accreditation Council for Graduate Medical Education.

recommendations based on survey data, suggesting appropriate types of scholarship for EM residents to provide more structure to the scholarship requirement.[6] However, these recommendations have been cited as being too strict and not taking into account more modern forms of scholarship such as social media, podcasts, or online curricula, which are now recognized as fulfilling the Boyer components of scholarship.[7,8] Since academic institutions are increasingly considering more varied types of scholarship in the faculty promotion process, it is reasonable to similarly allow residents to participate in traditional and nontraditional activities based on their interests.

In addition to the historical variation in programs' interpretations of scholarship requirements, enforcing a single standard for the scholarly activity requirement may not be appropriate, as many trainees do not plan to pursue a career in academic medicine. Trainees often equate research or scholarly activity with academia, which can result in diminished engagement in these projects if they intend to pursue a different career path. Further complicating the scholarly process, many residents have difficulty completing original research projects due to lack of mentorship or institutional support for data collection or statistical analysis.[1,9] It is, therefore, not surprising that inadequate scholarship has led to a high rate of Review Committee (RC) citations since the scholarship requirement was introduced in 1994.[1,9]

In 2018, a meta-analysis evaluating graduate medical education (GME) scholarship initiatives found that, while no specific strategy was more effective at increasing trainee publications, there was a significant increase in publications following the implementation of any initiative. The authors concluded that a "culture of emphasis on resident scholarship" was the critical factor in increasing scholarly production among trainees.[10] Several other strategies have also been described that may improve resident scholarly output, with the most effective being providing dedicated time for scholarship, having a research curriculum, a defined scholarship requirement, requiring a presentation at a research day, or a combination of these.[11] However, the optimal approach remains unclear.

OBJECTIVE

The purpose of this innovation was to improve the quantity and quality of scholarship by providing a well-defined scholarly activity framework for our trainees while simultaneously incorporating options for a variety of traditional and modern scholarly activities.

CURRICULAR DESIGN

Development of the Scholarly Activity Guideline

After a literature review in 2014, we used existing recommendations for scholarly output in an EM training program along with a previously published unique scholarship point system to create a Scholarly Activity Guideline (SAG, Supplemental Material).[3-5,12,13] While not a proven method, we chose this point system based on the novelty of the idea and the inclusion of a wide variety of options for scholarship. The point system was tailored to our program's goals for fulfilling the scholarship requirement. It provides multiple options for scholarship with associated point values ranging from 1–10 (Table 2).

The first version of SAG required that residents obtain a minimum of 10 points on the scholarly point system, attend one department research meeting yearly, complete evidence-based learning modules, and present their work at our annual departmental Scholar's Day. The meeting and module requirements have since been removed as they are addressed elsewhere in the residency curriculum. The guideline includes a suggested timeline for completion to assist in keeping residents on schedule. Finally, it includes an idea form which serves as a guide for in-person project discussions with

Table 2. The original scholarly activity point system, created in 2014, adapted from Seehusen et al.[a]

Type of scholarly activity	Points
IRB-approved project completed with manuscript submitted to a peer-reviewed journal	≥10
Submission of a manuscript describing a case series, systematic review, or meta-analysis	≥10
Presentation of a poster or oral presentation at a regional, national, or international conference	5
Publication of a book chapter or section	10
Non IRB-approved quality-improvement (QI) project completed and results shared with peers	7
Initiation of IRB-approved research or QI project but project still ongoing at time of graduation	8 – 10
Submission of a grant for intramural or extramural funding (with IRB approval)	10
Creation and maintenance of an online teaching tool	5
Publication of a letter to the editor in a peer-reviewed medical journal	3 – 5
Creation of simulation case for simulation curriculum (not published vs published)	3 – 10
Submission to peer-reviewed journal or national conference of a series of interesting cases (ie, visual diagnosis cases or photo competition)	3.5
Publications for the lay public, such as newspaper articles, on medical topics	3
Participation on a national committee	5
Critically appraised topic write-up and submission to journal	5

[a]Table adapted from Seehusen DA, Asplund CA, Friedman M. A point system for resident scholarly activity. *Fam Med*. 2009 Jul–Aug;41(7):467–9. PMID: 19582627.
IRB, institutional review board.

members of the research committee. Residents are required to obtain approval from the Research Committee for any scholarship for which they wish to obtain points, but generally they can choose any combination of activities from the guideline to achieve the goal of 10 points. If there is a project that does not fit well within the options listed, residents can present their idea for consideration to the Research Committee and, if approved, the committee assigns points by consensus.

The SAG was implemented in August 2014 and was first applied to the graduating class of 2016 as well as all subsequent residents. This time gap allowed the intern class of 2014 two academic years to meet their requirements. As a matter of background, our EM residency is a longstanding three-year program located at a Level 1 trauma and tertiary care hospital in the South Central United States. Prior to the introduction of the SAG, there was a scholarship requirement for all residents without a specific curriculum or guide defining what types of projects were appropriate. Over the seven years of this data analysis, our residency complement increased from eight to 10 residents per year. We also added several additional faculty, including one research-focused faculty member.

For quality improvement purposes, the guideline has been reviewed periodically and adjustments to it have been made when necessary. For example, we removed the requirement to attend a research meeting as they were not found to be high yield. To avoid diminishing educational value, restrictions on case reports were also added to prevent residents from only completing case reports during their training. Lastly, the category of abstracts for the *Journal of Emergency Medicine* was added, as one of the program's faculty is the section editor for the Abstracts section of the journal and allows residents to contribute as authors.

Methods for Analysis of the Scholarly Activity Guideline

As part of routine residency documentation, scholarly activity output for all residents is recorded in real time. In June 2020 we abstracted all recorded scholarship for graduates between 2014-2020 from each graduate's exit letter to assess the improvement in scholarly output related to the introduction of the new guideline. While all projects after 2015 had points assigned to them at the time they were completed, three authors (SG, RFR, AY) who were not members of the Research Committee independently assigned points for the pre-SAG cohort and re-measured point totals for each resident in the post-SAG group to ensure consistency and reduce bias. To further reduce bias, two authors (TE, CE) removed the name and graduation year of the resident and replaced the project title with a project type. This blinded list was then randomized and entered into RedCap, an electronic data capture tool hosted at University of Arkansas for Medical Sciences for rating. The same authors (SG, RFR, AY) also analyzed the quality of each resident's output based on how many, if any, of the Boyer components of scholarship were represented. Therefore, our two primary outcomes were the comparison of the median number of points per resident and the mean number of the Boyer components of scholarship present per resident, before and after implementation of the SAG.

Although the consensus document regarding appropriate scholarly output for EM residents by Kane et al was published several years after implementation of our guideline, we wanted to incorporate these criteria into our analysis as well.[6] In addition to recommending that programs maintain an archive in residency record files, Kane et al proposed four other primary elements of resident scholarship: a developed and implemented protocol; a research paper with a hypothesis, collected and analyzed data, and a conclusion; a research abstract presentation; or an oral research presentation. The consensus authors stated these were recommendations rather than requirements, and while those options were considered to be best practices, they still believed that program directors could accept alternative types of scholarship.[6] As a pre-planned secondary analysis, our three raters (SG, RFR, AY) also rated which projects met at least one of the consensus criteria for scholarship, which we defined as "significant scholarly output."

The university's institutional review board (IRB) did not consider this review to be human subjects research and, therefore, did not require IRB oversight. We used descriptive statistics where appropriate. The median value among the three raters was used as the final count for each variable. We treated our scholarly activity point variable, as ordinal as different activities could achieve differing point values. Counts of the Boyer components and significant scholarly output were treated as continuous. Categorical variables were compared using chi-squared tests (or the Fisher exact test if counts were rare), ordinal variables were compared using the Mann-Whitney U test, and continuous variables were compared using independent *t*-test. We calculated inter-rater reliability (Fleiss Kappa) to assess the agreement between the three raters. Analyses were performed using SPSS Statistics for Macintosh version 28.0 (IBM Corp, Armonk, NY).

IMPACT

Analysis of Scholarly Output

Sixty-four residents graduated in the period studied, producing 676 scholarly points. Before the guideline, only one of 16 (6.25%) residents would have met the minimum point requirement (Table 3). Since the SAG was implemented, 40/48 (83.3%) residents in the classes of 2016–2020 met their scholarly point requirements based on the blinded review. Total points per resident increased significantly after implementation of the guideline (median 7 points per resident [interquartile range (IQR) 7, 7] before vs 11 points per resident after [IQR 10, 13], $P < 0.002$). See Figure 1 for graphical

Table 3. Scholarly output results, before and after.

		Guideline group			
		Before		After	
		Count	%	Count	%
Successfully achieved minimum points	≥10 points	1	6.3%	40	83.3%
	<10 points	15	93.8%	8	16.7%
Boyer components present	0	3	18.8%	2	4.2%
	1	13	81.3%	23	47.9%
	2	0	0.0%	19	39.6%
	3	0	0.0%	4	8.3%
	4	0	0.0%	0	0.0%
At least one Boyer component present	Yes	13	81.3%	46	95.8%
	No	3	18.8%	2	4.2%
Significant scholarly output present	0	2	12.5%	16	33.3%
	1	9	56.3%	22	45.8%
	2	3	18.8%	3	6.3%
	3	1	6.3%	7	14.6%
	4	1	6.3%	0	0.0%
At least one significant scholarly output	Yes	14	87.5%	31	64.6%
	No	2	12.5%	17	35.4%

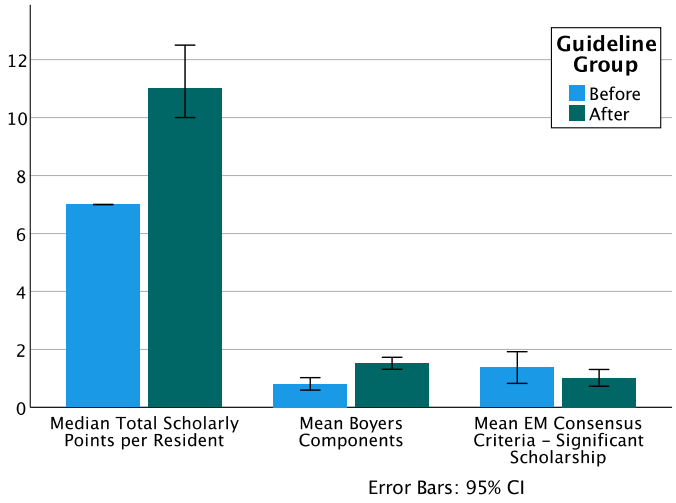


Figure 1. Outcomes before vs after scholarly guideline. *EM*, emergency medicine.

representation of all outcomes. Of note, 54.2% (26/48) of residents in the post-guideline period ended their training with more points than the minimum required, compared with 6.25% (1/16) before (relative risk [RR] 2.05, 95% confidence interval [CI] 1.47–2.85, $P < 0.001$).

Regarding the quality of scholarship, we found at least one of the Boyer components of scholarship in 92% (59/64) of resident portfolios as well as at least one significant scholarly achievement in 71.8% (46/64). When comparing before and after the SAG, we found a significant increase in the mean number of Boyer components (mean before 0.81 [SD 0.40], mean after 1.52 [SD 0.71], mean difference 0.71, 95% CI 0.332–1.09, $P < 0.001$), although the proportion of residents with at least one component did not change (81.25% vs 95.3%, RR = 4.5, 95% CI 0.82–25.47, $P = 0.10$). There was no change in the average number of significant scholarly outputs per resident (mean before 1.38 [SD 1.02], mean after 1.02 [SD 1.00], mean difference −0.35, 95% CI −0.93 – 0.23, $P = 0.23$) or in the proportion of residents with at least one significant scholarly output (87.5% vs 64.58%, RR 0.35, 95% CI 0.09 = −1.36, $P = 0.12$). Overall interrater agreement was measured as moderate (K = 0.538, 95% CI 0.499–0.577, $P < 0.001$).

As a natural consequence of seeing more of the Boyer components of scholarship with the SAG, we noticed that the types of scholarship appeared to be more varied as well. In the pre-guideline period, most scholarly activities were local quality improvement projects that resulted in data collection and analysis, but most were only presented locally. Two of these resulted in research abstracts presented at national meetings, and there was one resident who participated in a multicenter, chart review study. In the post-guideline period, residents not only had regional and national research abstract presentations, peer-reviewed manuscripts, and book chapters, but they also published evidence-based reviews, edited online resources for medical students, wrote articles for community newsletters, and recorded educational, evidence-based podcasts. In addition, while participation in national committees was initially a controversial addition to our accepted forms of scholarship, residents who have chosen this option have been highly engaged and were often invited to be authors on subsequent publications or participate in national presentations.

DISCUSSION

We are excited about the improved resident scholarship we achieved after implementation of the SAG. We believe that having a clearer and more diverse list of options has allowed residents to successfully choose projects in which they would feel engaged while the point requirement has ensured a minimum standard and accountability. Although anecdotal, the faculty members overseeing resident scholarship have noted that the clarity provided by the SAG seems to have reduced frustration on the part of both residents and faculty. While the SAG concept is novel to EM, this point system was adapted from a similar system used in a family medicine residency by Seehusen et al.[12] Our improvements are congruent with the increase they found in their scholarly output with this approach, describing more presentations, book chapters, and peer-reviewed publications. Since implementation of our guideline,

execution of a similar point system has been described in the radiology literature, but no official quantitative analyses have been reported.[14]

We found it interesting that while the total points increased and we found more of the Boyer components of scholarship present after the guideline, we did not see a difference in significant scholarly output as defined as one of the four criteria described by Kane et al in their consensus statement.[6] While Kane et al's recommendation was made with input and support from members of several EM organizations, it was primarily crafted by members of the Research Directors Interest Group and Evidence-based Healthcare Implementation interest groups of the Society for Academic Emergency Medicine. In their study, the authors identified the best practices based on a survey of possible scholarly outputs, and only those with high consensus among respondents were considered appropriate scholarship. While the survey respondents were affiliated with most of the national EM groups, representatives of several EM groups, such as the Council of Residency Directors and various EM resident organizations, responded with concern that these recommendations were too stringent and that the approach used to determine the criteria were not consistent with widely accepted definitions of consensus.[7] They recommended using a less strict consensus threshold, which would result in a more varied list of acceptable scholarship opportunities.

Understanding the limitations of the consensus, it is not surprising that given our inclusion of non-traditional and more modern forms of scholarship (eg, online educational resources, participation in national committees, or FOAMed), we did not see a significant increase in those types of scholarships only noted in the consensus document. It is certainly possible that the lack of increase indicates a lack of impact of our scholarly activity guideline, but we feel it more reflects the bias of the consensus guideline toward more traditional research activities. For example, in the post-SAG group, we had residents pursue podcasts, evidence-based reviews, and participate in national committees, all types of scholarship we feel are valuable that would not have otherwise been counted in the consensus guideline.

There are several other potential explanations for the small change seen in our analysis. Even with the addition of diverse faculty and increasing the focus on resident scholarship, our research infrastructure has remained minimal, which we feel has slowed the advancement of our research mission and potentially limited the potential of the point system. The majority of our residents also become community emergency physicians and are not necessarily focused on research, similar to trainees in many EM residencies. While we did not analyze the points from residents who pursued community practice against those who pursued fellowships or academic medicine, we suspect that those entering community emergency departments likely chose less traditional research and may have been more likely to finish with the minimum points required. If true, this would not necessarily be a negative reflection of the point system; rather, for us it would highlight the flexibility of this approach to all types of residents. We never expected that all our residents would suddenly engage in complex scholarship, but we did hope for an explicit guideline, a clear minimum standard for completion and, overall, more high quality output. We still see our improvements, while modest from a statistical standpoint, as a major culture shift for our program.

Next Steps

We believe that future, similar investigations would be beneficial to enhance generalizability of our findings. If other programs were to find success in implementing similar scholarly point systems, especially programs with a variety of resources, we may learn in which settings the point system performs best. Applying this to other groups may also be useful. For example, our program is considering creating a point system for faculty to improve their scholarly output and engagement. While still in the planning stage, this approach could help less research-focused faculty participate in the research mission with a variety of options for compliance.

Based on the experience gained by implementing the SAG, we have realized that documentation is imperative, and suggest having clear, ongoing documentation from the time of idea generation through project completion. This provides transparency for project approval and progression, how many points will be awarded, and when the scholarly work is considered complete. We have found documentation of project status to be most successful in a shared online format with access for the resident, the research committee, and program leadership. Additionally, once a point system is implemented, periodic adjustments are necessary to incorporate new areas of scholarship, or to remove or limit items that may not provide incremental educational benefit to the learner.

LIMITATIONS

This dataset is limited by recall bias, as there could be projects that were not documented and not available to include in the analysis. While the authors that judged point values were blinded to resident names and graduation year, they may have been able to identify residents' work based on the project type. Additionally, while the raters had moderately good agreement, they had not previously judged point totals, so these numbers may have been incongruent with the points awarded by the research committee in real time based on knowing the specifics of the project. This is particularly evident when considering that at the time of their graduation, all residents in the post-implementation group were felt to have met the 10-point minimum, yet not all were judged to have met the requirement in this analysis,

suggesting that blinding led to underestimation of points scored. However, we felt that creating a blinded review would allow for the most unbiased comparison.

It is also possible that retrospective application of the point system may have overestimated the difference, but we feel this is unlikely. Another limitation is that additional faculty were hired at the time of and following the SAG implementation, and these newer faculty could have improved residents' abilities to complete high-quality scholarship regardless of guideline implementation. Lastly, while we have found the SAG to be effective in our program, it is possible that, as Wood et al suggest, any initiative that provided enhanced emphasis on resident scholarship could have been equally effective.[10]

CONCLUSION

The implementation of a point-based scholarly activity guideline improves the quantity, breadth and, in our opinion, the quality of scholarly activity among emergency medicine residents. Given the inclusion of a variety of traditional and non-traditional forms of scholarship and its simplicity, this system could be easily adapted for other EM residencies or any other subspecialty training programs.

Address for Correspondence: Carly Eastin, MD, University of Arkansas for Medical Sciences, Department of Emergency Medicine, Department of Pediatrics, 4301 W Markham St, Slot 584, Little Rock, Arkansas 72211. Email: cdeastin@uams.edu

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.

REFERENCES

1. Geyer BC, Kaji AH, Katz ED, et al. A national evaluation of the scholarly activity requirement in residency programs: a survey of emergency medicine program directors. *Acad Emerg Med*. 2015;22(11):1337–44.
2. Poston L, Boyer EL. Scholarship reconsidered: priorities of the professoriate. *Academe*. The Carnegie Foundation for the Advancement of Teaching. 1990.
3. Grady EC, Roise A, Barr D, et al. Defining scholarly activity in graduate medical education. *J Grad Med Educ*. 2012;4(4):558–61.
4. Accreditation Council for Graduate Medical Education. ACGME Common Program Requirements (Residency). Available at: https://www.acgme.org/globalassets/pfassets/programrequirements/cprresidency_2022v3.pdf. Accessed July 2020.
5. Accreditation Council for Graduate Medical Education. ACGME Program Requirements for Graduate Medical Education in Emergency Medicine. Available at: https://www.acgme.org/globalassets/pfassets/programrequirements/110_emergencymedicine_2022_tcc.pdf. Accessed November 2022.
6. Kane BG, Totten VY, Kraus CK, et al. Creating consensus: revisiting the emergency medicine resident scholarly activity requirement. *West J Emerg Med*. 2019;20(2):369–75.
7. Pasichow SH, Jarou ZJ, Nikolla DA, et al. Response to "creating consensus: revisiting the emergency medicine scholarly activity requirement." *West J Emerg Med*. 2019;20(2):376–9.
8. Quinn A, Chan TM, Sampson C, et al. Curated collections for educators: five key papers on evaluating digital scholarship. *Cureus*. 2018;10(1):e2021.
9. Levine RB, Hebert RS, Wright SM. Resident research and scholarly activity in internal medicine residency training programs. *J Gen Intern Med*. 2005;20(2):155–9.
10. Wood W, McCollum J, Kukreja P, et al. Graduate medical education scholarly activities initiatives: a systematic review and meta-analysis. *BMC Med Educ*. 2018;18(1):318.
11. Stevenson MD, Smigielski EM, Naifeh MM, et al. Increasing scholarly activity productivity during residency: a systematic review. *Acad Med*. 2017;92(2):250–66.
12. Seehusen DA, Asplund CA, Friedman M. A point system for resident scholarly activity. *Fam Med*. 2009;41(7):467–9.
13. Summers RL, Fish S, Blanda M, et al. Assessment of the "scholarly project" requirement for emergency medicine residents: report of the SAEM Research Directors' workshop. SAEM Research Directors' Interest Group. *Acad Emerg Med*. 2008;6(11):1160–5.
14. Bhatt AA, Garner HW, Bowman AW, et al. Resident scholarly activity for diagnostic radiology residency: a point system approach. *Curr Probl Diagn Radiol*. 2022;51(3):301–3.

Prehospital mSOFA Score for Quick Prediction of Life-Saving Interventions and Mortality in Trauma Patients: A Prospective, Multicenter, Ambulance-based, Cohort Study

Francisco Martín-Rodríguez, PhD[*†‡]
Ancor Sanz-García, PhD[‡§]
Ana Benito Justel, PhD[†]
Almudena Morales Sánchez, PhD[†]
Cristina Mazas Perez Oleaga, PhD[#**]
Irene Delgado Noya, PhD[#††]
Irene Sánchez Soberón, PhD[†]
Carlos del Pozo Vegas, PhD[*‡‖]
Juan F. Delgado Benito, MD[†‡]
Raúl López-Izquierdo, PhD[*‡¶]

[*]Universidad de Valladolid, Faculty of Medicine, Valladolid, Spain
[†]Emergency Medical Services (SACYL), Advanced Life Support, Valladolid, Spain
[‡]Prehospital Early Warning Scoring-System Investigation Group, Valladolid, Spain
[§]Universidad de Castilla la Mancha, Faculty of Health Sciences, Talavera de la Reina, Spain
[‖]Hospital Clínico Universitario, Department of Emergency Medicine, Valladolid, Spain
[¶]Hospital Universitario Rio Hortega, Department of Emergency Medicine, Valladolid, Spain
[#]Universidad Europea del Atlántico, Department of Emergency Medicine, Santader, Spain
[**]Universidad Internacional Iberoamericana, Department of Emergency Medicine, Campeche, México
[††]Universidade Internacional do Cuanza, Department of Emergency Medicine, Cuito, Bié, Angola

Section Editor: Mark Langdorf, MD, MHPE
Submission history: Submitted September 29, 2022; Revision received May 17, 2023; Accepted May 19, 2023
Electronically published August 8, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59048

Background: Prehospital emergency medical services (EMS) are the main gateway for trauma patients. Recent advances in point-of-care testing and the development of early warning scores have allowed EMS to improve patient classification. We aimed to identify patients presenting with major trauma involving life-saving interventions (LSI) using the modified Sequential Organ Failure Assessment (mSOFA) score in the prehospital scenario, and to compare these results with those of other trauma scores.

Methods: This was a prospective, ambulance-based, multicenter, training-validation study in trauma patients who were treated in a prehospital setting and subsequently transported to a hospital. The study involved six Advanced Life Support units, 38 Basic Life Support units, and four hospitals. The primary outcome was LSI performed at the scene or en route and intensive care unit (ICU) admission and all-cause two-day in-hospital mortality. We collected epidemiological variables, creatinine, lactate, base excess, international normalized ratio, and vital signs. Discriminative power (area under the receiver operating characteristic curve [AUC]), calibration (observed vs predicted outcome agreement), and decision-curve analysis (DCA, clinical utility) were used to assess the reliability of the mSOFA in comparison to other scores.

Results: Between January 1, 2020–April 30, 2022, a total of 763 patients were selected. The mSOFA score's AUC was 0.927 (95% confidence interval [CI] 0.898–0.957) for LSI, 0.845 (95% CI 0.808–0.882) for ICU admission, and 0.979 (95% CI 0.966–0.991) for two-day mortality.

Conclusion: The mSOFA score outperformed the other scores, allowing a quick identification of high-risk patients. The routine implementation in EMS of mSOFA could provide critical support in the decision-making process in time-dependent trauma injuries. [West J Emerg Med. 2023;24(5)868–877.]

BACKGROUND

Several complex consequences follow a severe trauma (eg, hypoperfusion, coagulopathy, hypothermia, acidosis, and tissue inflammation). These responses increase morbidity and mortality in trauma patients.[1] Discriminating major trauma that require life-saving interventions (LSI) vs trauma without systemic repercussions is a particular challenge for emergency medical services (EMS), particularly in prehospital care.[2,3] The identification of patients requiring LSI on the scene is critical in deciding whether to transport to the emergency department (ED) of a hospital equipped to manage complex trauma cases (trauma center). Conversely, rapid identification of patients who are not at high risk allows EMS personnel to transport those patients to hospitals with fewer resources and/or clinicians with less training in treating complex trauma. The ability to quickly differentiate between high-risk trauma patients and those not at immediate risk improves the transfer rate of high-complexity cases to trauma centers, thereby optimizing the use of resources. The use of trauma scores to determine patient risk in non-prehospital scenarios has been successfully adopted in clinical practice.[4]

In prehospital care, the usefulness of an early warning score (EWS) has been broadly demonstrated and has become standard practice across numerous EMS agencies.[5,6] However, few specific scores are available for EMS application to trauma patients (eg, the revised trauma score [RTS];[7] new trauma score [NTS];[8] the combination of mechanism, Glasgow Coma Scale, age, and arterial pressure score [MGAP];[9] or the Vittel criteria).[10] However, prehospital point-of-care testing (POCT) has been widely used.[11] Measurements such as hemoglobin, base excess, pH, lactate, creatinine, or the international normalized ratio (INR) provide relevant feedback, guiding the resuscitation of polytrauma patients from the first moments of EMS arrival on the scene.[12,13]

The major advantage of using an EWS or POCT, either alone or jointly, is the potential standardization of patient assessment, enabling EMS personnel to recognize high-risk patients without obvious clinical symptoms. On-scene use of diagnostic and/or prognostics tools streamlines the decision-making process. Specifically, these tools provide EMS personnel detailed short-term evolution data that enables them to decide whether to transport the patient to a higher resource facility. Applying EWS in trauma patients also makes it possible to standardize a trauma patient's management throughout the entire healthcare system. This uniform terminology simplifies patient transfer between clinicians, ultimately lowering the risk of adverse events.[14,15]

The combined application of physiological parameters and analytical measures has significantly improved the prognostic performance of both EWS and POCT in helping to quickly and decisively identify high-risk patients. A particularly striking example is the Sequential Organ Failure Assessment (SOFA) score, which can discriminate multiorgan damage and is routinely used in intensive care units (ICU).[16] More recently, the Traumasis-SOFA scoring system is used specifically for patients who have been in a traffic collision.[17] Despite technological advances, there is no portable POCT capable of measuring bilirubin or platelets in the prehospital setting; thus, prospective estimation of the SOFA score is not currently available at the scene or while en route to the ED. The SOFA score, which combines physiological measurements (Glasgow Coma Scale [GCS], mean arterial pressure [MAP], and pulse oximetry saturation/fraction of inspired oxygen ratio [SaFi]) with analytical determinations (creatinine and lactate), was developed to be used at the scene or en route.[18] In their 2010 study, Grissom et al proposed the use of a modified SOFA (mSOFA) score,[19] which was specifically designed and validated for prehospital care, including physiological and analytical parameters available bedside.

In this investigation, our primary aim was to evaluate the effectiveness of prehospital mSOFA scores for predicting the need for LSI (invasive mechanical ventilation, and/or administration of tranexamic acid and/or noradrenaline) in trauma patients. Secondary aims were to explore the performance of mSOFA in predicting ICU admissions and two-day in-hospital mortality, and to compare the mSOFA

Population Health Research Capsule

What do we already know about this issue?
Prehospital identification of major trauma patients requiring life-saving interventions has not yet been elucidated.

What was the research question?
Does mSOFA (an early warning score) allow quick identification of high-risk trauma patients?

What was the major finding of the study?
Major comparison with p-value and confidence interval
The mSOFA score presents an area under the receiver operating characteristic curve of 0.927 (95% CI 0.898–0.957) for life-saving interventions.

How does this improve population health?
Using mSOFA to quickly identify high-risk trauma patients could improve treatment and management of these rapidly evolving and complex cases.

with four trauma scores (RTS, NTS, MGAP, and the BIG [base deficit, INR, and GCS] score).

METHODS

Study Design and Settings

This was a prospective, ambulance-based, multicenter, training-validation study of trauma patients who were treated in the prehospital setting and subsequently transported to an ED. The study involved six Advanced Life Support (ALS) units, 38 Basic Life Support (BLS) units, and four EDs. All the facilities—distributed over three provinces (covering inner city areas, suburbs, and rural areas)—are part of the Public Health System of Castilla y León (Spain), with a reference population of 995,137 inhabitants. The BLS units are staffed by two emergency medical technicians (EMT), and the ALS units are composed of an emergency registered nurse (ERN), a physician, and two EMTs.

Between January 1, 2020–April 30, 2022, patient data was collected from two back-to-back prospective studies conducted under an identical operative guideline. The institutional review board of the Public Health Service reviewed and approved the investigation. The study was registered in the WHO International Clinical Trials Registry Platform (ISRCTN48326533 and ISRCTN49321933); we followed the Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis (TRIPOD)[20] guidelines (Supplementary data p3).

Participants

We included in this study adult trauma patients (>18 years) who were screened by the ALS physician and evacuated by ALS or BLS units to the ED. Only cases with venous line and subsequent blood analysis performed at the scene or en route were included in the follow-up cohort.

Exclusion criteria included the following: cardiorespiratory arrest not recovered at the scene; pregnant women; potential danger to staff; discharged in situ (after evaluation by the ALS physician); or inability to obtain informed consent at the site, en route, or at the ED.

Score Selection

The scores compared with the mSOFA fulfilled the following conditions: they have been validated; they are available in the prehospital scope of care; and they are based on the determination of standard vital signs or clinical observations and/or a basic blood test. The exclusion criteria included the following: scores with an already known modest predictive capacity (eg, shock index[21]), complex anatomical scales (eg, Injury Severity Score[22]); systems requiring laboratory tests not available at the scene (eg, Emergency Trauma Score[23]); or scores requiring imaging studies (eg, Trauma-associated Severe Hemorrhage Score[24]). Finally, the selected scores included the RTS,[7] NTS,[8] MGAP,[9] and BIG.[25]

OUTCOMES

Primary outcome of the current study was LSI performed at the scene or en route. The following LSI were included in the analysis: invasive mechanical ventilation (conventional orotracheal intubation and videolaryngoscope in cases of difficult airway); and/or administration of tranexamic acid and/or noradrenaline (any dose). We did not include additional vasopressors as LSI (eg, dopamine, dobutamine or vasopressin) for the composite outcome because noradrenaline is the standard pharmacologic agent in ALS, in accordance with the internal procedure guidelines of our health system, which describe noradrenaline as the vasopressor of choice for hypovolemic shock unresponsive to volume with hemodynamic compromise. Neither did we include blood administration, since this procedure is conducted exclusively in the ED in our health system. As a secondary outcome we included unplanned ICU admission, and two-day in-hospital mortality (all cause).

Cases (ie, patients showing a confirmed positive outcome [LSI and/or ICU admission and/or two-day mortality]), were all re-checked by the study coordinator. We excluded from analysis cases with missing data (complete-case study).

Predictors and Data Abstraction

Before starting the project, specific training was given to all the staff in the correct use of the data collection notebook, how to take blood samples, perform the analysis, and maintain and clean the devices used for variables collection, which are stated below. The study coordinator regularly visited all the ambulance stations.

Epidemiological variables (gender, age, urban or rural area, vector of transfer, and intervention times) were collected by an EMT, and baseline vital signs (respiratory rate, oxygen saturation, blood pressure, heart rate, temperature, and GCS), were collected by the ERN during the first contact of the ALS unit with the trauma patient. Pulse oxygen saturation, blood pressure, and pulse were determined with the LifePAK 15 monitor-defibrillator (Physio-Control, Inc, Redmond, WA), and temperature with the ThermoScan PRO 6000 thermometer (Welch Allyn, Inc, Skaneateles Falls, NY).

Subsequently, once the venous line was cannulated, a blood sample was extracted by the ERN for analysis of parameters, including creatinine, lactate, base excess, and INR. Blood analysis was conducted using the epoc Blood Analysis System (Siemens Healthcare GmbH, Erlangen, Germany) and CoaguChek Pro II System (Roche Diagnostics GmbH, Basel, Switzerland).

The ALS physician documented the application of LSI (invasive mechanical ventilation, and/or administration of tranexamic acid and/or noradrenaline), and the final prehospital diagnosis. Two days after the index event, a research associate from each hospital, collected the following hospital outcomes via electronic health records (EHR)

review: hospital-inpatient, ICU admission, and two-day mortality (any cause).

Statistical Analysis

All patient data was recorded electronically in a database created specifically for this purpose. Data was prospectively collected and registered in a database generated with the IBM SPSS Statistics for Apple version 20.0 (IBM Corp, Armonk, NY). The caseload entry system was test-run to delete unclear or ambiguous items and to verify the adequacy of the data-gathering system. To make a link between EMS medical records and the hospital's EHR, an exact match was made with five of the following extractors: patient name; gender; age; day, arrival time, and incident code; and ambulance code and/or healthcare card number.

Data was never de-identified for the team responsible for data analysis. We assessed the descriptive results and the association between predictors and the outcome using the Mann-Whitney U test or the chi-squared test, as appropriate, and the effect size was provided as standardized mean difference. We used absolute values and percentages for categorical variables, and medians and interquartile ranges (IQR) for continuous variables. The a priori statistical plan was to use medians and IQRs if continuous variables were not normally distributed. Sample-size calculations were performed by assessing the power calculation based on a specific comparison using pwr package in R (The R Project for Statistical Computing, Vienna, Austria), considering a statistical power (from 1–100) of 97, a significance level of $P = .001$, and a mSOFA score difference between cases and non-cases of 84%. The sample used for training and validation, derived from a cross validation (ie, n/10), was n = 76.

Prior to score development and validation the sample was randomly split, preserving the proportion of the outcome variable, by using a 10-fold cross-validation, which has been used to overcome overfitting. (Further detail can be found in supplementary data p4.) The mSOFA score validation and calibration required a first step of fitting a logistic regression in which the score (as a continuous variable) was the predictive variable and the LSI, two-day mortality, or ICU admission the outcome. Considering the whole cohort, we plotted the observed distribution of the outcomes and a curve of the predicted probability of the outcome according to the mSOFA score, including the confidence interval (CI).

To assess the reliability of mSOFA and its comparison against other well-established scores, we evaluated all the scores in three different ways: with their discriminative power (assessed by the area under the receiver operating characteristic [ROC] curve and the area under the ROC curve [AUC]); their calibration (observed vs predicted outcome agreement; and with decision curve analysis [DCA], clinical utility). In particular, the mSOFA discrimination capacity was assessed by the AUC. The calibration was also performed by calculating the calibration curve, that is, plotting predicted vs observed probability of the outcome, and determining several metrics associated with calibration (explained below).

We assessed the discriminative power of mSOFA by ROC curve analysis and AUC, including 95% CIs, a *P*-value of the hypothesis testing (H0: AUC = 0.5). All 95% CIs were obtained by bootstrapping (2,000 iterations). We assessed further parameters of the ROC: specificity; sensitivity; positive predictive value; negative predictive value; positive likelihood ratio; and negative likelihood ratio. We also reported the maximum potential effectiveness achieved by the scores, with the Youden Index (in terms of sensitivity and specificity) serving also as a summary of the whole ROC curve. We compared AUCs using the Delong test.

We analyzed the goodness of fit of the model against the observed probability using different adjustments: logistic and nonparametric fit using LOWESS. We calculated several additional statistics: Somers' D rank correlation; ROC area; Nagelkerke-Cox-Snell-Maddala-Magee R-squared index; discrimination index; unreliability index; the quality index; Brier score (average squared difference in p and y); intercept, slope, maximum absolute difference in predicted and loess-calibrated probabilities; the average of the previous parameter; the 0.9 of the previous parameter; and the Spiegelhalter Z-test for calibration accuracy and its two-tailed *P*-value.

We used DCA to compare mSOFA with those scores already used in clinical practice.

All statistical analyses were performed in R version 4.0.3 using packages described in supplementary data p4.

Role of the Funding Source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

RESULTS

Patient Characteristics

In the current study, 763 patients from 44 ambulance stations (six ALS and 38 BLS) fulfilled the inclusion criteria (supplementary figure S1). Their median age was 52 years (IQR: 37–70 years), and 266 (34.9%) were female.

The prehospital-LSI rate was 14.5% (111 cases), while 48 cases (6.3%) were treated with tranexamic acid, 28 (3.7%) with noradrenaline, and 92 cases (12.1%) with invasive mechanical ventilation. In 69 of the prehospital-LSI patients (62.2%), only one intervention was performed; two prehospital-LSI were performed in 27 patients (24.3%), and in 15 patients (13.5%) all three prehospital-LSI were required. Trauma patients subjected to prehospital LSI were predominantly male, 18–49 years, and polytraumatized (life-threatening involvement of two or more systems), with a

Table 1. Baseline clinical and biomarker characteristics of the study population.

	Total	Non-LSI	LSI	Standardized difference[b]	*P*-value[c]
No. (%) with data[a]	763 (100)	652 (85.5)	111 (14.5)	N.A.	N.A.
Age, years	52 (37–70)	52 (37–70)	50 (34–65)	0.086	.402
Age groups, years				0.101	.559
18–49	349 (45.7)	295 (45.2)	54 (48.6)		
50–74	269 (35.3)	232 (35.6)	37 (33.3)		
>75	145 (19)	125 (19.2)	20 (18)		
Gender, female	266 (34.9)	234 (35.9)	32 (28.8)	0.151	.149
ALS	507 (66.4)	401 (61.5)	106 (95.5)	0.909	<.001
Zone, urban	478 (62.6)	422 (64.7)	56 (50.5)	0.292	.004
Isochronous, min					
Arrival time	11 (8–16)	11 (8–16)	12 (10–23)	0.361	.001
Support time	31 (23–40)	30 (22–28)	34 (26–48)	0.423	<.001
Evacuation time	12 (8–20)	12 (8–19)	15 (10–28)	0.44	<.001
Basal vital signs					
RR, breaths/min	18 (14–21)	18 (14–20)	18 (12–27)	0.176	.147
SpO_2, %	97 (95–99)	97 (95–99)	93 (87–97)	0.894	<.001
FiO_2, %	0.21 (0.21–0.21)	0.21 (0.21–0.21)	0.21 (0.21–0.21)	0.608	.031
SaFi	462 (448–471)	462 (452–471)	429 (310–462)	0.952	<.001
SBP, mm Hg	133 (117–146)	134 (120–147)	121 (89–142)	0.523	<.001
DBP, mm Hg	80 (68–90)	80 (70–90)	66 (55–87)	0.508	<.001
MBP, mm Hg	97 (85–108)	98 (88–108)	86 (77–104)	0.543	<.001
HR, beats/min	84 (71–100)	83 (70–98)	92 (77–118)	0.521	<.001
Temperature, °C	36 (35.7–36.4)	36 (35.8–36.4)	35.8 (34.8–36.1)	0.474	<.001
GCS, points	15 (15–15)	15 815–15)	9 (5–14)	1.634	<.001
Lactate, mmol/L	2.42 (1.64–3.54)	2.16 (1.45–3.09)	5.67 (3.25–8.71)	1.158	<.001
Creatinine, mgr/dL	0.86 (0.74–1.09)	0.84 (0.73–1.01)	1.09 (0.87–1.68)	0.616	<.001
BE, mEq/L	0.6 (−2.6;−1.8)	0.8 (−1.6;1.9)	−4.6 (−10;−1.5)	1.143	<.001
INR	1 (1–1.1)	1 (1–1.1)	1 (1–1.1)	0.228	.057
mSOFA, points	1 (0–3)	1 (0–2)	6 (4–8)	1.994	<.001
Trauma mechanism				0.419	<.001
Penetrating	39 (5.1)	22 (3.4)	17 (15.3)		
Blunt	724 (94.9)	630 (96.6)	94 (84.7)		
Trauma type				0.343	<.001
Polytraumatized	106 (13.9)	53 (8.1)	53 (47.7)		
Polycontused	83 (10.9)	83 (12.7)	0		
Head and neck	257 (33.7)	221 (33.9)	36 (32.4)		
Thorax	52 (6.8)	47 (7.2)	5 (4.5)		
Abdomen-pelvic	32 (4.2)	25 (3.8)	7 (6.3)		
Spinal	46 (6)	45 (6.9)	1 (0.9)		
Orthopedic	156 (20.4)	153 (23.5)	3 (2.7)		
Burns	31 (4.1)	25 (3.8)	6 (5.4)		
Hospital outcomes					
Hospital-inpatient	372 (48.8)	265 (40.6)	107 (94.9)	1.501	<.001
ICU admission	162 (21.2)	58 (8.9)	104 (93.7)	3.204	<.001
2-day mortality	47 (6.2)	8 (1.2)	39 (35.1)	0.979	<.001

LSI, life-saving interventions; *NA*, Not applicable; *ALS*, Advanced Life Support; *RR*, respiratory rate; SpO_2, oxygen saturation; FiO_2, fraction of inspired oxygen; *SaFi*, pulse oximetry saturation/fraction of inspired oxygen ratio; *SBP*, systolic blood pressure; *DBP*, diastolic blood pressure; *MBP*, mean blood pressure; *HR*, heart rate; *GCS*, Glasgow coma scale; *BE*, base excess; *INR*, International normalized ratio; *mSOFA,* modified Sequential Organ Failure Assessment; *ICU*, intensive care unit.

[a]Values expressed as total number (fraction) and medians [25th percentile-75th percentile], as appropriate.

[b]The Cohen d-test was used for estimated effect size.

[c]The Mann-Whitney U test, *t*-test, or chi-squared test was used as appropriate.

remarkable rate of penetrating trauma (15.3%). Of the LSI group cases, 93.7% presented ICU admission (104 cases), and the two-day in-hospital mortality rate was 35.1% (39 cases). The mSOFA-associated variables showed statistically significant differences between cases with prehospital-LSI and non-LSI cases ($P < .001$) (see Table 1).

mSOFA Validation

The validation of the mSOFA score was performed by ROC analysis assessing AUC values. The AUCs were as follows: 0.927 (95% CI 0.898–0.957) for LSI; 0.845 (95% CI 0.808–0.882) for ICU admission; and 0.979 (95% CI 0.966–0.991) for two-day mortality. Further details on the model performance can be found in supplementary tableS2. As can be observed in Figure 1, the predictive probability for each outcome as a function of mSOFA presented a typical sigmoid curve, meaning that the number of cases (for all the outcomes) increased with increasing mSOFA values. Curves were steeper for LSI and ICU, indicating that the mSOFA value at which the cases increased for this outcome was lower than that for mortality.

Finally, the calibration results showed that the best performance of mSOFA was for mortality according to Brier, resulting in 0.06 (95% CI 0.063–0.067) for LSI; 0.11 (95% CI 0.110–0.115) for ICU; and 0.03 (95% CI 0.019–0.049) for mortality. However, when considering the slope or the calibration-in-the-large (or intercept), the best performance was for ICU, followed by LSI and mortality (in that order). Results of slope were 0.98 (95% CI 0.73–1.23) for LSI; 1.00 (95% CI 0.86–1.15) for ICU; and 0.89 (95% CI 0.48–1.30) for mortality, while those of calibration-in-the-large were 0.02 (95% CI −0.39–0.45) for LSI;

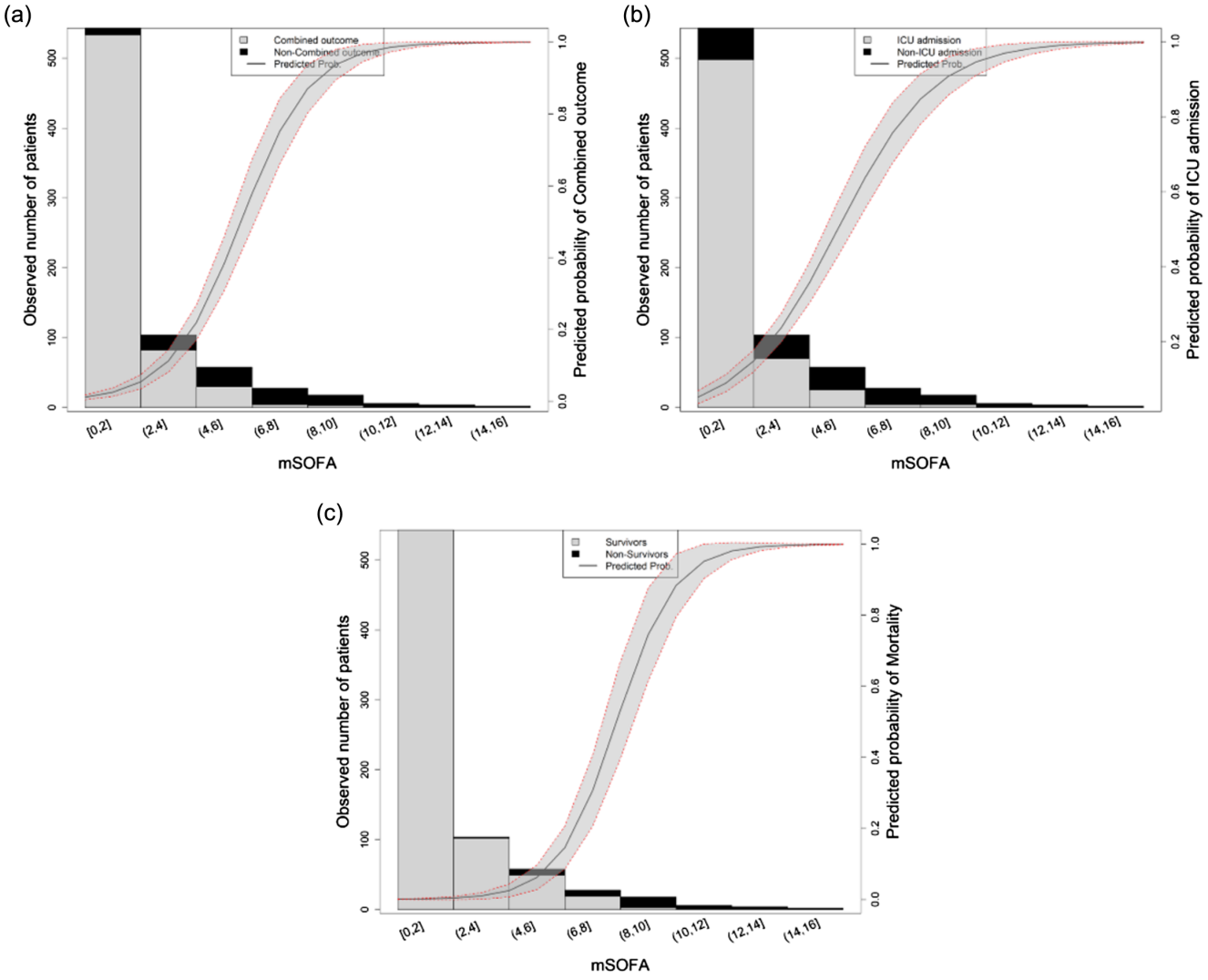


Figure 1. Probability of different outcomes based on the value of mSOFA in prehospital care: a) life-saving interventions; b) ICU admission; and c) two-day mortality. The solid line shows the predicted probability of the outcome; gray-shadowed area shows the 95% confidence interval.
mSOFA, modified Sequential Organ Failure Assessment; *ICU*, intensive care unit.

0.004 (95% CI −0.24–0.25) for ICU; and −0.50 (95% CI −1.82–0.82) for mortality.

mSOFA vs Other Scoring Systems

The comparison between mSOFA and the other scores was assessed by three different procedures. First, the discrimination power using the AUC comparison showed that mSOFA outperformed the other scores for all the outcomes evaluated (Figure 2); this was corroborated by the results from the Delong test (Supplementary tableS3) in which mSOFA presented statistically significant differences vs all the scores for all outcomes (*P*-value ranged between $P < .01$ and $P < .001$, except for LSI in which $P = .078$ vs RTS, and $P = .061$ vs MGAP). Secondly, similarly to discrimination analysis, DCA (Figure 3) showed a higher net benefit for mSOFA than other scores throughout all the threshold probability and for all outcomes, with the exception of the higher threshold, in which the net benefit was similar for LSI or lower for ICU admission compared to RTS.

Thirdly, the calibration-derived metrics showed that mSOFA presented the best performance for LSI. For instance, the Brier score of mSOFA was the lowest compared to the other scores for all the evaluated outcomes. Interestingly, when considering the fitted calibration curves, either logistic or nonparametric (LOWESS), mSOFA presented the best fit. Further details on the calibration results can be found in supplementary FigureS4.

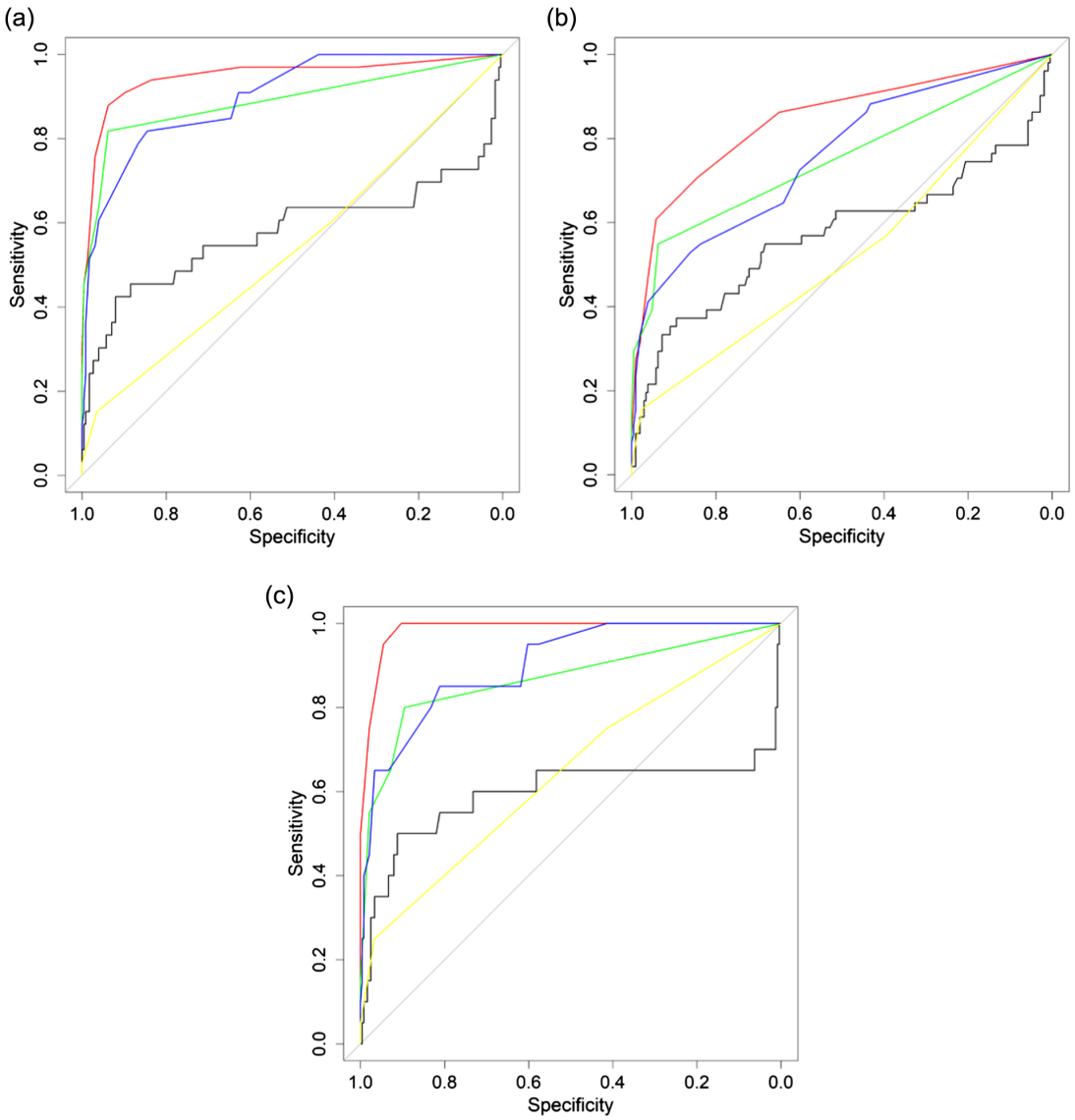


Figure 2. Discrimination analysis results of each model. Discrimination capacity of the scores was assessed by the area under the receiver operating characteristic (ROC) curve (AUC) for a) life-saving interventions; b) intensive care unit (ICU) admission; and c) two-day mortality. Red line = modified Sequential Organ Failure Assessment (mSOFA); green line = revised trauma score (RTS); blue line = combination of mechanism, Glasgow Coma Scale, age, and arterial pressure score (MGAP); black line = BIG score; yellow line = new trauma score (NTS).

DISCUSSION

To our knowledge, this is the first study to analyze the predictive ability of prehospital mSOFA scores to detect high-risk trauma patients at the scene or en route. The mSOFA score presented an excellent AUC for prediction of prehospital LSI, unplanned ICU admissions, and two-day in-hospital mortality, outperforming all the scores analyzed.

The X-A-B-C-D-E resuscitation guidelines clearly outline the priorities in primary assessment and initial care of major trauma.[26] Upon identification and control of external bleeding hemorrhage, the next life-threatening priority is to ensure airway patency and/or ineffective ventilation, coupled with quick recognition of subtle signs of shock at early onset that allow rapid treatment start. Considering the above, in the first moments post-injury, EMS personnel should prioritize the rapid identification and response to hypovolemic shock of hemorrhagic origin as a top priority, together with initial airway management on scene.[27,28]

Several scores have been developed to forecast the severity of a trauma patient's condition; however, studies evaluating the predictive ability of different scores to determine prehospital LSI requirement are scarce. Galvagno et al[11] analyzed the performance of venous lactate to predict prehospital LSI, showing an AUC of 0.71. Radowsky et al[29] examined the ability of the prehospital, handheld, tissue oximeter to identify occult shock, with poor results (AUC = 0.51). Liu et al[30] studied the capability of different standard vital signs (heart rate, lower systolic blood pressure,

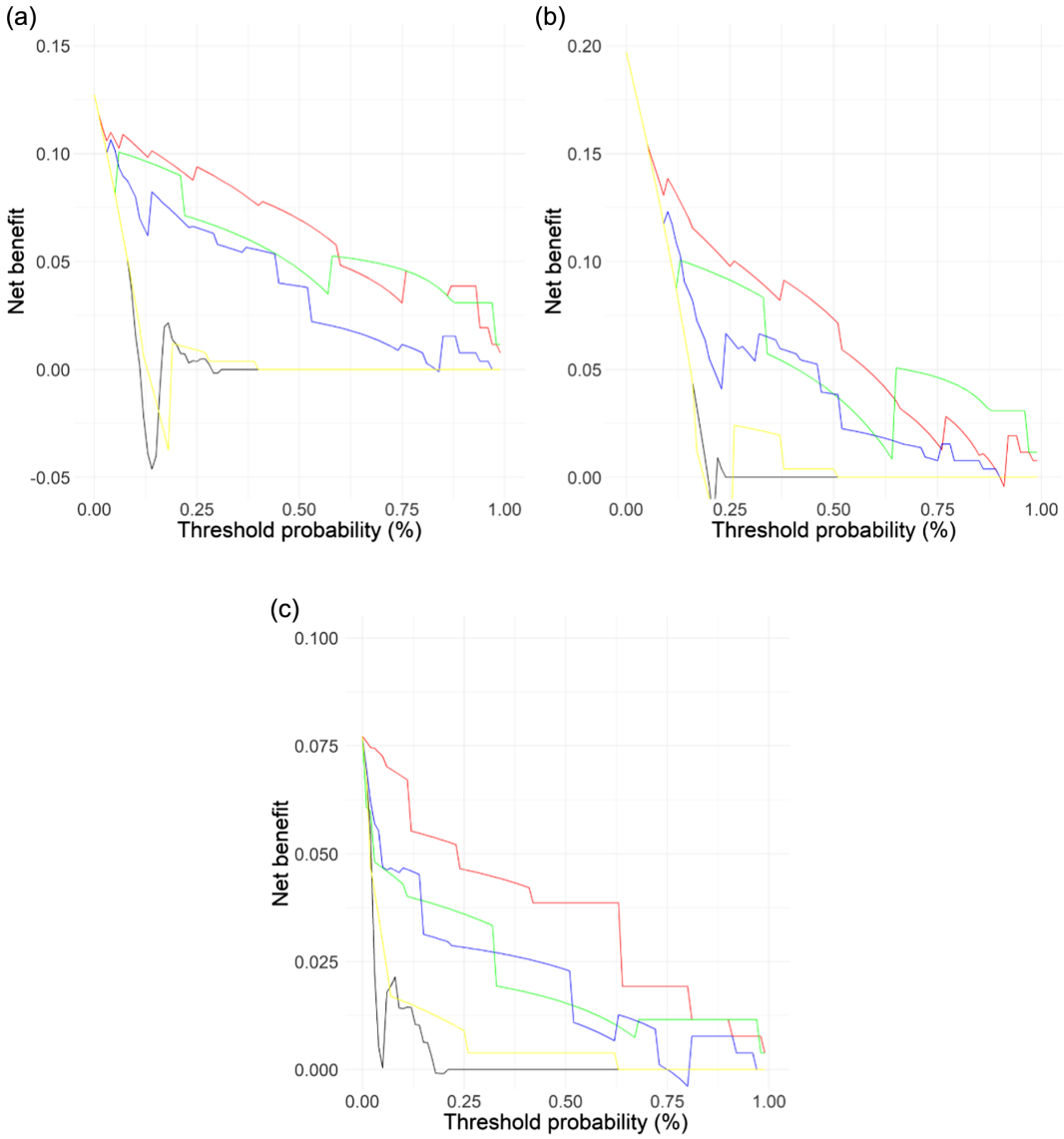


Figure 3. Decision curve analysis results of each model: a) life-saving interventions; b) intensive care unit admission; and c) two-day mortality. Red line = modified Sequential Organ Failure Assessment; green line = revised trauma score); blue line = combination of mechanism, Glasgow Coma Scale, age, and arterial pressure score; black line = BIG score; yellow line = New Trauma Score. *BIG score*, admission base deficit + international normalized ratio + Glasgow Coma Scale.

shock index, pulse pressure, and GCS components), while Kumar et al[31] analyzed the feasibility to predict LSI of a model based on heart rate variability. In both cases overall results were modest (AUC = 0.72 and 0.75, respectively). In summary, isolated studies have analyzed standard vital signs and/or trauma scores, reporting AUCs lower than that of the mSOFA score.

The mSOFA is a five-parameter system assessable in prehospital care from the first contact with patients,[18] which allows the identification of potential high-risk trauma patients. This scoring system includes respiratory (SaFi), hemodynamic (MAP), neurological (GCS), and oxidative metabolism (creatinine and lactate) endpoints, providing a global overview of the trauma patient's status.

LIMITATIONS

While the strengths of the present study are the large number of EMS records we examined over a long period of time and the use of standardized procedures for the management of trauma patients, as well as the homogeneous training of all EMS personnel involved, the study does have several limitations. First, the data was not blinded. To minimize bias, data was collected continuously 24 hours a day throughout the year, and ambulances served both urban and rural areas, involving different EDs. In addition, EMS personnel did not know the scores analyzed or their interpretation or calculated risks, and the outcomes were not known to hospital investigator associates. As a double-check setup, the study coordinator audited all notified patients with a primary positive outcome. Second, some of the scores tested required the use of prehospital POCT, which requires a certain training and is not widely implemented in EMS. Third, even though thoracic decompression techniques are considered to be LSI, they were not included in the study nor was there exact data on the crystalloid volume administered. (In future studies these inputs will be recorded to improve predictive capacity and to improve the identification of high-risk patients.)

Fourth, the ongoing study started before the current COVID-19 pandemic and was in progress, continuously adding cases into the database. The potential long-term consequences of COVID-19 are yet to be determined; thus, it remains unclear what the effect of this new pathology has on patients who have already suffered the disease or its long-term sequelae. Larger studies are required to understand the impact of the pandemic on medical emergency care, and specifically on trauma patients. Fifth, the interpretation of the DCA and calibration results should be interpreted from a qualitative point of view, rather than from a quantitative/statistical point of view. They are intended to support the AUC findings rather than be interpreted alone. Finally, the current study was developed in a single country, with particular conditions of the Spanish health system, such as POCT availability in the EMS. The generalizability of this study will require further studies in different health systems.

CONCLUSION

The mSOFA score can help EMS personnel recognize high-risk patients. The identification of three key outcomes—life-saving interventions on scene, unplanned ICU admission, and two-day mortality—can play a critical role in better management of these rapidly evolving and complex cases.

Address for Correspondence: Ancor Sanz-García, PhD, Universidad de Castilla la Mancha, Faculty of Health Sciences, Avda. Real Fábrica de Seda, s/n 45600, Talavera de la Reina, Toledo. Email: ancor.sanz@uclm.es, ancor.sanz@gmail.com

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.

REFERENCES

1. Pape HC, Moore EE, McKinley T, et al. Pathophysiology in patients with polytrauma. *Injury*. 2022;53(7):2400–12.
2. Mitra B, Bade-Boon J, Fitzgerald MC, et al. Timely completion of multiple life-saving interventions for traumatic haemorrhagic shock: a retrospective cohort study. *Burns Trauma*. 2019;7:22.
3. Meizoso JP, Valle EJ, Allen CJ, et al. Decreased mortality after prehospital interventions in severely injured trauma patients. *J Trauma Acute Care Surg*. 2015;79(2):227–31.
4. Serviá L, Badia M, Montserrat N, et al. Severity scores in trauma patients admitted to ICU. Physiological and anatomic models. *Med Intensiva (Engl Ed)*. 2019;43(1):26–34.
5. Martín-Rodríguez F, Sanz-García A, Medina-Lozano E, et al. The value of prehospital early warning scores to predict in-hospital clinical deterioration: a multicenter, observational base-ambulance study. *Prehosp Emerg Care*. 2021;21(5):597–606.
6. Williams TA, Tohira H, Finn J, et al. The ability of early warning scores (EWS) to detect critical illness in the prehospital setting: a systematic review. *Resuscitation*. 2016;102:35–43.
7. Filipescu R, Powers C, Yu H, et al. Improving the performance of the Revised Trauma Score using Shock Index, Peripheral Oxygen Saturation, and Temperature: a National Trauma Database study 2011 to 2015. *Surgery*. 2020;167(5):821–8.

8. Jeong JH, Park YJ, Kim DH, et al. The new trauma score (NTS): a modification of the revised trauma score for better trauma mortality prediction. *BMC Surg*. 2017;17(1):77.
9. Cassignol A, Markarian T, Cotte J, et al. Evaluation and comparison of different prehospital triage scores of trauma patients on in-hospital mortality. *Prehosp Emerg Care*. 2019;23(4):543–50.
10. Cotte J, Courjon F, Beaume S, et al. Vittel criteria for severe trauma triage: characteristics of over-triage. *Anaesth Crit Care Pain Med*. 2016;35(2):87–92.
11. Galvagno SM, Sikorski RA, Floccare DJ, et al. Prehospital point of care testing for the early detection of shock and prediction of lifesaving interventions. *Shock*. 2020;54(6):710–6.
12. Martín-Rodríguez F, López-Izquierdo R, Medina-Lozano E, et al. Accuracy of prehospital point-of-care lactate in early in-hospital mortality. *Eur J Clin Invest*. 2020;50(12):e13341.
13. Schött U. Prehospital coagulation monitoring of resuscitation with point-of-care devices. *Shock*. 2014;41(Suppl 1):26–9.
14. Martín-Rodríguez F, López-Izquierdo R, Del Pozo Vegas C, et al. A multicenter observational prospective cohort study of association of the prehospital national early warning score 2 and hospital triage with early mortality. *Emerg Med Int*. 2019;51478008.
15. Durantez-Fernández C, Martín-Conty JL, Medina-Lozano E, et al. Early detection of intensive care needs and mortality risk by use of five early warning scores in patients with traumatic injuries: an observational study. *Intensive Crit Care Nurs*. 2021;67:103095.
16. McCarthy SL, Stewart L, Shaikh F, et al. Prognostic value of Sequential Organ Failure Assessment (SOFA) score in critically ill combat-injured patients. *J Intensive Care Med*. 2022;37(11):1426–34.
17. Jo S, Jeong T, Park B. Evaluation of the sequential organ failure assessment score and newly introduced criteria - Traumasis - in traffic collision patients. *Am J Emerg Med*. 2022;51:98–102.
18. Martín-Rodríguez F, Sanz-García A, Del Pozo Vegas C, et al. Time for a prehospital-modified Sequential Organ Failure Assessment score: an ambulance-based cohort study. *Am J Emerg Med*. 2021;49:331–7.
19. Grissom CK, Brown SM, Kuttler KG, et al. A modified Sequential Organ Failure Assessment score for critical care triage. *Disaster Med Public Health Prep*. 2010;4(4):277–84.
20. Collins GS, Reitsma JB, Altman DG, et al. Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis (TRIPOD): the TRIPOD statement. *Ann Intern Med*. 2015;162(1):55–63.
21. Harada M, Takahashi T, Haga Y, et al. Comparative study on quick Sequential Organ Failure Assessment, systemic inflammatory response syndrome and the shock index in prehospital emergency patients: single-site retrospective study. *Acute Med Surg*. 2019;6(2):131–7.
22. Galvagno SM, Massey M, Bouzat P, et al. Correlation between the Revised Trauma Score and Injury Severity Score: implications for prehospital trauma triage. *Prehosp Emerg Care*. 2019;23(2):263–70.
23. Park HO, Kim JW, Kim SH, et al. Usability verification of the Emergency Trauma Score (EMTRAS) and Rapid Emergency Medicine Score (REMS) in patients with trauma: a retrospective cohort study. *Medicine (Baltimore)*. 2017;96(44):e8449.
24. Sperry JL, Guyette FX, Brown JB, et al. Prehospital plasma during air medical transport in trauma patients at risk for hemorrhagic shock. *N Engl J Med*. 2018;379(4):315–26.
25. Yoon TJ, Ko Y, Lee J, et al. Performance of the BIG score in predicting mortality in normotensive children with trauma. *Pediatr Emerg Care*. 2021;37(12):e1582–88.
26. Kondo Y, Fukuda T, Uchimido R, et al. Advanced Life Support vs. Basic Life Support for patients with trauma in prehospital settings: a systematic review and meta-analysis. *Front Med (Lausanne)*. 2021;8:660367.
27. Fecher A, Stimpson A, Ferrigno L, et al. The pathophysiology and management of hemorrhagic shock in the polytrauma patient. *J Clin Med*. 2021;10(20):4793.
28. Tran A, Yates J, Lau A, et al. Permissive hypotension versus conventional resuscitation strategies in adult trauma patients with hemorrhagic shock: a systematic review and meta-analysis of randomized controlled trials. *J Trauma Acute Care Surg*. 2018;84(5):802–8.
29. Radowsky JS, DuBose JJ, Scalea TM, et al. Handheld tissue oximetry for the prehospital detection of shock and need for lifesaving interventions: technology in search of an indication? *Air Med J*. 2019;38(4):276–80.
30. Liu NT, Holcomb JB, Wade CE, et al. Inefficacy of standard vital signs for predicting mortality and the need for prehospital life-saving interventions in blunt trauma patients transported via helicopter: a repeated call for new measures. *J Trauma Acute Care Surg*. 2017;83(Suppl 1):S98–S9S103.
31. Kumar A, Liu N, Koh ZX, et al. Development of a heart rate variability and complexity model in predicting the need for life-saving interventions amongst trauma patients. *Burns Trauma*. 2019;7:12.

Social Determinants of Health in EMS Records: A Mixed-methods Analysis Using Natural Language Processing and Qualitative Content Analysis

Susan J. Burnett, MS, EMT-P*
Rachel Stemerman, PhD†
Johanna C. Innes, MD*
Maria C. Kaisler, MD*
Remle P. Crowe, PhD, NREMT†
Brian M. Clemency, DO, MBA*

*Jacobs School of Medicine and Biomedical Sciences, University at Buffalo, The State University of New York, Department of Emergency Medicine, Buffalo, New York
†ESO, Austin, Texas

Section Editor: Daniel Joseph, MD
Submission history: Submitted September 30, 2022; Revision received April 17, 2023; Accepted April 10, 2023
Electronically published August 8, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59070

Introduction: Social determinants of health (SDoH) are known to impact the health and well-being of patients. However, information regarding them is not always collected in healthcare interactions, and healthcare professionals are not always well-trained or equipped to address them. Emergency medical services (EMS) professionals are uniquely positioned to observe and attend to SDoH because of their presence in patients' environments; however, the transmission of that information may be lost during transitions of care. Documentation of SDoH in EMS records may be helpful in identifying and addressing patients' insecurities and improving their health outcomes. Our objective in this study was to determine the presence of SDoH information in adult EMS records and understand how such information is referenced, appraised, and linked to other determinants by EMS personnel.

Methods: Using EMS records for adult patients in the 2019 ESO Data Collaborative public-use research dataset using a natural language processing (NLP) algorithm, we identified free-text narratives containing documentation of at least one SDoH from categories associated with food, housing, employment, insurance, financial, and social support insecurities. From the NLP corpus, we randomly selected 100 records from each of the SDoH categories for qualitative content analysis using grounded theory.

Results: Of the 5,665,229 records analyzed by the NLP algorithm, 175,378 (3.1%) were identified as containing at least one reference to SDoH. References to those SDoH were centered around the social topics of accessibility, mental health, physical health, and substance use. There were infrequent explicit references to other SDoH in the EMS records, but some relationships between categories could be inferred from contexts. Appraisals of patients' employment, food, and housing insecurities were mostly negative. Narratives including social support and financial insecurities were less negatively appraised, while those regarding insurance insecurities were mostly neutral and related to EMS operations and procedures.

Conclusion: The social determinants of health are infrequently documented in EMS records. When they are included, they are infrequently explicitly linked to other SDoH categories and are often negatively appraised by EMS professionals. Given their unique position to observe and share patients' SDoH information, EMS professionals should be trained to understand, document, and address SDoH in their practice. [West J Emerg Med. 2023;24(5)878–887.]

INTRODUCTION

Social determinants of health (SDoH), including housing, employment, education, income, neighborhoods, access to healthcare, and education are known to impact the health and well-being of patients, yet these variables are not always accounted for during interactions with the healthcare system.[1,2] While unmet basic social needs have measurable impacts on individuals, communities, and the public health system,[1,3,4] little guidance exists for healthcare clinicians to address patients' SDoH, and current strategies focus on the population and policy levels.[5] Greater attention is needed to individual-level social issues, as leaving them unaddressed leads to poor clinical outcomes, health disparities, and increased healthcare costs.[3] Patients with unmet social needs frequently access healthcare through hospitals and, particularly, emergency departments (ED) only, warranting an increased focus on SDoH in emergency medicine (EM).[6–8]

Emergency medical services (EMS) professionals operating at the intersection of public safety, public health, and healthcare are uniquely positioned to observe and attend to SDoH in productive and influential ways.[9] They use their perceptions of patients' social and physical environments to aid in medical decision-making, such as determining whether to transport the patient to the hospital or not.[10] Additionally, conveying information to ED staff about factors such as unsafe housing, lack of access to medications, or inability of patients to safely care for themselves can ultimately affect whether or not that patient can be safely discharged from the ED. Nevertheless, information exchange through verbal hand-offs from EMS professionals to ED nursing staff and subsequent reporting to additional hospital personnel often results in lost information and miscommunication.[11–19]

Electronic health record documentation by EMS is a reliable channel through which information about a patient's SDoH can be shared with all healthcare personnel associated with the patient's hospitalization.[20] There is a paucity of SDoH information in EMS records for pediatric patients,[21] but the presence, appraisal, and connections of SDoH information in EMS records for adult patients is unknown. Our objective in this study was to determine the presence and frequency of SDoH documentation in adult EMS records and understand the ways in which those insertions are referenced, appraised, and linked to other determinants.

Population Health Research Capsule

What do we already know about this issue?
The ability of emergency medical services (EMS) personnel to assess patients' social determinants of health (SDoH) can have a great impact on patient care.

What was the research question?
We sought to evaluate the presence, appraisal, and relationships of SDoH documentation in EMS records.

What was the major finding of the study?
Of 5,665,229 adult patient EMS records we analyzed, 3.1% were identified as containing at least one reference to SDoH.

How does this improve population health?
Understanding how EMS personnel recognize and document patients' SDoH is key to identifying their diverse needs and expanding out-of-hospital care options.

METHODS

Study Design and Setting

We retrospectively analyzed 9-1-1 records for adult patients (≥18 years) in the 2019 ESO Data Collaborative public-use research dataset. The ESO Data Collaborative consists of de-identified prehospital electronic patient care records created by EMS personnel during the course of patient care. All EMS agencies that contribute to the dataset agree to share their de-identified data for research and benchmarking. Annual research datasets are made available free of charge following a proposal process and review by an institutional review board (IRB). We selected this database for the diversity of included practice settings and the ability to request free-text narratives. In 2019, this database contained more than eight million records from 1,322 EMS agencies with encounters across all four US Census regions (South: 58%; Midwest: 22%; West: 16%; and Northeast: 5%) and 6% of encounters occurring in rural settings. A total of 31% of encounters occurred in communities classified within the most vulnerable quartile of socioeconomic status based on the US Centers for Disease Control and Prevention's social vulnerability index.[22] This study was designated not human subjects research by the State University of New York at Buffalo IRB.

Selection of Cases

All cases, regardless of complaint or disposition, were screened. We used a multilabel classification machine-learning model which, when identifying SDoH topics, has area under the curve receiver operating characteristics of 93.9.[23] This natural language processing (NLP) algorithm has a framework of applications to EM and EMS records.[21,23] By applying this algorithm, we identified free-text narratives containing documentation of at least one SDoH from categories associated with food, housing, employment, insurance, financial, and social support insecurities.

Measures and Analysis

We performed descriptive statistical analysis and randomization of records for qualitative analysis using Stata MP version 17.0 (StataCorp LLC, College Station, TX). From the corpus produced by the NLP algorithm, a random sample of 100 narratives was chosen from each determinant category for qualitative content analysis. Using an interpretive paradigm,[24] the three study team members read each narrative to understand the first-person perspectives of the EMS professionals who documented their interactions with patients in the records they kept. This approach was necessary to facilitate a hermeneutical approach and understand the social construction of those EMS professionals' experiences on the calls about which they documented. Team members used a grounded theory framework[24–26] to describe the content found in the EMS records.

Three researchers (JCI, an ED attending, EMS physician, and paramedic; MCK, an ED attending and EMS fellow; and SJB, a paramedic and EMS educator) reviewed narratives, performed primary coding to understand the content of the EMS records, and further immersed themselves in the data by discussing their findings for each category with the other qualitative-analysis study team members.[24,27] During this data immersion phase, codes were developed. For example, patients who were documented as not having eaten in several days were coded as food insecure (if their cases were not otherwise categorized in the food insecurity determinant category by the NLP corpus), or patients who reported they could not afford medications were coded as financially constrained. Then, using the constant comparative method,[24,28] researchers organized the primary codes into secondary codes to synthesize social topics illustrated by the data throughout the determinant categories. For example, patients who reported financial constraints were categorized as having accessibility problems. Researchers further collaborated to assure that the content of the EMS records was represented by the social topics and each concept was robustly supported by data.[29]

In a separate round of purposive coding, researchers looked for documentation of other insecurities in each determinant category to determine the relationship, frequency, and directionality of their reference. For example, if a narrative was determined by the NLP corpus to contain information about social support insecurities, but the patient was documented as not having eaten in several days, they were coded as food insecure, as referred to in the social support category. Additionally, the team members qualitatively appraised each narrative to identify the valence of the narratives as a means of further understanding the EMS professionals' perspectives. To limit potential perceptions of bias, the qualitative researchers frequently checked in with themselves and the others as a means of reflexivity.[24,28] They verified that their interpretations and models were representative of the data and that their own and the others' experiences and biases did not result in misinterpretation. They also collaboratively built models and interrogated their data to assure their findings were strongly supported by the data from the EMS record narratives.

RESULTS

Of 5,665,229 records analyzed by the NLP algorithm, 175,378 (3.1%) were identified as containing at least one reference to a SDoH. Of the records in this corpus, 171,740 (97.93%) contained only one identifiable reference to SDoH, while 3,580 records (2.04%) contained two identifiable references; 57 (0.03%) contained three identifiable references; and one of the records (<0.01%) contained four identifiable references to SDoH. Records containing appearances of SDoH in the corpus were as follows: housing (52.28%); employment (33.06%); general financial (8.04%); insurance (4.73%); social support (3.86%); and food (0.14%).

Social Topics Illustrated in Emergency Medical Services Records

Similar SDoH topics were identified throughout the various social determinant categories. These SDoH topics were accessibility, mental health concerns, physical health concerns, and substance use. Examples of the social topics' appearances in each determinant category can be found in the Table.

Accessibility

All determinant categories included documentation of concerns about patients' lack of access to services or goods, often because of an inability to afford or physically get to their needed interventions. Patients with employment/income insecurities were documented as unable to afford safe housing, medications, or medical care. Attending EMS professionals linked these financial constraints to the calls for help, particularly when ambulances were used as a means of transportation or facilitators for additional, non-urgent care, such as access to medications, treatments, or social services. It was also noted that financial barriers to access compounded existing health conditions because patients could not afford necessary medications or follow-up care. When other patients with documented financial insecurities encountered EMS for non-chronic conditions (eg, motor vehicle collisions or falls), they refused treatment and transport by EMS because of reported inabilities to afford ambulance or hospital bills.

When documenting food insecurities, EMS personnel wrote that patients could not readily afford or access nutritious foodstuffs. In some cases, patients were reported as selling, skipping, or misusing medications to divert funds to their food budgets. Housing insecurity information was documented because of patients' lack of safe or permanent

Table 1. Representative quotes for each social topic within each determinant category.

		Social Topics			
		Accessibility	**Mental health**	**Physical health**	**Substance use**
SDoH categories	Food	"She had been standing in line outside <the food bank> for approx. 30min, felt light headed <sic>, and passed out . . . states she hasn't eaten since yesterday."	"<The patient> advised that he was suicidal because his roommates had been bullying him by taking his belongings, including his phone, food stamps, etc. <He> also advised that he was feeling homicidal, but that those feelings had passed."	"<The patient> states she vomited yesterday and her chest hurts today . . . she went to WIC today to get food at the food bank."	"He relays he was on a meth binge over the weekend and feels tired but needs to be here to get his food stamps for the week."
	Employment/ income	Male at day labor staffing building "was standing next to the counter and began having a seizure . . . <the patient> states he does have a hx of seizures and has been off his Keppra for quite some time now, 'states he can't afford it.'"	Patient living in a community facility "started having hallucinations . . . <The patient> was talking about baby geese that staff did not see."	"<The patient> states he felt dizzy and went to ground from seated position. <The patient> states he feels fine and is refusing all treatment or transport . . . <he> states he is a diabetic but <cannot> afford medical bill<s>. <His mother> states she will take him to the ED."	Dispatched to a motel for a stroke: "<the patient> is homeless but came to stay with her sister . . . <the patient> admitted to smoking marijuana this morning . . . She advised <of medical history including> drug use and she hasn't drank <sic> alcohol in several days . . . or eaten in a few days."
	Financial	The patient presented as "hyperglycemic, hypertensive, <with altered mental status> . . . He has a history of hypertension and diabetes, but it is not controlled with medications, as he has been unable to afford them for several months."	A representative from the patient's bank called because the patient "had made suicidal comments to them during a phone conversation involving a bill . . . <the patient> states that she is depressed about the passing of her husband and has been having financial issues as well."	"The patient stated she has a history of COPD and had complications <with> breathing for the past 12 hours . . . The patient stated she is normally on home oxygen but has been unable to afford her medications this month."	After receiving naloxone, "she began to come around. She admitted to alcohol use but no other drugs . . . she wanted to sign out of the hospital before she accumulated any bills because she felt they could not afford them."
	Insurance	Patient "reporting a headache that started last night at 1900 hours due to withdrawals from Depakote and amitriptyline. She reports she has been out approx. one week due to the cost because she lost her Medicaid."	Call for psychiatric complaints and crew found the patient requesting assistance "getting her Medicaid . . . pt was being uncooperative and yelling angrily . . . pt refused <transport>, becoming angry again and stating she didn't want to go to the ED and that she just wanted her Medicaid again."	After an MVC, a patient complained of "lower back pain . . . Patient stated she wanted to be check out by EMS but refuse to be transport by EMS due to no insurance."	The patient left an ED for a heroin overdose . . . "patient became belligerent and aggressive when asked about drug use since leaving <hospital> patient stated the blood <on his face> was from him vomiting blood and the abrasions were for <an> allergic reaction to the <heroin> . . . patient does not have insurance."

(*Continued on next page*)

Table 1. Continued.

	Social Topics			
	Accessibility	**Mental health**	**Physical health**	**Substance use**
Social support	Patient at a physician's office was found hypertensive. "The patient's niece related that there has been a problem with the patient's pharmacy and <the medications have not been in stock>." The niece also reported the patient lives alone and, while she checks on him, "she feels that he is not taking them because he doesn't remember to <take his medications>."	The patient's friend reported, "she started hiding in different places in the house . . . <then went> into a neighbor's garage <to> hide from her friend . . . " When a police officer arrived, the patient "stated she did not want to be shot and put her hands over her head as if she was told to raise her hands." After speaking with a mental health professional on scene, "a family friend came and . . . stated that she would take her to the hospital and pick up her medication."	The patient called 911 for chest pain and reported inability "to sleep . . . nausea and felt like she might faint. She waited to see if she would improve. as time went by, she states she became more worried and finally decided to call 911." She refused transport and "admits her anxiety was a significant factor in her calling 911. Pt frequently calls 911. Pt lives alone." Her visiting nurse was due soon and the "patient does not believe her nurse will make her go as she is feeling better."	An elderly female who lived alone was checked on by a friend who found her stating she had "progressively been feeling weaker over the past week . . . pt is normally able to walk and take care of herself with no assistance." The patient's friend also revealed the patient "is an alcoholic and was drinking heavily up until one week ago."
Housing	Call for patient at facility who seized: "staff states <the patient was without> his medications x1 week. <The patient> states they were stolen from him while he as at the homeless center."	Homeless shelter staff called because the patient "was walking around with broken glass bottles and was paranoid." The patient was "hyper paranoid. And stated, 'they are trying to kill me.' <The patient> advised that 'some put a hit' out on her and that someone has been following her."	"Found a <female patient> at local women's shelter with c/c of contractions, abdominal pain. <The patient> states she is 34 w pregnant with twins."	"Patient advised he is addicted to meth and wants to get help with detox." Upon arriving the homeless shelter, "he did about ½ gram of meth about two hours ago . . . he attempted to spray 'bleach bathroom cleaner' in his mouth to assist him in passing a drug test."

Approx., approximately; min, minute; *WIC,* Women, Infants and Children; *hx,* history; *ED,* emergency department; *pt,* patient; *MVC,* motor vehicle collision; *EMS,* emergency medical services; *w*, weeks.

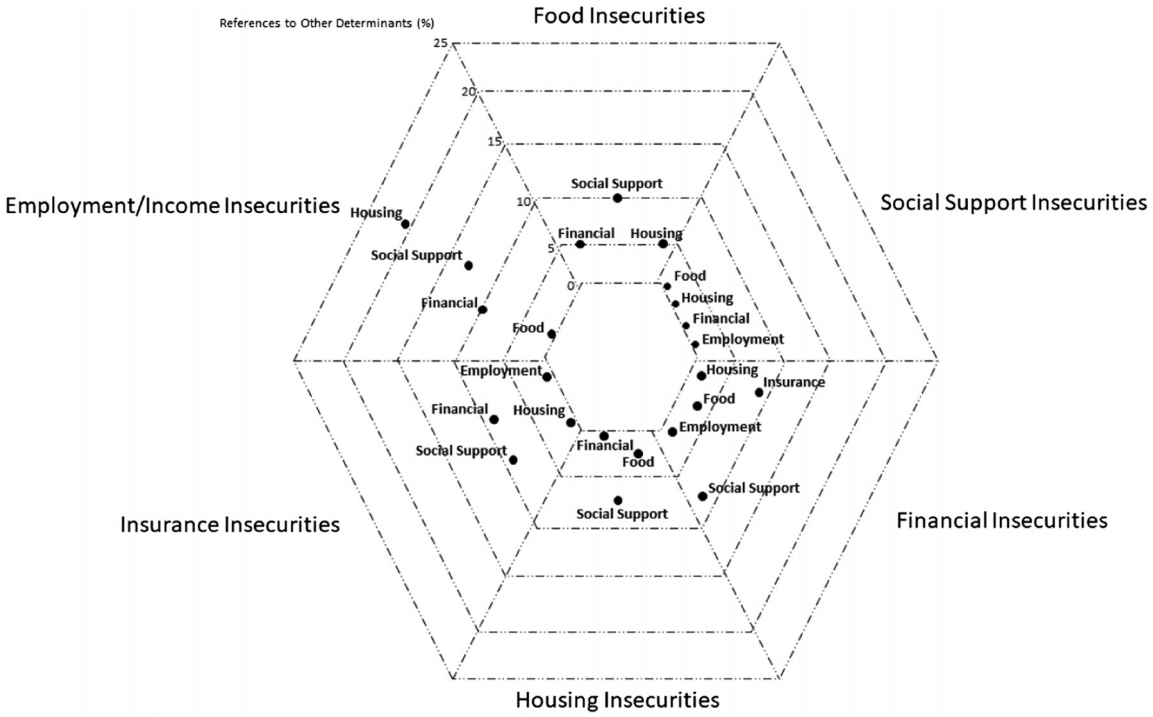


Figure 1. Explicit references to other determinant categories in charts (%).

housing, which may have presented problems upon discharge. Insurance insecurities were documented because of a lack of access to health insurance, sometimes secondary to lack of employment; however, more often, EMS personnel wrote about patients' using the 9-1-1 system to express their desires to obtain insurance or care covered by insurance. These patients explicitly requested help in signing up for insurance or referrals to other sectors of the healthcare system, and in one case a person called 9-1-1 for transport to a facility to have an already prescribed medical procedure because their insurance would not otherwise cover it as an outpatient treatment. In the documentation of social support insecurities, patients lacked family members, friends, or healthcare personnel to aid in safely caring for their conditions, accessing food, or finding safe living environments. When strong social support was available, access to resources and assistance was clearly documented in this determinant category.

Mental Health Concerns

When mental health concerns were documented, regardless of determinant category, EMS professionals conveyed they were precipitated by the insecurities. Patients with employment and food insecurities expressed depression or suicidality while patients with housing insecurities primarily described anxiety. Those with documented financial and insurance insecurities also reported suicidality, but the EMS professionals explicitly linked the cause of financial constraints as ongoing expenses of chronic health conditions. Additionally, there were cases of documented elder or financial abuse perpetrated on or by patients who interacted with EMS. Those with social support insecurities were primarily anxious or nervous about living alone, but these issues often were not the reasons for why the calls were made for emergency services.

Physical Health Concerns

Patients with employment and housing insecurities were often found outside, exposed to the elements, and with complaints related to those conditions. For example, many complained of pain in their legs or backs that could have been attributed to their frequent walking or hot- or cold-related issues. Some of these cases were results of calls for other conditions, but EMS crews often found these patients were more interested in shelter than medical care at the hospital. Those with food insecurities complained of weakness, hypoglycemia, or near or completed syncope, particularly while standing in line, awaiting access to a food bank. Some reported being without food because of financial problems, but others reported they had no other way of accessing goods without community resources. In some cases, patients reported prioritizing accessing medications over food. Those with financial and insurance insecurities most often complained of manifestations of their chronic conditions and inability to treat them. In some cases, patients with both determinant types had acute health concerns and many had diagnoses, but they could not afford or otherwise access the prescribed treatments. Patients with social support

insecurities most often complained of acute medical- or trauma-related issues and an inability to properly address them. These patients were most often elderly patients who complained of weakness and falls.

Substance Use

Patients with documented employment and housing insecurities were more often described to be using or withdrawing from various substances. Those with food insecurities were also described as engaging in heavy use of substances while their ability to access or not access food was documented. Documentation of alcohol use with food, financial, housing, insurance, and social support insecurities were rarely associated with patients' complaints or conditions, but they were frequently written about as part of the scene-setting descriptions.

Relationships Between Determinant Categories

Within the social determinants categories, EMS personnel sometimes documented links to other determinant categories. For example, when a chart was flagged because of a documented food insecurity, EMS personnel included information about concurrent housing, financial, or social support insecurities. (See Figure for articulated relationships between determinant categories.) Some of these relationships were unidirectional (eg, insurance insecurities were linked to social support insecurities, but social support insecurities were not linked to insurance insecurities), although there were frequent bidirectional referrals between determinants but for varying reasons. For example, patients with financial insecurities refused EMS treatment and transport because they were documented as reporting a lack of insurance, but patients with insurance insecurities requested EMS transportation because they could not afford alternative treatment or transport.

Most often, however, the other determinants were not explicitly referenced in the documentation, but plausible explanations could be inferred from context. For example, in the case of a patient with housing insecurity, the EMS professional documented the patient had not eaten or taken their medications in several days. These elements could be indicative of food, insurance, or financial insecurities, but they were not explicitly cited.

Appraisal of EMS Professionals' Perspectives

When EMS professionals wrote about employment, food, and housing insecurities, most of the appraisals were negative and appeared to discursively position the patients as at fault for their 9-1-1 complaints and life conditions. Some of the content in these narratives was unnecessary and unrelated to the patients' needs within the context of the EMS call. For example, in the case of a patient with housing insecurity who complained of lower extremity pain, the writer included several insertions about how the patient did not appear to have discomfort or unsteady gait and hypothesized the patient had ulterior motives for the call to 9-1-1. For those with insurance insecurity, most of the documentation in the EMS narratives included inability for patients or crew members to obtain the billing information for another part of the chart. Narratives for patients with financial or social support insecurities contained less perceivable negativity in the descriptions of those patients' conditions.

Within the social support category, specifically, the narratives were generally much longer than in the other categories and the scenes were described with greater detail. Although some of the patients were documented as repeat customers, the overtone was positive, and the EMS professionals described their familiarity in association with the help they provided for the patients in the current and previous interactions. Only the social support insecurities category contained descriptions of the advocacy work provided by the EMS crews on the scene, including referrals to mobile integrated health or other community resources, assisting in patients' errands, calling a patient's primary healthcare physician for them, or delivering food from their own station so the patient could eat a meal. This category also contained richer descriptions of safety concerns for patients who lived in homes, generally alone, yet the reflection of safety concerns did not come up for patients who did not have homes, food, medications, or money.

DISCUSSION

Understanding how EMS professionals document SDoH within electronic health records is vital for improving emergency care, subsequent treatment, and outcomes for patients with insecurities. Most often, SDoH information was not included in EMS records and, when present, was neither holistic nor interconnected to other insecurities that may impact a patient's health and well-being. Additionally, EMS personnel often—likely unintentionally—wrote about patients' insecurities with a negative valence or tone. Such negativity in health records has demonstrated downstream impressions of the patients themselves.[30]

Because EDs are venues that perform as safety nets for myriad health and social problems, there are proposals for employing social emergency care to screen and connect patients with the resources they need to address their insecurities.[6,31] As members of the patients' care teams, EMS professionals should be included in any efforts to collect and apply information about patients' SDoH. Patient navigators and other hospital personnel collect data and add SDoH information to patients' medical records,[31,32] but hospital personnel should be aware of the EMS records' content and the reduced likelihood of social desirability bias or influence by the EMS professionals.

Social EM is a burgeoning sub-field of EM[6] and can be seen as a way for the EMS profession to expand its scope, as well. Calls to expand training and curricula for emergency

practitioners[33,34] can be extended to EMS professionals to improve the quantity and quality of SDoH-related content in EMS records. While addressing SDoH in all medical records, terminology should be consistent to avoid miscommunication.[8] Systematic and prescribed formatting for verbal hand-offs from EMS to ED personnel have improved efficacy and information transmission,[11,16,18,35] and the National Emergency Medical Services Information System (NEMSIS)[36] has standardized and improved the collection of EMS data. The creation of a specific data collection tool can increase and improve information acquisition and neutral reporting of patients' SDoH.

Additionally, recent initiatives to address patients' needs and avoid unnecessary transports to overwhelmed EDs—such as the Emergency Triage, Treat, and Transport (ET3) Model[37]—by addressing SDoH through community engagement have resulted in fewer unnecessary calls to 9-1-1, fewer unnecessary visits to EDs, less out-of-service time for first responder units, and decreased incidence of patient falls.[38,39] All EMS personnel should learn about the resources available in their own communities for addressing SDoH (eg, emergency shelters, food banks, or home healthcare and outreach organizations). If EMS professionals are aware of support services in their communities, they may be more likely to help their patients make necessary connections. Emergency medical services personnel of all levels and in all organization types should undergo specific training to recognize and address patients' insecurities. Future research about EMS personnel's knowledge about SDoH, their roles in this type of data collection, and perceptions of education about the topic may be informative to EMS and other fields' implementation of interventions to improve longitudinal patient care.

Over the past several years, increased recognition and research linking emergency care and SDoH have significantly impacted the volume of literature in this salient area. These studies have examined SDoH and training,[33,34,40,41] documentation and screening,[8,23,42–44] interventions,[6,45,46] homelessness,[47] mental health,[48,49] insurance types,[50] and links to chronic or acute illness and injuries.[7,51–54] Nearly all of these studies focused on EDs, which are not the only points of contact for all patients seeking emergency care and lack the perspective of seeing from where a patient hails. Emergency medical services personnel have the benefit of sharing in patients' lived experiences and interacting with patients who may not subsequently present to EDs. This study provides a view from this novel vantage point.

LIMITATIONS

The narratives analyzed in this study were from EMS records from various sources throughout the US, including first response agencies, transporting ambulance agencies, and flight EMS organizations. The certification levels of the EMS personnel were unknown during analysis. There may be differences in documentation of SDoH based on geographic location, organization types, or levels of training. Since this was a retrospective analysis of free-text narratives, we did not assess other sections of the records for information about patients' SDoH. Given the de-identified nature of this dataset, it was also unclear whether individual agencies provided guidance to their personnel about SDoH or their documentation. Additionally, this analysis leveraged records from a large convenience sample of EMS agencies that use a single, privately owned electronic health record system; thus, the generalizability of these findings to communities served by EMS agencies using other documentation systems is unknown.

The use of three qualitative researchers and joint analysis sessions may have increased the potential for groupthink, which could have narrowed the focus on themes and concepts for the benefit of consensus-building. Future studies should evaluate whether these variables are associated with SDoH documentation and valence of EMS personnel's perspectives. Use of the interpretive paradigm and hermeneutical approach could account for any potential differences in message reception and intention during documentation.

CONCLUSION

Addressing social determinants of health can lead to improved health outcomes, reduced strain on healthcare systems, and decreased health spending. Emergency medical services professionals are uniquely positioned to collect and share information on patients' SDoH through their documentation, but the overwhelming majority of EMS records lack such content. Education about SDoH and their relationships to one another, along with training on how to neutrally include such content in their documentation can be beneficial for EMS professionals and their patients. The creation of standardized educational content and documentation tools to collect SDoH information and collections of organizations' community resources for addressing insecurities may improve EMS professionals' awareness, documentation, and treatment of SDoH.

Address for Correspondence: Susan J. Burnett, MS, EMT-P, Jacobs School of Medicine and Biomedical Sciences University at Buffalo, The State University of New York, Department of Emergency Medicine, 77 Goodell St., Buffalo, NY 14203. Email: burnett8@buffalo.edu

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. Dr. Clemency is a speaker/consultant for Stryker. The other authors have no funding or conflicts of interest to disclose.

REFERENCES

1. Centers for Disease Control and Prevention. About Social Determinants of Health (SDOH). Published March 10, 2021. Available at: https://www.cdc.gov/socialdeterminants/about.html. Accessed September 24, 2022.
2. Thornton RLJ, Glover CM, Cené CW, et al. Evaluating strategies for reducing health disparities by addressing the social determinants of health. *Health Aff (Millwood)*. 2016;35(8):1416–23.
3. Hammond G, Johnston K, Huang K, et al. Social determinants of health improve predictive accuracy of clinical risk models for cardiovascular hospitalization, annual cost, and death. *Circ Cardiovasc Qual Outcomes*. 2020;13(6):e006752.
4. Office of Disease Prevention and Health Promotion USD of H and HS. Social Determinants of Health - Healthy People 2030 | health.gov. Available at: https://health.gov/healthypeople/priority-areas/social-determinants-health. Accessed March 7, 2022.
5. Gottlieb L, Sandel M, Adler NE. Collecting and applying data on social determinants of health in health care settings. *JAMA Intern Med*. 2013;173(11):1017–20.
6. Anderson ES, Lippert S, Newberry J, et al. Addressing social determinants of health from the emergency department through social emergency medicine. *West J Emerg Med*. 2016;17(4):487–9.
7. Foster CC, Simon TD, Qu P, et al. Social determinants of health and emergency and hospital use by children with chronic disease. *Hosp Pediatr*. 2020;10(6):471–80.
8. Samuels-Kalow ME, Ciccolo GE, Lin MP, et al. The terminology of social emergency medicine: measuring social determinants of health, social risk, and social need. *J Am Coll Emerg Physicians Open*. 2020;1(5):852–6.
9. National Highway Traffic Safety Administration Office of EMS. EMS.gov | What is EMS? What is EMS? Available at: https://www.ems.gov/whatisems.html. Accessed September 24, 2022.
10. Halter M, Vernon S, Snooks H, et al. Complexity of the decision-making process of ambulance staff for assessment and referral of older people who have fallen: a qualitative study. *Emerg Med J*. 2011;28(1):44–50.
11. Bost N, Crilly J, Patterson E, Chaboyer W. Clinical handover of patients arriving by ambulance to a hospital emergency department: a qualitative study. *Int Emerg Nurs*. 2012;20(3):133–41.
12. Meisel ZF, Shea JA, Peacock NJ, et al. Optimizing the patient handoff between emergency medical services and the emergency department. *Ann Emerg Med*. 2015;65(3):310–7.e1.
13. Horsky J, Suh EH, Sayan O, et al. Uncertainty, case complexity and the content of verbal handoffs at the emergency department. *AMIA Annu Symp Proc*. 2015;2015:630–9.
14. Goldberg SA, Porat A, Strother CG, et al. Quantitative analysis of the ontent of EMS handoff of critically ill and injured patients to the emergency department. *Prehosp Emerg Care*. 2017;21(1):14–7.
15. Horwitz LI, Moin T, Krumholz HM, et al. Consequences of inadequate sign-out for patient care. *Arch Intern Med*. 2008;168(16):1755–1760.
16. Maddry JK, Arana AA, Clemons MA, et al. Impact of a standardized EMS handoff tool on inpatient medical record documentation at a Level I trauma center. *Prehosp Emerg Care*. 2021;25(5):656–63.
17. Ong MS, Coiera E. A systematic review of failures in handoff communication during intrahospital transfers. *Jt Comm J Qual Patient Saf*. 2011;37(6):274–84.
18. Reay G, Norris JM, Nowell L, et al. Transition in care from EMS providers to emergency department nurses: a systematic review. *Prehosp Emerg Care*. 2020;24(3):421–33.
19. Troyer L, Brady W. Barriers to effective EMS to emergency department information transfer at patient handover: a systematic review. *Am J Emerg Med*. 2020;38(7):1494–503.
20. American College of Emergency Physicians. Transfer of Patient Care Between EMS Providers and Receiving Facilities. Available at: https://www.acep.org/patient-care/policy-statements/transfer-of-patient-care-between-ems-providers-and-receiving-facilities/. Accessed March 7, 2022.
21. Lowery B, D'Acunto S, Crowe RP, et al. Using natural language processing to examine social determinants of health in prehospital pediatric encounters and associations with EMS transport decisions. *Prehosp Emerg Care*. 2022;0(0):1–6.
22. Data and Research - ESO. Published 2023. Available at: https://www.eso.com/data-and-research/. Accessed March 21, 2023.
23. Stemerman R, Arguello J, Brice J, et al. Identification of social determinants of health using multi-label classification of electronic health record clinical notes. *JAMIA Open*. 2021;4(3):ooaa069.
24. Tracy S. *Qualitative Research Methods: Collecting Evidence, Crafting Analysis, Communicating Impact*. Hoboken, NJ: Wiley-Blackwell, 2013.
25. Glaser BG, Strauss AL. *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Manchester, UK: John Rylands Library: Aldine Publishing; 1967.
26. Strauss AL, Corbin JM. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Thousand Oaks, CA: Sage; 1998.
27. Saldaña J. *The Coding Manual for Qualitative Researchers*. 3rd ed. Thousand Oaks, CA: Sage; 2016.
28. Charmaz K. *Constructing Grounded Theory*. 2nd ed. Thousand Oaks, CA: Sage; 2014.
29. Low J. A Pragmatic definition of the concept of theoretical saturation. *Sociol Focus*. 2019;52(2):131–9.
30. Park J, Saha S, Chee B, et al. Physician use of stigmatizing language in patient medical records. *JAMA Netw Open*. 2021;4(7):e2117052.

31. Friedman NL, Banegas MP. Toward addressing social determinants of health: a health care system strategy. *Perm J*. 2018;22:18–95.
32. Thomas-Henkel C, Schulman M. Screening for social determinants of health in populations with complex needs: implementation considerations. 2017. Available at: https://www.chcs.org/media/SDOH-Complex-Care-Screening-Brief-102617.pdf. Accessed September 25, 2022.
33. Axelson DJ, Stull MJ, Coates WC. Social determinants of health: a missing link in emergency medicine training. *AEM Educ Train*. 2017;2(1):66–8.
34. Moffett SE, Shahidi H, Sule H, et al. Social determinants of health curriculum integrated into a core emergency medicine clerkship. *MedEdPORTAL*. 2019:10789.
35. Smith CJ, Buzalko RJ, Anderson N, et al. Evaluation of a novel handoff communication strategy for patients admitted from the emergency department. *West J Emerg Med*. 2018;19(2):372–9.
36. National Highway Traffic Safety Administration Office of EMS. What is NEMSIS. NEMSIS. Available at: https://nemsis.org/what-is-nemsis/. Accessed September 25, 2022.
37. Centers for Medicare & Medicaid Services. Emergency Triage, Treat, and Transport (ET3) Model. Published July 28, 2022. Available at: https://cmmicoordinator.survey.fm/was-this-helpful?iframe=https%3A%2F%2Finnovation.cms.gov%2Finnovation-models%2Fet3&ft=1. Accessed September 25, 2022.
38. Bronsky ES, McGraw C, Johnson R, et al. CARES: a community-wide collaboration identifies super-utilizers and reduces their 9-1-1 call, emergency department, and hospital visit rates. *Prehosp Emerg Care*. 2017;21(6):693–9.
39. Yoder CM, Pesch MS. An academic-fire department partnership to address social determinants of health. *J Nurs Educ*. 2020;59(1):34–8.
40. Balhara KS, Irvin N. A community mural tour: facilitating experiential learning about social determinants of health. *West J Emerg Med*. 2021;22(1):60–2.
41. Grossman LG, Mechanic OJ, Orr Z, et al. An analysis of social determinants of health and structural competency training in global emergency medicine fellowship programs in the United States. *AEM Educ Train*. 2021;5(S1):S28–32.
42. Gottlieb L, Hessler D, Long D, et al. A randomized trial on screening for social determinants of health: the ISCREEN study. *Pediatrics*. 2014;134(6):e1611–8.
43. Hsieh D. Achieving the quadruple aim: treating patients as people by screening for and addressing the social determinants of health. *Ann Emerg Med*. 2019;74(5):S19–24.
44. Wallace AS, Luther BL, Sisler SM, et al. Integrating social determinants of health screening and referral during routine emergency department care: evaluation of reach and implementation challenges. *Implement Sci Commun*. 2021;2(1):114.
45. Walter LA, Schoenfeld EM, Smith CH, et al. Emergency department–based interventions affecting social determinants of health in the United States: A scoping review. *Acad Emerg Med*. 2021;28(6):666–74.
46. Ordonez E, Dowdell K, Navejar NM, et al. An assessment of the social determinants of health in an urban emergency department. *West J Emerg Med*. 2021;22(4):890–7.
47. Doran KM, Kunzler NM, Mijanovich T, et al. Homelessness and other social determinants of health among emergency department patients. *J Soc Distress Homelessness*. 2016;25(2):71–7.
48. Barker LC, Bronskill SE, Brown HK, et al. Hospital admission at the time of a postpartum psychiatric emergency department visit: the influence of the social determinants of health. *Epidemiol Psychiatr Sci*. 2021;30:e33.
49. Shyman L, Sukhorukov R, Barbic D, et al. Social determinants of health and depression in adults presenting to the emergency department: Implications for family medicine. *Can Fam Physician*. 2021;67(12):e337–47.
50. McCarthy ML, Zheng Z, Wilder ME, et al. The influence of social determinants of health on emergency departments visits in a medicaid sample. *Ann Emerg Med*. 2021;77(5):511–22.
51. Balhara KS, Fisher L, El Hage N, et al. Social determinants of health associated with hemodialysis non-adherence and emergency department utilization: a pilot observational study. *BMC Nephrol*. 2020;21(1):4.
52. Baptiste DL, Turkson-Ocran RA, Han HR, et al. Social determinants of emergency department visits among persons diagnosed with coronary heart disease and stroke. *Ethn Dis*. 31(1):41–6.
53. Cortright L, Buckman C, Tumin D, et al. Social determinants of health and emergency department use among children with sickle cell disease. *J Pediatr Hematol Oncol*. 2020;42(1):e42–5.
54. Singu S, Acharya A, Challagundla K, et al. Impact of social determinants of health on the emerging COVID-19 pandemic in the United States. *Front Public Health*. 2020. Available at: https://www.frontiersin.org/articles/10.3389/fpubh.2020.00406. Accessed March 3, 2023.

Racial Differences in Triage for Emergency Department Patients with Subjective Chief Complaints

Cassandra Peitzman, MD, PhD, MPH
Jossie A. Carreras Tartak, MD, MBA
Margaret Samuels-Kalow, MD, MSHP, MPhil
Ali Raja, MD, MBA, MPH
Wendy L. Macias-Konstantopoulos, MD, MPH, MBA

Massachusetts General Hospital, Harvard Medical School, Department of Emergency Medicine, Boston, Massachusetts

Section Editor: Rama Salhi, MD
Submission history: Submitted September 29, 2022; Revision received March 30, 2022; Accepted April 10, 2023
Electronically published August 30, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59044

Introduction: Black and Hispanic patients are frequently assigned lower acuity triage scores than White patients. This can lead to longer wait times, less aggressive care, and worse outcomes. In this study we aimed to determine whether these effects are more pronounced for patients with subjective complaints.

Methods: We performed a retrospective analysis for all adult visits between 2016-2019 at an urban academic emergency department (ED) with acuity-based pods. We determined rates of initial high-acuity triage both across all patients and among the subset located in the high-acuity pod at time of disposition (either through initial assignment or subsequent up-triage). Analysis was performed for common chief complaints categorized as subjective (chest pain, dyspnea, any pain); observed (altered mental status); numeric (fever, hypotension); or protocolized (stroke, ST-elevation myocardial infarction). We constructed logistic regression models to control for age, race, gender, method of arrival, and final disposition.

Results: We analyzed 297,355 adult ED visits. Black and Hispanic patients were less likely to be triaged to high-acuity beds (adjusted odds ratio [aOR] 0.76, 95% confidence interval [CI] 0.73-0.79 for Black, and aOR 0.87, 95% CI 0.84-0.90 for Hispanic patients). This effect was more pronounced for those with subjective chief complaints, including chest pain (aOR 0.76, 95% CI 0.73-0.79 for Black and 0.88, 95% CI 0.78-0.99 for Hispanic patients), dyspnea (aOR 0.79, 95% CI 0.68-0.92 and 0.8, 95% CI 0.72-0.99), and any pain (aOR 0.83, 95% CI 0.75-0.92 and 0.89, 95% CI 0.82-0.97, respectively). Among patients in the high-acuity pod at time of disposition, Black and Hispanic patients were disproportionately triaged to lower acuity pods on arrival (aOR 1.47, 95% CI 1.33-1.63 for Black and aOR 1.27, 95% CI 1.15-1.40 for Hispanic adults), with significant differences observed only for subjective chief complaints. No differences were observed for observed, objective, or protocolized complaints in either analysis.

Conclusion: Black and Hispanic adults, including those who ultimately required high-acuity resources, were disproportionately triaged to lower acuity pods. This effect was more pronounced for patients with subjective chief complaints. Additional work is needed to identify and overcome potential bias in the assessment of patients with subjective chief complaints in ED triage. [West J Emerg Med. 2023;24(5)888–893.]

INTRODUCTION

Over the past several decades, a robust literature has developed demonstrating racial-, gender-, and language-based disparities in the quality and intensity of medical care in the United States.[1–5] Black and Hispanic patients are consistently offered less intensive care,[6–8] subjected to longer

wait times,[9] and seen as less acutely ill then their White counterparts, even when controlling for other possible explanatory factors.[10,11] In some cases, these differences can lead to delays in care, inadequate intensity of intervention or monitoring,[12–16] and greater risk of adverse outcomes.[17]

Triage provides a natural context in which to assess encounter-level drivers of such disparities because of both its well-defined, episodic nature and because it initiates a treatment path that may influence a patient's care throughout their clinical course. In this study we sought to 1) determine whether racial differences are present in either initial rates of high-acuity triage or need for later re-assignment to a high-acuity pod and 2) whether these differences vary by patient chief complaint. We hypothesized that Black and Hispanic patients experience higher rates of under-triage, and these differences are more pronounced for patients presenting with subjective or symptom-based chief complaints. This hypothesis is in keeping with prior literature suggesting that subjective assessments with incomplete information may lead to greater introduction of bias,[18] whereas chief complaints that trigger clear protocols (such as ST-elevation myocardial infarction [STEMI] or stroke alerts) may tend toward more prescriptive and, therefore, less biased triage processes. We hope that by identifying the circumstances under which racial disparities in triage appear, we may better understand and thereby intervene and act upon the phenomena that drive them.

Population Health Research Capsule

What do we already know about this issue?
Racial disparities in triage can lead to less aggressive care and worse outcomes.

What was the research question?
Is race-based triage more pronounced for patients with subjective chief complaints, such as pain and dyspnea?

What was the major finding of the study?
Black and Hispanic patients were less likely than similar White patients to be triaged to high-acuity bays when presenting with chest pain (aOR 0.76 for Black and 0.88 for Hispanic patients), dyspnea (aOR 0.79 and 0.80), or any pain (aOR 0.83 and 0.89). However, patients whose complaints activated protocolized pathways (e.g., "Code Stroke") were triaged identically across racial groups.

How does this improve population health?
Further integration of objective data (eg, vital signs and ECGs) and protocols for specific complaints may help reduce disparities in triage.

METHODS

We conducted a retrospective analysis of all adult patient visits between 2016–2019 to an urban academic ED with nursing-led triage to acuity-based pods (including low-acuity/fast-track, mid-acuity, and critical-care/high-acuity pods) based on hospital-specific, resource-based guidelines. Our analysis considered both the full set of visits and selected chief complaints, which were chosen to represent four types of complaint: "subjective" complaints were those relating to patients' reports of their own symptoms; "objective" complaints were defined by numeric cutoffs in prehospital or home assessments; "observed" complaints were subjectively defined but reported based on assessments by a third party; and finally, "protocolized" chief complaints were defined as those for which triage is assigned by protocol.

For this, we included the three most common chief complaints with at least a 20% rate of high-acuity triage (chest pain and shortness of breath as "subjective" complaints and altered mental status as "observed"). "Objective" complaints included both the most common and highest acuity complaints with numerical definitions (fever and hypotension). Two common "protocolized" chief complaints (STEMI and stroke) were also included. To better assess a broad group of subjective complaints, we assessed an additional category of any chief complaint including "pain," (approximately 10% of which was initially triaged as high acuity). Chief complaints were identified via search and manual review of free-text chief complaints entered at triage. Racial categories were taken from data entered at time of registration, with pooled categories including Black, White, Asian, multiracial, other, and unknown. Records with missing variables (316 total) were excluded from the analysis.

We evaluated two outcomes of interest: relative probability of initial triage to the high-acuity pod (Table 2a) and relative probability of having required up-triage (reassignment to the

Table 1. Summarized racial, gender, and age distribution of full adult emergency department sample 2016–2019.

	Mean age (years)	Percentage male	Percentage high-acuity triage	Number
White	50.7	52.9%	19%	210,596
Black	42.4	52.7%	11.7%	32,645
Hispanic	34.0	49.9%	10.6%	49,973
Asian	41.5	47.1%	14.3%	14,875
Multiracial	41.48	51.5%	14.6%	8,216
Other	37.7	51.4%	11%	10,833
Unknown	39.4	53.7%	20.1%	7,154

Table 2. (A) Adjusted odds of initial triage to high-acuity pod and (B) adjusted odds of initial lower-acuity triage among patients completing emergency department (ED) course in high-acuity pod among adult ED patients 2016–2019, stratified by chief complaint. Controls included for age, age squared, age categories (18–44 years, 45–64 years, 65+ years), ED death and admission. "Other" and "Unknown" racial categories omitted for clarity. STEMI and stroke-alert patients were uniformly triaged to a high-acuity setting and, therefore, regression analysis was not possible. Results reported as adjusted odds ratios with 95% confidence intervals.

2A. Adjusted odds of triage to high-acuity pod by race

Chief complaint	All patients	Chest pain	Dyspnea	Pain	Fever	Hypotension	AMS
Black	0.76***	0.77***	0.79**	0.83***	1.08	0.99	1.06
	(0.73, 0.79)	(0.67, 0.88)	(0.68, 0.92)	(0.75, 0.92)	(0.85, 1.37)	(0.70, 1.41)	(0.44, 2.54)
Hispanic	0.87***	0.88*	0.84*	0.89**	1	0.99	1.07
	(0.84, 0.90)	(0.78, 0.99)	(0.72, 0.99)	(0.82, 0.97)	(0.77, 1.30)	(0.76, 1.29)	(0.46, 2.51)
Asian	1.06*	1.07	1.15	1.13	1.24	1.33*	2.63
	(1.01, 1.12)	(0.88, 1.30)	(0.92, 1.44)	(0.99, 1.30)	(0.84, 1.82)	(1.01, 1.75)	(0.74, 9.30)
Multiracial	0.91*	1.15	0.9	1.05	0.69	1.05	2.32
	(0.85, 0.98)	(0.88, 1.50)	(0.68, 1.20)	(0.88, 1.26)	(0.44, 1.06)	(0.62, 1.78)	(0.27, 20.20)
Gender (male)	1.26***	1.55***	1.27***	1.58***	1.03	1.21*	1.23
	(1.23, 1.28)	(1.43, 1.68)	(1.18, 1.38)	(1.50, 1.67)	(0.91, 1.18)	(1.04, 1.40)	(0.82, 1.84)
BIBA[a]	3.01***	2.66***	1.78***	2.59***	2.16***	2.39***	1.80**
	(2.95, 3.07)	(2.45, 2.88)	(1.64, 1.93)	(2.45, 2.73)	(1.88, 2.48)	(2.04, 2.81)	(1.20, 2.69)
Observations	297,034	16,171	13,150	73,486	4,108	6,331	638

2B. Adjusted odds of initial lower-acuity triage for patients requiring high-acuity resources prior to disposition by race

Chief complaint	All patients	Chest pain	Dyspnea	Pain	Fever	Hypotension	AMS
Black	1.47***	1.68***	1.3	1.47***	1.15	0	1.28
	(1.33, 1.63)	(1.25, 2.26)	(0.90, 1.89)	(1.18, 1.83)	(0.49, 2.70)	(0.00, Inf)	(0.64, 2.55)
Hispanic	1.27***	1.08	1.54*	1.11	1.34	1.28	1.17
	(1.15, 1.40)	(0.79, 1.47)	(1.06, 2.24)	(0.90, 1.37)	(0.72, 2.48)	(0.12, 13.10)	(0.52, 2.63)
Asian	1.09	1.09	1.01	1.15	1.23	2.3	1.52
	(0.94, 1.26)	(0.70, 1.72)	(0.57, 1.79)	(0.85, 1.56)	(0.65, 2.35)	(0.26, 20.40)	(0.53, 4.37)
Multiracial	1.11	1.64	1	1.59*	1.68	0	2.06
	(0.91, 1.36)	(0.98, 2.77)	(0.45, 2.19)	(1.08, 2.35)	(0.53, 5.26)	(0.00, Inf)	(0.70, 6.05)
Gender (male)	0.91**	1.03	0.77*	0.91	0.94	0.35	1.34
	(0.86, 0.96)	(0.85, 1.25)	(0.63, 0.95)	(0.80, 1.03)	(0.66, 1.35)	(0.08, 1.48)	(0.90, 2.02)
BIBA[a]	0.65***	0.52***	0.87	0.65***	0.84	0.62	0.61*
	(0.61, 0.69)	(0.43, 0.63)	(0.71, 1.07)	(0.57, 0.74)	(0.57, 1.23)	(0.15, 2.52)	(0.40, 0.94)
Observations	51,902	5,535	4,564	7,845	932	419	1,895

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.
AMS, altered mental status; *BIBA*, brought in by ambulance.

high-acuity pod) for patients ultimately requiring high-acuity care (Table 2b). Logistic regression was performed to assess the relationship between these outcome variables and self-reported race, across both the full sample and by chief complaint. Controls were included for gender, age (including squared and bin terms), method of arrival (ambulance vs walk-in), and final disposition (admission, observation, discharge, or death). We performed analysis was performed in R 4.1.0 (R Foundation for Statistical Computing, Vienna, Austria),[19,20] with results reported as odds ratios for ease of interpretation. Although moderate collinearity was identified among our control variables, variance inflation factors were <2 in all cases, and main effects were robust to multiple model specifications. (See Appendix 1 for representative sensitivity analyses.) The study was reviewed and approved by the hospital Institutional Ethics Review Board.

RESULTS

Of 297,355 adult ED visits analyzed, 66% (196,040) were of patients who identified as White, approximately 10%

(29,214) who identified as Black, and 13% (38,396) who identified as Hispanic. Patients were 48% (143,079) female, 52% (154,268) male, and had a mean age of 51 years.

Overall, the adjusted odds of triage to the high acuity pod were lower for Black (adjusted odds ratio [aOR] 0.76, 95% confidence interval [CI] 0.73-0.79 and Hispanic patients aOR 0.87, 95% CI 0.84-0.90). Among our identified chief complaints, this effect was only demonstrated for patients with subjective chief complaints, including chest pain (aOR 0.76, 95% CI 0.73, 0.79 for Black, and aOR 0.88, 95% CI 0.78, 0.99 for Hispanic patients), dyspnea (aOR 0.79, 95% CI 0.68-0.92 for Black, and aOR 0.84, 95% CI 0.72-0.99 for Hispanic patients), and any pain (aOR 0.83, 95% CI 0.75-0.92 for Black, and aOR 0.89, 95% CI 0.82-0.97 for Hispanic patients). No differences were detected across observed, numeric, or protocolized complaints.

We performed analysis of need for up-triage on the subset of patients located in the high-acuity pod at time of ED disposition (death, hospital admission, or discharge), constituting approximately 16% of adult visits (51,959). Patients were considered to have required up-triage if they were initially assigned to a lower acuity pod and required reassignment to the high-acuity pod during their ED course. Racial differences were also identified in this measure, with Black and Hispanic adults experiencing higher rates of up-triage. This was demonstrated across the full all-complaint study sample (aOR of 1.47, 95% CI 1.3-1.63 for Black, and aOR of 1.27, 95% CI 1.15-1.40 for Hispanic adults), as well as for Black patients presenting with chest pain (aOR 1.68, 95% CI 1.25-2.26), or any pain (aOR 1.47, 95% CI 1.1-1.83) and Hispanic patients presenting with dyspnea/shortness of breath (aOR 1.54, 95% CI 1.06-2.24). No differences were observed for observed, objective, or protocolized complaints.

DISCUSSION

In our analysis we found that Black and Hispanic adults in our population were disproportionately triaged to lower acuity areas, and that this phenomenon was more pronounced for patients presenting with subjective chief complaints. Further analyses demonstrated that of patients requiring critical care/high-acuity resources at the time of ED discharge, Black and Hispanic patients tended to have been disproportionately triaged to lower acuity pods during initial assessment. These findings suggest that the pattern of lower acuity triage cannot be explained by true differences in resource requirements over the ED course (ie, accurate prediction of lower resource requirements related to less severe clinical presentations), but rather a tendency to consistently underestimate the needs of Black and Hispanic adults. This pattern is also more pronounced for patients presenting with subjective chief complaints, suggesting that triage clinicians' assessments of the severity of patient-reported symptoms for Black and Hispanic patients may have played a role in this underestimation.

Many potential mechanisms may underlie this pattern, possibly including racially correlated differences in patients' descriptions of their symptoms,[21,22] differences in affective communication and stoicism,[23] differences in symptom presentation from "canonical" cases historically used in medical education,[24,25] differences in style or content of report or in actions taken by prehospital personnel,[26] differential impact of clinicians' cognitive "heuristics" regarding disease presentation,[27–29] and differences in patient-clinician interaction style or other forms of bias.[30–32] These phenomena may also have been exacerbated by structural factors (such as ease of access to interpreter services when needed, crowding, clinician fatigue or cognitive burden, time of day, etc), which are beyond the scope of our analysis. Reassuringly, we did not observe racially correlated triage differences in protocolized chief complaints.

LIMITATIONS

This was a single-center study that used an acuity-based triage system to identify race-related differences in triage assignment, potentially limiting generalizability of this finding. This analysis also focused on a subset of ED chief complaints that represent approximately 32% of total ED presentations and were developed based on frequency, acuity, and ease of identification in our data. It is possible that these patterns would not emerge in a dataset where other chief complaints were more common, more frequently represented high-acuity presentations, or were more readily identifiable. This analysis was also performed on data collected under hospital-developed triage guidelines but prior to the 2021-2022 implementation of a formalized Emergency Severity Index (ESI) assignment protocol within our system, which may alter these patterns.

In addition to the potential structural factors listed above, we did not control for other interpersonal or individual factors that may contribute to pod selection within this system (including current staffing, hourly throughput time, relative crowding, recent triage to the same pod, etc). Neither did we assess nursing factors (including race, age, seniority, languages spoken, etc.). Thus, further work will be needed to both assess these additional factors and to identify potential mechanisms underlying our findings.

CONCLUSION

Overall, our analysis identifies a pattern of significant racial differences in triage accuracy, which tends to underestimate the critical-care needs of Black and Hispanic adults, especially those with symptom-based complaints, potentially compromising both the timeliness and appropriateness of their care. These findings suggest that further work to better understand and improve triage

encounters and the nature of the interactions within them may be important in helping to reduce disparities in ED care.

ACKNOWLEDGMENTS

The authors would like to thank Cassie Kraus and the MGH ED Quality and Analytics program for their support in data identification and stewardship.

Address for Correspondence: Cassandra Peitzman, MD, PhD, MPH, Massachusetts General Hospital, Department of Emergency Medicine, 55 Fruit St., Boston, Massachusetts 02114. Email: cpeitzman@partners.org

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.

REFERENCES

1. Smedley BD, Stith AY, Nelson AR. *Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care (Full Printed Version) Editors, Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care*. 2003;782.
2. Kelley E, Moy E, Stryer D, et al. The National Healthcare Quality and Disparities Reports an Overview. *Med Care* 2005;43(3 Suppl):18–8.
3. Cooper LA, Powe NR. Disparities in patient experiences, health care processes, and outcomes: the role of patient – provider racial, ethnic, and language concordance. *Commonw Fund.* Published online 2004.
4. Zhang X, Carabello M, Hill T, et al. Racial and ethnic disparities in emergency department care and health outcomes among children in the United States. *Front Pediatr*. 2019;7:525.
5. Williams RA.Eliminating Healthcare Disparities in America: Beyond the IOM Report. Totawa, NJ: Humana Press; 2007.
6. Groeneveld PW, Kruse GB, Chen Z, et al. Variation in cardiac procedure use and racial disparity among Veterans Affairs hospitals. *Am Heart J*. 2007;153(2):320–7.
7. Soto GJ, Martin GS, Gong MN. Healthcare disparities in critical illness. *Crit Care Med*. 2013;41(12):2784–93.
8. López L, Wilper AP, Cervantes MC, et al. Racial and sex differences in emergency department triage assessment and test ordering for chest pain, 1997-2006. *Acad Emerg Med*. 2010;17(8):801–8.
9. Lu FQ, Hanchate AD, Paasche-Orlow MK. Racial/ethnic disparities in emergency department wait times in the United States, 2013–2017. *Am J Emerg Med*. 2021;47:138–44.
10. Schrader CD, Lewis LM. Racial disparity in emergency department triage. *J Emerg Med*. 2013;44(2):511–8.
11. Vigil JM, Alcock J, Coulombe P, et al. Ethnic disparities in Emergency Severity Index scores among U.S. Veteran's Affairs emergency department patients. *PLoS One*. 2015;10(5):1–10.
12. Natale JE, Joseph JG, Rogers AJ, et al. Relationship of physician-identified patient race and ethnicity to use of computed tomography in pediatric blunt torso trauma. *Acad Emerg Med*. 2016;23(5):584–90.
13. Welch LC, Teno JM, Mor V. End-of-life care in black and white: race matters for medical care of dying patients and their families. *J Am Geriatr Soc*. 2005;53(7):1145–53.
14. El Turabi A, Abel GA, Roland M, et al. Variation in reported experience of involvement in cancer treatment decision making: evidence from the National Cancer Patient Experience Survey. *Br J Cancer*. 2013;109(3):780–7.
15. Burgess DJ, Crowley-Matoka M, Phelan S, et al. Patient race and physicians' decisions to prescribe opioids for chronic low back pain. *Soc Sci Med*. 2008;67(11):1852–60.
16. Henderson J, Gao H, Redshaw M. Experiencing maternity care: the care received and perceptions of women from different ethnic groups. *BMC Pregnancy Childbirth*. 2013;13:196.
17. Chapman EN, Kaatz A, Carnes M. Physicians and implicit bias: how doctors may unwittingly perpetuate health care disparities. *J Gen Intern Med*. 2013;28(11):1504–10.
18. Burgess DJ. Are providers more likely to contribute to healthcare disparities under high levels of cognitive load? How features of the healthcare setting may lead to biases in medical decision making. *Med Decis Mak*. 2010;30(2):246–57.
19. R Core Team. (2021) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: https://www.R-project.org/. Accessed March 16, 2023.
20. RStudio Team. (2020) RStudio: Integrated Development for R. RStudio, PBC, Boston, MA. Available at: http://www.rstudio.com/. Accessed March 16, 2023.
21. Payne JS. Influence of race and symptom expression on clinicians' depressive disorder identification in African American men. *J Soc Social Work Res*. 2012;3(3):162–77.
22. Carpenter-Song E, Chu E, Drake RE, et al. Ethno-cultural variations in the experience and meaning of mental illness and treatment: implications for access and utilization. *Transcult Psychiatry*. 2010;47(2):224–51.
23. Meints SM, Cortes A, Morais CA, et al. Racial and ethnic differences in the experience and treatment of noncancer pain. *Pain Manag*. 2019;9(3):317–34.

24. Amutah C, Greenidge K, Mante A, et al. Misrepresenting race — the role of medical schools in propagating physician bias. *N Engl J Med*. 2021;384(9):872–8.
25. McSweeney JC, O'Sullivan P, Cleves MA, et al. Racial differences in women's prodromal and acute symptoms of myocardial infarction. *Am J Crit Care*. 2010;19(1):63–73.
26. Kennel J, Withers E, Parsons N, et al. Racial/ethnic disparities in pain treatment: evidence from Oregon emergency medical services agencies. *Med Care*. 2019;57(12):924–9.
27. O'Sullivan ED, Schofield SJ. Cognitive bias clinical medicine. *J R Coll Physicians Edinb*. 2018;48(3):225–32.
28. Croskerry P. Achieving quality in clinical decision making: cognitive strategies and detection of bias. *Acad Emerg Med*. 2002;9(11):1184–204.
29. Tversky A, Kahneman D. Judgment under uncertainty: heuristics and biases. Biases in judgments reveal some heuristics of thinking under uncertainty. *Science*. 1974;185(4157):1124–31.
30. Elliott AM, Alexander SC, Mescher CA, et al. Differences in physicians' verbal and nonverbal communication with black and white patients at the end of life. *J Pain Symptom Manage*. 2016;51(1):1–8.
31. Mende-Siedlecki P, Qu-Lee J, Backer R, et al. Perceptual contributions to racial bias in pain recognition. *J Exp Psychol Gen*. 2019;148(5):863–89.
32. RLS Jr, Gordon H, Haidet P. Physicians' communication and perceptions of patients: Is it how they look, how they talk, or is it just the doctor? *Soc Sci*. 2010;65(3):586–98.

Emergency Department Use Among Recently Homeless Adults in a Nationally Representative Sample

Caitlin Ryus, MD, MPH[*]
Elina Stefanovics, PhD[†‡]
Jack Tsai, PhD[‡§‖]
Taeho Greg Rhee, PhD[†‡¶]
Robert A. Rosenheck, MD[†‡]

[*]Department of Emergency Medicine, Yale University School of Medicine, New Haven, Connecticut
[†]U.S. Department of Veterans Affairs New England Mental Illness Research, Education, and Clinical Center, West Haven, Connecticut
[‡]Department of Psychiatry, Yale University School of Medicine, New Haven, Connecticut
[§]VA National Center on Homelessness among Veterans, Washington, DC
[‖]School of Public Health, University of Texas Health Science Center at Houston, Houston, Texas
[¶]Department of Public Health Sciences, University of Connecticut School of Medicine, Farmington, Connecticut

Section Editor: Tony Zitek, MD
Submission history: Submitted September 29, 2022; Revision received May 11, 2023; Accepted May 24, 2023
Electronically published August 11, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59054

Introduction: In this study we examined the association of homelessness and emergency department (ED) use, considering social, medical, and mental health factors associated with both homelessness and ED use. We hypothesized that social disadvantage alone could account for most of the association between ED use and homelessness.

Methods: We used nationally representative data from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC-III). Emergency department use within the prior year was categorized into no use (27,674; 76.61%); moderate use (1–4 visits: 7,972; 22.1%); and high use (5 or more visits: 475; 1.32%). We used bivariate analyses followed by multivariable-adjusted logistic regression analyses to identify demographic, social, medical, and mental health characteristics associated with ED use.

Results: Among 36,121 respondents, unadjusted logistic regression showed prior-year homelessness was strongly associated with moderate and high prior-year ED use (odds ratio [OR] 2.31 and 7.34, respectively, $P < 0.001$). After adjusting for sociodemographic factors, the associations of homelessness with moderate/high ED use diminished (adjusted OR [AOR] 1.27 and 1.62, respectively, both $P < 0.05$). Adjusting for medical/mental health variables, alone, similarly diminished the association between homelessness and moderate/high ED use (AOR 1.26, $P < .05$ and 2.07, $P < 0.001$, respectively). In a final stepwise model including social and health variables, homelessness was no longer significantly associated with moderate or high ED use in the prior year.

Conclusion: After adjustment for social disadvantage and health problems, we found no statistically significant association between homelessness and ED use. The implications of our findings suggest that ED service delivery must address both health issues and social factors. [West J Emerg Med. 2023;24(5)894–905.]

INTRODUCTION

Emergency departments (EDs) have long served as a healthcare safety net for the medical needs of marginalized populations in the US, such as people experiencing homelessness.[1] Over the past several years, there has been increasing recognition that in providing this service, EDs play a distinct role in delivering "social emergency medicine" to address the structural determinants of poor health such as poverty, racism, inadequate housing, and food insecurity.[2–4] "Emergency department use is costly,[5] and some question the appropriateness and efficiency of addressing social problems within the ED and healthcare system, especially in the US where social services are limited.[5,6]

Previous studies have shown that ED patients are far more likely to be homeless than other adults.[7,8] A multisite study conducted in Northeastern Pennsylvania estimated that the prevalence of homelessness in EDs ranged from 7–18%.[7] At one ED in New York City, 14% of patients were homeless and 25% had been concerned about becoming homeless during the prior two months.[8] Homelessness is specifically associated with high levels of ED use.[9–14] National data from the Veterans Health Administration found that patients experiencing homelessness were 6.6 times more likely than others to have more than 25 ED visits annually.[15] Furthermore, patients experiencing homelessness are four times more likely than others to re-present to the ED within three days of a prior evaluation.[16] Although homelessness is strongly associated with high ED use, it may not be independently associated with such use since many social and medical factors may drive this association; however, this needs to be empirically examined.

Previous research on ED utilization among patients experiencing homelessness has been almost exclusively based on data from patient populations sampled in clinical settings, potentially biasing our understanding of how homelessness relates to ED use in the general population.[7–11,13–16] Few studies have examined ED use in nationally representative samples that included non-health service users. The few available reports from community-based studies among homeless individuals suggest that only a small minority (8–12%) use the ED more than three times per year.[17,18] Thus, there is a need to examine this issue in a nationally representative sample.

In this study, we used a nationally representative survey, the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC-III), to examine the association of recent homelessness and factors that may be associated with ED use.[19] We hypothesized that social disadvantage (eg, poverty, racism, educational attainment, and neighborhood environment) might account for much of the extensive ED use by homeless adults, although we suspected that health-related factors would also play a role. We thus sought to examine evidence to clarify how social, medical, and mental health factors play into the association between homelessness and ED use among the most socially disadvantaged sectors of the US population.

Population Health Research Capsule

What do we already know about this issue?
Previous research among patient populations in clinical settings demonstrated a strong association between homelessness and high frequency ED use.

What was the research question?
Do social disadvantage and health-related factors account for much of the extensive ED use by homeless adults?

What was the major finding of the study?
Adjusted for social and health factors, homelessness and ED use were not significantly associated (AOR 1.27, 95% CI 0.79–2.03).

How does this improve population health?
The complex interplay between social and medical issues should encourage the development of service delivery models linking these intersecting dimensions of need.

METHODS

Data Source and Study Sample

We performed a cross-sectional analysis to assess the association between homelessness and ED use using data from NESARC-III. The NESARC-III is a nationally representative survey of 36,906 adults, which includes information on experiences of prior-year homelessness and emergency care utilization as well as demographic and recent social, medical, and mental health characteristics.[19] This data allows examination of the association of both recent homelessness and other factors that are likely to be associated with ED use, thus offering an examination of the independent association of homelessness and ED use when social, medical, and mental health factors are taken into consideration. The survey was sponsored by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) and conducted between April 2012–June 2013 among the non-institutionalized US civilian population ≥18 years old.[19] Multistage probability sampling was used to randomly select persons from this population. Primary sampling units were individual counties or groups of contiguous counties. Secondary sampling units consisted of area segments of census-defined blocks. Households within the sampled

secondary sampling units were then selected. Finally, eligible adults within the sampled households were randomly selected.[19] An initial 43,364 eligible sample persons were identified, and 36,309 participated in the NESARC-III, while 7,055 were classified as nonresponders, for a person-level response rate of 84.0%.[19]

A total of 36,309 respondents completed the Alcohol Use Disorder and Associated Disabilities Interview Schedule, DSM-5 version (AUDADIS-5), a fully structured, computer-assisted diagnostic interview conducted by trained NIAAA interviewers.[20] Institutionalized individuals (eg, in nursing homes, prisons, hospitals, or shelters) were excluded along with active duty military personnel. Racial/ethnic minorities were oversampled to assure representative analysis. Data was adjusted for oversampling and nonresponse and then weighted to represent the US civilian population based on the 2012 American Community Survey.[21] Informed consent was electronically recorded, and respondents received $90 for participation. Institutional review boards (IRB) at the US National Institutes of Health and Westat, Inc. (Rockville, MD) approved the study protocol. This study was approved by the IRBs of the Department of Veterans Affairs Connecticut Healthcare System and Yale School of Medicine.

MEASURES

ED Utilization

We measured the primary outcome variable, ED utilization, based on self-report by respondents and categorized into a three-level variable representing no use (0 visits), moderate use (1–4 visits), and high use (5 or more visits) in the prior year.

Sociodemographics

Sociodemographic characteristics included age, gender, race, marital status, annual household income, level of education, employment status, military service, rural vs urban residence, and health insurance coverage.

Social History

Social history variables addressed homelessness, incarceration, interaction with law enforcement, parental social history, adverse childhood experiences such as sexual abuse or neglect, experiences of racial discrimination, social contacts, and social support. We created two dichotomous homelessness variables that identified adults with homelessness in the past year and homelessness prior to the most recent past year. Lifetime homelessness was assessed with this question: "Since you were 15, did you have a time that lasted at least one month when you had no regular place to live—like living on the street or in a car?" A separate question—"In the last 12 months, have you at any time been homeless?"—was the independent variable of central interest in this study. A previous study using NESARC-III data reported the lifetime and one-year prevalence of homeless to be 4.2% and 1.5%, respectively.[22]

Other social history variables included questions such as "During the last 12 months, did you have serious trouble with the police or law?" which was coded into a dichotomous variable for police involvement. Experiencing racial discrimination was a continuous variable assessed from six questions within AUDADIS-5 that have been shown to have good validity and reliability for measuring experiences of racial discrimination.[22] The six discrimination questions ask about experienced racial discrimination in six contexts: obtaining healthcare/health insurance; receiving care; in public; obtaining a job; being called racist names; being hit/threatened with harm. We used a Likert scale to assess the frequency of experiences of discrimination in the past year: 0 = never; 1 = almost never; 2 = sometimes; 3 = fairly often; or 4 = very often.

Parental history included experiences of incarceration, psychiatric hospitalization, suicide attempt or completion, and substance use. The extent of social support was assessed using the Interpersonal Support Evaluation List[23,24]: perceived availability of others to share activities, talk about one's problems and from whom to potentially receive material support. Social contacts were assessed through a series of questions regarding how many people the respondents had contact with in the previous two weeks, which were summed to create an index of social contacts. Veterans were identified as those who responded to the question "Have you ever served on active duty in the U.S. Armed Forces, Military Reserves, or National Guard?" with "Yes, in the past, but not now."

Medical, Mental Health, and Service Use History

Medical history variables included number of medical comorbidities, up to 18; presence of moderate to severe pain; number of injuries in the past year; cancer history; body mass index (BMI) > 40; and mental- and physical health-related quality of life. Respondents were asked whether or not they had each of 18 medical conditions (eg, arthritis, diabetes, and insomnia) in the past 12 months. Those who responded positively were further asked, "Did a doctor or health professional tell you that you had [a medical condition]?" Using these two questionnaire items for each medical condition, we created a measure of chronic conditions experienced in the past year. Quality of life was measured using the Short Form-12, version 2 (SF-12), a reliable and valid measure of health status commonly used in population surveys.[25,26] The 12 questions can be scored into subscales to yield a mental component summary (MCS) score and a physical component summary (PCS) score as well as overall subjective health status. The number of injuries reported by respondents was assessed by the question, "During the last 12 months, how many injuries have you had that caused you to seek medical help or to cut down your usual activities for

more than half a day?" This variable was measured as a continuous variable.

We assessed lifetime or past year presence of DSM-5 mental health diagnoses with the AUDADIS-5 and included the following: mood disorders (major depressive disorder, bipolar I disorder, dysthymia); anxiety disorders (generalized anxiety disorder, specific phobia, panic disorder); post-traumatic stress disorder (PTSD), and eating disorder. We used AUDADIS-5 scoring for all disorders except schizophrenia/psychosis, which was addressed with the following question, "Did a doctor or other health professional tell you that you had schizophrenia or a psychotic illness or episode?" Personality disorders included antisocial, borderline, and schizotypal. Lifetime and past year substance use disorders (SUD) included alcohol use disorder, as well as cannabis, cocaine, opiate, heroin, stimulant, and sedative use disorders (considered together as non-alcohol drug use disorders), and tobacco use disorder.

Multimorbidity was addressed with dichotomous variables indicating the following: the presence of only one psychiatric diagnosis and another indicating two or more such diagnoses; the presence of only one SUD diagnosis and another indicating two or more such diagnoses. An additional measure captured the presence of both psychiatric disorder and SUD (dual diagnosis).

Data Analysis

We used a series of bivariate analyses to evaluate the association of each demographic, social, or medical and mental health characteristic with each level of ED usage. Because there was inflated statistical power given the large sample size, we selected variables for inclusion in subsequent multivariable analyses based on effect sizes rather than *P*-values. We identified risk ratios > 1.5 or < 0.7 as representing substantial and meaningful effects for dichotomous variables.[27] For continuous variables we used Cohen d as an indicator of effect size, with d > 0.20 or <−0.20 indicating at least a small effect size.[28]

We then conducted a series of four logistic regression analyses conducted separately with different sets of independent variables, all including past year homelessness. The first logistic regression was unadjusted and included only past year homelessness as the independent variable. The second model was adjusted only for demographic and social variables meeting criteria for substantial bivariate effects and thus evaluated the concurrent role of social determinants of health. A third logistic model examined only co-occurring medical and mental health variables showing substantial association with ED use in bivariate analyses. We included variables regarding parental suicide, drug use, and psychiatric hospitalization in the third (health) model, whereas parental prison history was included in the second model of non-medical social risk factors. Finally, we entered all variables with meaningful effect sizes per the above criteria into a stepwise multinomial logistic regression analysis with forward selection to identify a parsimonious set of statistically significant factors that were independently associated with moderate and high ED use. Since all these variables had passed the effect size screens on bivariate analysis, we applied a conventional $P < 0.05$ level of statistical significance to these models.

We computed standardized regression coefficients to allow identification of variables most strongly associated with ED use. Comparison of −2 log likelihood indicators were used to assess goodness of fit with larger values indicating superior fit. We performed all analyses using SAS version 9.4 (SAS Institute Inc, Cary, NC).

RESULTS

Sample

Of the total 36,121 respondents with complete data, 27,674 (76.61%) reported no ED use in the past year, 7,972 (22.07%) reported moderate ED use, and 475 (1.32%) reported high use. Having experienced homelessness within the past year was reported by 559 (1.55%) respondents, and 1,541 (4.27%) responded that they had experienced homelessness within their lifetime.

Bivariate Correlates of ED Use

Bivariate analyses showed past year homelessness (relative risk [RR] = 6.83) to be among the three variables most strongly associated with high ED use, exceeded only by past year suicide attempt (RR = 11.51) and receipt of a diagnosis of schizophrenia or psychosis in the past year (RR = 8.61) (Tables 1–3). Demographic variables substantially associated with moderate and high ED use included receiving disability benefits (RR = 2.71 and RR = 7.68, respectively). Having a college education was protective (Table 1).

Among the social variables (Table 2) associated with moderate and high ED use, homelessness in the past year (RR = 2.27 and RR = 6.83) and homelessness within one's lifetime (RR = 1.97 and RR = 4.38) were associated with the highest relative risk. Experiencing trouble with the police (RR = 4.17) and history of incarceration before and after age 18 (RR = 3.74 and RR = 2.64) were also associated high ED use, as were adverse childhood events such as neglect, sexual abuse, parental suicide attempts, parental suicide completion, parental imprisonment, parental drug use, and parental psychiatric hospitalization. As Black race was associated with high ED use, it should be noted that experiencing racial discrimination in the past year was also significantly associated with high ED use.

Health status variables (Table 3) associated with moderate and high ED use included worse general health (Cohen d = 1.11 and 1.12), experiencing moderate or severe pain, and a BMI > 40. Higher scores on both the PCS and MCS were protective.

Table 1. Bivariate associations of demographic variables with emergency department use.

Variable	ED use Group 1 N = 27,674 0 visits mean (SD)/%	ED use Group 2 n = 7,972 1–4 visits mean (SD)/%	ED use Group 3 n = 475 ≥5 visits mean (SD)/%	Bivariate analysis 2 vs 1 RR/Cohen d*	Bivariate analysis 3 vs 1 RR/Cohen d*
Gender					
Male	49.15%	44.91%	36.57%	0.91	0.74
Age*	46.25 (17.48)	47.61 (18.76)	44.82 (17.59)	0.08	−0.08
Annual income					
<$20,000	20.80%	28.20%	51.05%	1.36	2.45
$20,000–40,000	23.47%	26.46%	25.81%	1.13	1.1
$40,000–60,000	22.51%	20.87%	11.77%	0.93	0.52
>$60,000	33.22%	24.47%	11.39%	0.74	0.34
Race					
Black	10.74%	15.01%	20.90%	1.4	1.95
White	66.26%	66.37%	61.79%	1	0.93
Hispanic	15.25%	13.17%	10.09%	0.86	0.66
Other	7.75%	5.45%	7.24%	0.7	0.93
Marital status					
Separated or divorced	12.81%	16.89%	25.09%	1.32	1.96
Widowed	5.27%	7.48%	8.54%	1.42	1.62
Never married	22.58%	21.82%	29.68%	0.97	1.31
Married or cohabitating	59.34%	53.81%	36.69%	0.91	0.62
Employment					
Receives disability	3.61%	9.77%	27.70%	2.71	7.68
Looking for work	6.98%	8.65%	13.99%	1.24	2
Other employment	16.92%	17.60%	18.89%	1.04	1.12
Retired	16.68%	20.76%	14.11%	1.24	0.85
Employed	72.36%	63.01%	49.85%	0.87	0.69
Military service					
Any military service	9.08%	11.94%	10.54%	1.32	1.16
Rurality					
Urban	78.96%	78.21%	75.06%	0.99	0.95
Highest level of education					
Pre-high school	12.17%	15.27%	23.65%	1.26	1.94
High school	25.01%	28.31%	31.24%	1.13	1.25
Pre-college	32.41%	35.29%	36.49%	1.09	1.13
College	30.42%	21.14%	8.62%	0.69	0.28
Health insurance coverage					
Medicaid	8.22%	16.58%	32.40%	2.02	3.94
VA Tricare	4.18%	6.42%	8.20%	1.53	1.96
Medicare	19.43%	27.71%	32.85%	1.43	1.69
Any insurance	79.43%	83.49%	85.30%	1.05	1.07
Private insurance	59.83%	51.99%	35.23%	0.87	0.59

Bivariate analyses compare moderate and high ED users to non-users.
*Denotes continuous variable with Cohen d for measure of association.
ED, emergency department; *RR*, relative risk; *VA*, Veterans Administration.

Table 2. Bivariate associations of social variables with emergency department use.

Variable	ED use Group 1 n = 27,674 0 visits mean (SD)/%	ED use Group 2 n = 7,972 1–4 visits mean (SD)/%	ED use Group 3 n = 475 ≥5 visits mean (SD)/%	Bivariate analysis 2 vs 1 RR/ Cohen d*	Bivariate analysis 3 vs 1 RR/ Cohen d*
Homelessness					
Past year	1.14%	2.59%	7.81%	2.27	6.83
Lifetime	3.39%	6.68%	14.84%	1.97	4.38
Incarceration history					
Police trouble in past year	1.30%	2.50%	5.41%	1.92	4.17
Incarcerated before age 18	3.33%	5.86%	12.47%	1.76	3.74
Incarcerated after age 18	9.56%	14.91%	24.47%	1.61	2.64
Social history and social support					
History of child neglect*	12.22 (5.02)	13.49 (6.21)	15.62 (8.35)	0.19	0.52
History of child sexual abuse*	4.37 (1.54)	4.76 (2.40)	5.49 (3.18)	0.17	0.47
Racial discrimination in the past year*	1.21 (.43)	1.29 (.52)	1.47 (.70)	0.14	0.48
Social support*	3.02 (.464)	2.96 (.51)	2.83 (.61)	–0.12	–0.37
Number of contacts in the past two weeks*	16.36 (15.08)	15.91 (15.08)	14.28 (14.28)	–0.02	–0.11
Parental history					
Parent with suicide attempt	2.81%	4.20%	10.46%	1.49	3.72
Parent with prison history	6.48%	11.49%	19.07%	1.77	2.94
Parent with suicide completion	0.86%	0.98%	2.42%	1.14	2.82
Parent with drug use history	4.99%	8.15%	11.26%	1.63	2.38
Parent psychiatric hospitalization history	4.74%	7.47%	11.26%	1.58	2.38

Bivariate analyses compare moderate and high ED users to non-users.
*Denotes continuous variable with Cohen's d for measure of association.
ED, emergency department; *RR*, relative risk.

Among the mental health variables associated with ED use (Table 3), suicide attempt in the past year was the most strongly associated with both moderate (RR = 5.01) and high ED use (RR = 11.51). Moderate and high ED use were both associated strongly with personality disorders and diagnosis of schizophrenia or psychosis within one's lifetime. Having more than one substance use disorder, more than one psychiatric disorder, or dual diagnosis within the past year were also all associated with moderate and high use (Table 3).

Multivariate Multinomial Logistic Regression Analyses

Unadjusted logistic regression analysis demonstrated that people with experience of homelessness within the past year were approximately twice as likely to report moderate ED use (odds ratio [OR] 2.31; 95% confidence interval [CI] 1.93–2.76; $P < 0.001$) and seven times more likely to report high ED use (OR 7.34; 95% CI 5.04–10.68; $P < 0.001$) compared to those without past year experience (Figure 1).

After adjusting only for demographic, social variables, the association of homelessness and its statistical significance were greatly diminished as people with past year experience of homelessness were only 27% more likely to report moderate ED use than others (adjusted OR [AOR] 1.27; 95% CI 1.05–1.54; $P = 0.014$) and 62% more likely to report high ED use (AOR 1.62; 95% CI, 1.05–2.50; $P = 0.030$) (Figure 1).

The third model, which adjusted only for medical and mental health variables, also showed marked decline in ORs compared to the unadjusted model as participants experiencing past year homelessness were 26% more likely to report moderate use (AOR 1.26; 95% CI 1.03–1.55; $P = 0.025$) and about twice as likely as to have high ED use (AOR 2.07; 95% CI, 1.33–3.24; $P = 0.001$).

In the final stepwise model with forward selection at $P < 0.05$, including all substantially important variables (social, medical, and mental health), homelessness was no longer significantly associated with either moderate or high ED use at $P < 0.05$. A further analysis in which past year

Table 3. Bivariate associations of medical and mental health variables with emergency department use.

Variable	ED use Group 1 n = 27,674 0 visits mean (SD)/%	ED use Group 2 n = 7,972 1–4 visits mean (SD)/%	ED use Group 3 n = 475 ≥5 visits mean (SD)/%	Bivariate analysis 2 vs 1 RR/Cohen d*	Bivariate analysis 3 vs 1 RR/Cohen d*
Psychiatric and substance use disorders					
Past year suicide attempt	0.10%	0.50%	1.16%	5.01	11.51
Schizotypal disorder	5.04%	10.10%	22.14%	2.01	4.4
Antisocial disorder	3.58%	6.48%	15.61%	1.81	4.37
Lifetime diagnosis of schizophrenia or psychosis	1.73%	3.57%	7.41%	2.07	4.29
Past year greater than one substance use disorder diagnosis	1.79%	3.54%	6.84%	1.98	3.82
Past year single drug use disorder diagnosis	3.15%	5.93%	11.30%	1.88	3.58
Past year greater than one psychiatric diagnosis	6.72%	13.51%	23.34%	2.01	3.47
Borderline personality disorder	7.96%	16.87%	29.72%	2.01	3.47
Past year dual diagnosis: psychiatric/ substance use disorder	4.00%	7.16%	9.48%	1.79	2.37
Past year single psychiatric diagnosis	12.57%	16.91%	24.93%	1.35	1.98
Multiple recurring traumas	12.86%	16.00%	22.00%	1.24	1.71
Lifetime alcohol use disorder diagnosis	27.97%	32.56%	38.13%	1.16	1.36
Past year single substance use disorder diagnosis	12.85%	15.03%	17.01%	1.17	1.32
Past year alcohol use disorder diagnosis	13.16%	16.05%	17.01%	1.22	1.29
Medical history					
Medical conditions (range 1–18)*	0.62 (0.97)	1.28 (1.48)	2.26 (1.97)	0.45	1.12
Number of injuries*	0.20 (2.11)	0.96 (4.50)	2.44 (8.00)	0.16	0.46
General health (scale of 1 to 5)*	2.33 (1.04)	2.84 (1.15)	3.64 (1.14)	1.11	0.46
Short Form-12 mental component*	51.62 (9.18)	48.63 (11.42)	43.37 (12.56)	–0.27	–0.75
Short Form-12 physical component*	50.91 (9.49)	45.51 (12.37)	36.68 (12.85)	–0.47	–1.23
Moderate or severe pain	15.80%	32.77%	63.90%	2.07	4.04
Any history of cancer	3.65%	6.20%	12.94%	1.70	3.55
BMI >40	3.76%	6.76%	10.78%	1.8	2.86

Bivariate analyses compare moderate and high users to non-users.
*Denotes continuous variable with Cohen's d for measure of association.
ED, emergency department; *RR*, relative risk; *BMI*, body mass index.

homelessness was forced into the model to assess the point estimate of the effect size association of recent homelessness with ED use showed an AOR for moderate ED use of 1.13 (95% CI 0.91–1.40, not significant) and AOR 1.27 (95% CI 0.79–2.03, not significant) for high ED use (Figure 1).

Closer examination of the final model (Table 4) showed a notable commonality in variables associated with both moderate and high ED use (Table 4). Variables with the highest associations with *moderate* use included number of injuries (AOR 1.79, 95% CI 1.73–1.86, standardized regression coefficient [SRC] = 0.8), number or medical conditions (AOR 1.33, 95% CI 1.30–1.37, SRC = 0.18), and Medicaid insurance (AOR 1.49, 95% CI 1.37–1.62, SRC = 0.07).

Variables with the strongest independent associations with *high* ED use also included number of injuries in the past year (AOR = 1.82, 95% CI 1.75–1.89, SRC = 0.82), number of medical conditions (AOR = 1.53, 95% CI 1.43–1.64,

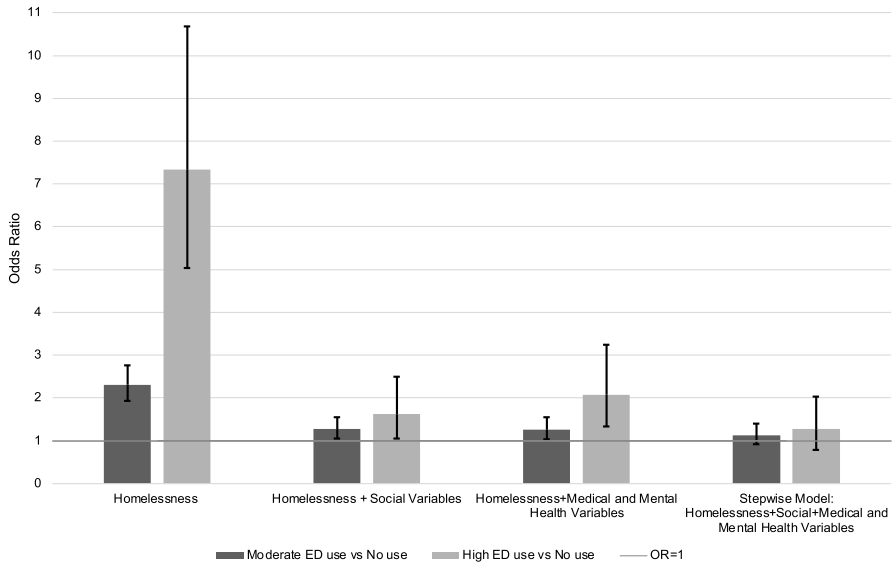


Figure 1. Association of past year homelessness with moderate and high ED use: Unadjusted and Adjusted Odds ratios from multinomial logistic regression models. *OR*, odds ratio.

SRC = 0.27), and Medicaid insurance (AOR = 1.97, 95% CI 1.55–2.51, SRC = 0.11), along with parental drug use history (AOR 1.95, 95% CI 1.40–2.71; SRC = 0.09). The strongest protective variables for both moderate and high ED use included high SF-12 component scores, college education, and being married or cohabitating.

Comparison of −2 log likelihood indicators of model fit showed the model of homelessness alone (−2LL = −41495, degrees of freedom [df] = 2) had a poorer goodness of fit than both the model of social (−2LL = 38,777, df = 40) and the model of medical and mental health factors alone (−2LL = 36,076, df = 52), and all three had a poorer model fit than the final combined stepwise model (−2LL = 35,188, df = 42) with each model fit significantly superior to that of the previous model at $P < 0.005$.

DISCUSSION

This study showed that homelessness was strongly associated with ED use in an unadjusted model, as has been found in many other studies.[9–14] However, estimates of the *independent* association of homelessness and ED use, adjusting first for measures of demographic characteristics and social disadvantage and then separately for medical and mental health, showed that both sets of factors largely accounted for this association. This suggests an important potential mediating role of these factors. The association of homelessness with ED use was further reduced to non-significance when both types of factors were included as covariates.

The strongest risk factors in the final model were injuries, medical conditions, Medicaid coverage, and parental drug use while the strongest protective variables were high physical- and mental health-related quality of life, college education, and being married or cohabitating. These findings are consistent with existing literature that has demonstrated lower socioeconomic status, lower educational attainment, public insurance, and poorer perceived health were predictors of frequent ED use.[29] Physical injuries have also been shown to be associated with frequent ED visits, including return visits.[30]

The strong unadjusted association between homelessness and ED use is consistent with prior literature.[15,31] However, in this study we further considered medical and social factors as separate blocks to explore the association of homelessness and ED use adjusting for these factors. Additionally, our study was based on a nationally representative sample extending its generalizability to populations that included people outside clinical settings.[17,18] The NESARC-III dataset was also exceptional in the rich array of social variables unavailable in medical records (eg, education, parental histories, adverse childhood events, social isolation, and criminal justice interaction.)

Implications

It has been suggested that the high cost of healthcare in the US compared to other wealthy countries reflects limited provision of social services.[5] Health policy experts increasingly recognize the social determinants of health, and federal and local initiatives are emerging to address social needs and reduce healthcare service use and costs, including ED costs.[32,33] While frequent ED users represent only 4–8% of ED patients, they account for 21–28% of all ED visits and generate significant costs.[34] Recent studies show that individualized case management interventions can modestly

Table 4. Stepwise multinomial logistic regression models of the association of ED use and social, medical, psychiatric, and substance use disorders.

	Moderate ED use vs Non-use*			High ED use vs Non-use*	
Variable	OR (95% CI)	Standardized regression coefficient	Variable	OR (95% CI)	Standardized regression coefficient
Number of injuries	1.79 (1.73–1.86)	0.8	Number of injuries	1.82 (1.75–1.89)	0.82
Medical conditions	1.33 (1.30–1.37)	0.18	Short Form-12 physical component	0.95 (0.94–0.96)	−0.32
Short Form-12 physical component	0.98 (0.977–0.983)	−0.12	Medical Conditions	1.53 (1.43–1.64)	0.27
Medicaid insurance	1.49 (1.37–1.62)	0.07	College education	0.47 (0.32–0.68)	−0.19
Short Form-12 mental component	0.99 (0.987–0.993)	−0.06	Married or cohabitating	0.56 (0.45–0.69)	−0.16
Black	1.34 (1.23–1.46)	0.05	Short Form-12 mental component	0.98 (0.966–0.984)	−0.14
Any traumatic experience	1.2 (1.13–1.27)	0.05	Medicaid insurance	1.97 (1.55–2.51)	0.11
College education	0.81 (0.76–.87)	−0.05	Parent with drug use history	1.95 (1.40–2.71)	0.09
Past year suicide attempt	3.03 (1.74–5.27)	0.03	Black	1.56 (1.19–2.05)	0.08
VA Tricare	1.29 (1.14–1.46)	0.03	Racial discrimination in the past year	1.35 (1.14–1.59)	0.07
Parent with prison history	1.23 (1.11–1.37)	0.03	Police trouble in past year	2.06 (1.25–3.38)	0.05
Borderline personality disorder	1.20 (1.09–1.21)	0.03	Past year homelessness	**	**
Social support	1.14 (1.07–1.21)	0.03	Past year suicide attempt	**	**
History of child sexual abuse	1.03 (1.01–1.04)	0.03	VA Tricare	**	**
Past year greater than one substance use disorder diagnosis	1.28 (1.08–1.52)	0.02	Past year greater than one substance use disorder diagnosis	**	**
Married or cohabitating	0.91 (0.86–0.97)	−0.02	Parent with prison history	**	**
Past year homelessness	**	**	Any traumatic experience	**	**
Police trouble in past year	**	**	Borderline personality disorder	**	**
Parent with drug use history	**	**	Social support	**	**
Racial discrimination in the past year	**	**	History of child sexual abuse	**	**

*All variables with a *P*-value for Wald chi-square <.01.
**Variable not included in the final stepwise regression.
ED, emergency department; *OR*, odds ratio; *CI*, confidence interval; *VA*, Veterans Administration.

reduce ED use.[35–37] Other studies that focus on primary care access are less promising since most frequent ED users already use high levels of primary care.[15] Housing-focused initiatives significantly reduce homelessness but have had limited effect on the physical or mental health of clients, on decreasing ED use, or on reducing health service costs. [38–42]

These mixed findings suggest there is a larger context beyond service integration and supported housing that requires attention.

The concurrence of homelessness, social disadvantage, and chronic medical and mental illness points to a vulnerability deeper than merely having multiple, chronic illnesses and may be best understood through the evolving concept of allostatic burden.[43] Allostasis is the general adaptive capacity of a person to respond effectively to physical or social demands. Allostatic burden refers to the magnitude of the demand for and potential failure of adaptive capabilities. In individuals with high allostatic burden, the cumulative effect of chronic stress and life events overwhelms adaptive capacities in a broad sense. Allostatic burden has been shown to be associated with poorer health outcomes in cardiovascular disease, diabetes, preeclampsia, geriatric frailty, periodontal disease, PTSD, psychotic disorders, and alcohol dependence,[43] and to arise from conditions of poverty, segregation, discrimination, sexual trauma, and low educational attainment and thus exceeds any conception of chronic disease that merely reflects illnesses continuing over a long-term course.[43] Many indicators of allostatic burden were significant in our model of high ED use and are disproportionately represented in the homeless population. While no studies to date have examined the association of allostatic load and frequent ED use, the allostatic burden model may facilitate understanding of frequent ED use, and specifically high use among people experiencing homelessness.

In recognition of what is currently known, social emergency medicine (EM) should be added to the EM research agenda and included in the core curriculum for ED residents via both didactics and community-based learning.[44] A useful framework could differentiate three distinct levels of care: acute care for immediate problems (eg, appendicitis, traumatic injuries); acute-on-chronic care for urgent treatment of exacerbated heart failure; diabetic ketoacidosis, etc; and care for long-term overwhelming allostatic burden, the complex of lifelong social and medical problems that challenges the ability of an individual to maintain themselves in the society in which they live, and about which much remains to be learned.[2,44]

LIMITATIONS

Several limitations warrant consideration. First, specific data on the immediate reasons for individual ED visits were not available in NESARC-III. While medical and mental health problems account for much of the association between ED use and homelessness, it is unclear whether ED visits were directly related to treatment of these health issues. Previous studies found that the majority of visits among patients with mental illness were for physical health conditions rather than reasons related to mental health.[45–48] We heuristically separated medical and mental health problems but recognize that they are tightly intertwined.[49–51]

Second, our study was cross-sectional and cannot support conclusions about causality. The variable representing homelessness referred to prior year homelessness without data on the recency or chronicity of the homelessness episode. Additionally, our cross-sectional data is from 2012–2013 and associations may have changed in the intervening time. Our findings suggest trends to be explored in longitudinal studies of how ED use among homeless adults, as well as others, relates to overwhelming long-term allostatic burden.

Third, the sample excluded institutionalized adults, omitting pertinent populations at high risk for homelessness such as incarcerated individuals and those in homeless shelters. This limitation is not unique to our study, although it is more comprehensive than in previous literature. Finally, some NESARC-III variables themselves are imprecise and of uncertain validity. Homelessness and ED use were based on self-report and thus subject to recall bias. The ED use item was limited to a maximum of 10 or more visits per year, limiting the precision with which we could analyze the construct of "high" ED use. It is possible that at the extremes of ED use, there may have been an even stronger association with homelessness and other evidence of extreme allostatic burden.[15]

CONCLUSION

Homeless individuals use the ED at higher rates than other individuals, but when adjusting for other social and medical factors, we did not find an independent association between homelessness and higher ED usage. This highlights the complex interplay between social and medical issues and should encourage the development and evaluation of more fully integrated training and service delivery models linking these intersecting dimensions of need.

Address for Correspondence: Caitlin Ryus, MD, MPH, Yale School of Medicine. Department of Emergency Medicine 464 Congress Ave., Suite 260, New Haven, CT 06519. Email: caitlin.ryus@yale.edu

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.

REFERENCES

1. Selby S, Wang D, Murray E, et al. Emergency departments as the health safety nets of society: a descriptive and multicenter analysis of social worker support in the emergency room. *Cureus*. 2018;10(9).
2. Alter HJ, Fahimi J, Wang NE.Social emergency medicine: history and principles. In: *Social Emergency Medicine.* New Yori, NY: Springer; 2021:3–12.
3. Fahimi J, Goldfrank L. Principles of social emergency medicine. *Ann Emerg Med*. 2019;74(5):S6–S10.
4. Theriault KM, Rosenheck RA, Rhee TG. Increasing emergency department visits for mental health conditions in the United States. *J Clin Psychiatry*. 2020;81(5).
5. Bradley E, Taylor L. *The American Health Care Paradox: Why Spending More Is Getting Us Less*. New York, NY: Public Affairs, Perseus Books Group; 2013.
6. Moore BJ, Liang L.Costs of Emergency Department Visits in the United States, 2017. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs [Internet]*. Agency for Healthcare Research and Quality (US); 2020.
7. Feldman BJ, Calogero CG, Elsayed KS, et al. Prevalence of homelessness in the emergency department setting. *West J Emerg Med*. 2017;18(3):366.
8. Doran KM, Johns E, Schretzman M, et al. Homeless shelter entry in the year after an emergency department visit: results from a linked data analysis. *Ann Emerg Med*. 2020;76(4):462–7.
9. Ku BS, Fields JM, Santana A, et al. The urban homeless: super-users of the emergency department. *Popul Health Manag*. 2014;17(6):366–71.
10. LaCalle EJ, Rabin EJ, Genes NG. High-frequency users of emergency department care. *J Emerg Med*. 2013;44(6):1167–73.
11. Cawley C, Raven MC, Martinez MX, et al. Understanding The 100 Highest Users of Health and Social Services in San Francisco. *Acad Emerg Med.* 2021.
12. Kanzaria HK, Niedzwiecki M, Cawley CL, et al. Frequent emergency department users: focusing solely on medical utilization misses the whole person. *Health Affairs*. 2019;38(11):1866–75.
13. Tsai J, Doran KM, Rosenheck RA. When health insurance is not a factor: national comparison of homeless and nonhomeless US veterans who use Veterans Affairs emergency departments. *Am J Public Health*. 2013;103(S2):S225–31.
14. Tsai J, Rosenheck RA. Risk factors for ED use among homeless veterans. *Am J Emerg Med*. 2013;31(5):855–8.
15. Doran KM, Raven MC, Rosenheck RA. What drives frequent emergency department use in an integrated health system? National data from the Veterans Health Administration. *Ann Emerg Med*. 2013;62(2):151–9.
16. Ku BS, Scott KC, Kertesz SG, et al. Factors associated with use of urban emergency departments by the US homeless population. *Public Health Reports*. 2010;125(3):398–405.
17. Moore DT, Rosenheck RA. Factors affecting emergency department use by a chronically homeless population. *Psychiatric Services*. 2016;67(12):1340–7.
18. Kushel MB, Perry S, Bangsberg D, et al. Emergency department use among the homeless and marginally housed: results from a community-based study. *Am J Public Health*. 2002;92(5):778–84.
19. Grant B, Chu A, Sigman R, et al. National Institute on Alcohol Abuse and Alcoholism National Epidemiologic Survey on Alcohol and Related Conditions-III (NESARC-III) source and accuracy statement. Bethesda, MD: NIAAA. 2015.
20. Hasin DS, Greenstein E, Aivadyan C, et al. The Alcohol Use Disorder and Associated Disabilities Interview Schedule-5 (AUDADIS-5): procedural validity of substance use disorders modules through clinical re-appraisal in a general population sample. *Drug Alcohol Depend*. 2015;148:40–6.
21. U.S. Census Bureau. American Community Survey, 2012. In: *Commerce USDo*, ed. Suitland, MD: U.S. Census Bureau 2013.
22. Tsai J. Lifetime and 1-year prevalence of homelessness in the US population: results from the National Epidemiologic Survey on Alcohol and Related Conditions-III. *J Public Health.* 2018;40(1):65–74.
23. Bommersbach TJ, Rhee TG, Stefanovics EA, et al. Comparison of Black and White individuals who report diagnoses of schizophrenia in a national sample of US adults: discrimination and service use. *Schizophr Res.* 2021.
24. Cohen S, Mermelstein R, Kamarck T, et al. Measuring the functional components of social support. In: *Social Support: Theory, Research and Applications*. New York, NY:Springer; 1985:73–94.
25. Ware J, Kosinski MJr, Turner-Bowker D, et al. *How to score version 2 of the SF-12 Health Survey (with a supplement documenting version 1)*. Lincoln, RI: QualityMetric Inc. 2002.
26. Hasin DS, Stinson FS, Ogburn E, et al. Prevalence, correlates, disability, and comorbidity of DSM-IV alcohol abuse and dependence in the United States: results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Arch Gen Psych*. 2007;64(7):830–42.
27. Ferguson CJ. An effect size primer: a guide for clinicians and researchers. *Professional Psychology: Research and Practice,* 40(5):532–538. https://doi.org/10.1037/a0015808.
28. Cohen J. Statistical power analysis for the behavioral sciences [Internet]. *Statistical Power Analysis for the Behavioral Sciences.* 1988:567.
29. Giannouchos TV, Kum HC, Foster MJ, et al. Characteristics and predictors of adult frequent emergency department users in the United States: a systematic literature review. *J Eval Clinical Prac*. 2019;25(3):420–33.
30. Laferté C, Dépelteau A, Hudon C. Injuries and frequent use of emergency department services: a systematic review. *BMJ Open*. 2020;10(12):e040272.
31. Davis CI, Montgomery AE, Dichter ME, et al. Social determinants and emergency department utilization: findings from the Veterans Health Administration. *Am J Emerg Med*. 2020;38(9):1904–9.
32. Wilensky G. Addressing social issues affecting health to improve US health outcomes. *JAMA*. 2016;315(15):1552–3.

33. CMS. Accountable Health Communities Model. Centers for Medicaid and Medicare Services. Available at: https://innovation.cms.gov/innovation-models/ahcm. Published 2021. Accessed November 27, 2021.
34. LaCalle E, Rabin E. Frequent users of emergency departments: the myths, the data, and the policy implications. *Ann Emer Med*. 2010;56(1):42–8.
35. Soril LJ, Leggett LE, Lorenzetti DL, et al. Reducing frequent visits to the emergency department: a systematic review of interventions. *PLoS ONE*. 2015;10(4):e0123660.
36. Raven MC, Kushel M, Ko MJ, et al. The effectiveness of emergency department visit reduction programs: a systematic review. *Ann Emerg Med*. 2016;68(4):467–483. e415.
37. Sandberg SF, Erikson C, Owen R, et al. Hennepin Health: a safety-net accountable care organization for the expanded Medicaid population. *Health Affairs*. 2014;33(11):1975–84.
38. National Academies of Sciences E, Medicine. Permanent supportive housing: evaluating the evidence for improving health outcomes among people experiencing chronic homelessness. 2018.
39. Goering PN, Streiner DL, Adair C, et al. The At Home/Chez Soi trial protocol: a pragmatic, multi-site, randomised controlled trial of a Housing First intervention for homeless individuals with mental illness in five Canadian cities. *BMJ Open*. 2011;1(2):e000323.
40. Rosenheck RA, Lam J, Morrissey JP, et al. Service systems integration and outcomes for mentally ill homeless persons in the ACCESS program. *Psychiat Ser*. 2002;53(8):958–66.
41. Sadowski LS, Kee RA, VanderWeele TJ, et al. Effect of a Housing and Case Management Program on Emergency Department Visits and Hospitalizations Among Chronically Ill Homeless Adults: a randomized trial. *JAMA*. 2009;301(17):1771–8.
42. Tinland A, Loubière S, Boucekine M, et al. Effectiveness of a housing support team intervention with a recovery-oriented approach on hospital and emergency department use by homeless people with severe mental illness: a randomised controlled trial. *Epidemiol Psychiatr Sci*. 2020;29.
43. Guidi J, Lucente M, Sonino N, et al. Allostatic load and its impact on health: a systematic review. *Psychothe Psychosom*. 2021;90(1):11–27.
44. Ryus CR, Yang D, Tsai J, et al. Using community-based participatory research methods to inform care for patients experiencing homelessness: an opportunity for resident education on health care disparities. *AEM Educ Train*. 2021;5:S121–5.
45. Merrick EL, Perloff J, Tompkins CP. Emergency department utilization patterns for Medicare beneficiaries with serious mental disorders. *Psychiat Serv*. 2010;61(6):628–31.
46. Mehl-Madrona LE. Prevalence of psychiatric diagnoses among frequent users of rural emergency medical services. *Canadian J Rural Med*. 2008;13(1):22.
47. Tsai J, Szymkowiak D, Kertesz SG. Top 10 presenting diagnoses of homeless veterans seeking care at emergency departments. *Am J Emerg Med*. 2021;45:17–22.
48. Paudyal V, Ghani A, Shafi T, et al. Clinical characteristics, attendance outcomes and deaths of homeless persons in the emergency department: implications for primary health care and community prevention programmes. *Public Health*. 2021;196:117–23.
49. Brewer LC, Cooper LA, Patten CA. Diabetes self-management education for special populations: the social determinants of health matter. *Public Health Rep*. 2019;134(3):313–4.
50. Hardman R, Begg S, Spelten E. What impact do chronic disease self-management support interventions have on health inequity gaps related to socioeconomic status: a systematic review. *BMC Health Serv Res*. 2020;20(1):1–15.
51. Muenchberger H, Kendall E. Predictors of preventable hospitalization in chronic disease: priorities forchange. *J Public Health Policy*. 2010;31(2):150–63

Race, Healthcare, and Health Disparities: A Critical Review and Recommendations for Advancing Health Equity

Wendy L. Macias-Konstantopoulos, MD, MPH, MBA[*†]
Kimberly A. Collins, MD, MPH[‡]
Rosemarie Diaz, MD[§]
Herbert C. Duber, MD, MPH[‖¶]
Courtney D. Edwards, DNP, RN, CLN[#]
Antony P. Hsu, MD**
Megan L. Ranney, MD, MPH[††]
Ralph J. Riviello, MD, MS[‡‡]
Zachary S. Wettstein, MD[§§]
Carolyn J. Sachs, MD, MPH[‖‖]

[*]Center for Social Justice and Health Equity, Department of Emergency Medicine, Boston, Massachusetts
[†]Harvard Medical School, Department of Emergency Medicine, Boston, Massachusetts
[‡]Tampa General Hospital, Tampa, Florida
[§]University of California-Los Angeles, Department of Emergency Medicine, Los Angeles, California
[‖]University of Washington School of Medicine, Department of Emergency Medicine, Seattle, Washington
[¶]Washington State Department of Health, Tumwater, Washington
[#]Samford University, Moffett & Sanders School of Nursing, Birmingham, Alabama
[**]Trinity Health Ann Arbor Hospital, Department of Emergency Medicine, Ypsilanti, Michigan
[††]Yale University, Yale School of Public Health, New Haven, Connecticut
[‡‡]University of Texas Health San Antonio, Department of Emergency Medicine, San Antonio, Texas
[§§]University of Washington School of Medicine, Department of Emergency Medicine, Seattle, Washington
[‖‖]Ronald Reagan-UCLA Medical Center and David Geffen School of Medicine at University of California-Los Angeles, Department of Emergency Medicine, Los Angeles, California

Section Editors: David Thompson, MD and Shahram Lotfipour, MD, MPH
Submission history: Submitted August 15, 2022; Revision received April 17, 2023; Accepted May 24, 2023
Electronically published August 8, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.58408

An overwhelming body of evidence points to an inextricable link between race and health disparities in the United States. Although race is best understood as a social construct, its role in health outcomes has historically been attributed to increasingly debunked theories of underlying biological and genetic differences across races. Recently, growing calls for health equity and social justice have raised awareness of the impact of implicit bias and structural racism on social determinants of health, healthcare quality, and ultimately, health outcomes. This more nuanced recognition of the role of race in health disparities has, in turn, facilitated introspective racial disparities research, root cause analyses, and changes in practice within the medical community. Examining the complex interplay between race, social determinants of health, and health outcomes allows systems of health to create mechanisms for checks and balances that mitigate unfair and avoidable health inequalities.

As one of the specialties most intertwined with social medicine, emergency medicine (EM) is ideally positioned to address racism in medicine, develop health equity metrics, monitor disparities in clinical performance data, identify research gaps, implement processes and policies to eliminate racial health inequities, and promote anti-racist ideals as advocates for structural change. In this critical review our aim was to (a) provide a synopsis of racial disparities across a broad scope of clinical pathology interests addressed in emergency departments—communicable diseases, non-communicable conditions, and injuries—and (b) through a race-conscious analysis, develop EM practice recommendations for advancing a culture of equity with the potential for measurable impact on healthcare quality and health outcomes. [West J Emerg Med. 2023;24(5)906–918.]

Keywords: *health disparities; social determinants of health; structural racism; implicit bias.*

INTRODUCTION

Social determinants of health (SDoH) as defined by the US Centers for Disease Control and Prevention (CDC) are the conditions in which people live, learn, work, and play that are determined by the distribution of money, power, and resources and that affect a wide range of health and quality-of-life risks and outcomes.[1] Influenced by the social construct of race, SDoH exert disparate impacts on the health of subpopulations. Economic disparities disproportionately place Black, indigenous, and people of color (BIPOC) within zones marked by substandard health promotion and excessive health risks. The compounding nature of adverse SDoH, such as housing instability, food insecurity, poor healthcare access, and hazardous exposures, has serious health implications. Health disparities are the profound downstream effect of the socioeconomic disadvantages that BIPOC endure under the moniker *structural racism*.

In addition to structural racism, *implicit bias*—defined as unconscious attitudes, positive or negative, toward a person, group, or idea—often leads to differential treatment based on perceived race.[2,3] Implicit bias further restricts quality healthcare as a separate factor above and beyond inequities of structural racism. Emergency department (ED) data indicates that Black (vs White) patients have longer treatment wait times,[4] longer lengths of stay,[5] and lower triage acuity levels.[6] Additionally, Black ED patients have a 10% lower likelihood of admission and 1.26 times higher odds of ED or hospital death than White patients.[7] Research also suggests that physicians' own implicit racial biases may contribute to disparities in healthcare quality and delivery.[8–10]

In this critical review we explore the complex effects of race, implicit bias, and structural racism on SDoH, healthcare quality and, ultimately, health outcomes. Although not intended as a comprehensive literature review on health disparities, this exercise informs a conceptual framework through which actionable steps and practice recommendations for emergency medicine (EM) are proposed as one part of a larger systemwide effort that requires thoughtful action and transformative policy to dismantle the hard-wired inequities of structural racism and advance health equity.

METHODS

Critical Review Methodology

We conducted a broad-scope critical review of the extant health disparities literature across three areas of clinical pathology interest: communicable diseases; non-communicable conditions; and injuries. The review was conducted through a race-conscious lens to examine the impact of race on health outcomes and inform a conceptual framework for the development of actionable steps and practice recommendations.

Critical reviews include "a degree of analysis and conceptual innovation" resulting in a product capable of launching a new phase of evaluation.[11] According to Grant and Booth, the critical review does not call for a systematic evaluation of all the literature related to a topic, but rather the emphasis is on the contribution of each piece of evidence included to the review's conceptual product.[11] As described by the Search, Appraisal, Synthesis, and Analysis framework, critical reviews are designed to identify key findings in the field of interest (health disparities literature), evaluate the evidence in accordance with its contribution (racial health disparities attributable to SDoH), synthesize the evidence in organized fashion (clinical pathology interests relevant to EM), and provide a conceptual output of analysis that contributes to the literature (actionable steps and practice recommendations).[11]

In this review we aimed to examine racial health disparities through the SDoH model and apply socioenvironmental theory[12] and resource deprivation theory[13] as race-conscious filters through which racial disparities data is analyzed and synthesized (Table 1). The analysis informed the conceptual framework through which we developed and propose actionable steps and practice recommendations.

RESULTS

Communicable Diseases

HIV/AIDS

Racial and ethnic disparities in the incidence and prevalence of HIV infection and AIDS have been documented in the US since the 1980s.[14] Despite prevention, identification, and treatment advances, Black-White and Hispanic-White disease incidence disparities have increased since 1984. In 2013, Blacks and Hispanics accounted for 46% and 21% of new HIV infections and 49% and 20% of new AIDS diagnoses despite representing 12% and 16% of the total US population, respectively.[14] Although HIV incidence rates have improved in recent decades, Blacks and Hispanics have benefitted less from antiretroviral therapy advancements.[15] Incidence rates (IR) have declined with the advent of pre-exposure prophylaxis (PrEP); however, PrEP usage remains disparately low among Black (5.9%) and Hispanic (10.9%) adults with an indication as compared to Whites (42.1%).[16,17]

ED Actionable Steps: Increase access to HIV testing and referrals to PrEP and post-exposure prophylaxis.

Viral Hepatitis

Hepatitis C virus (HCV) is the leading cause of liver disease-related death in the US.[18] Racial disparities in disease prevalence exist at a rate greater than twice that of Whites; Blacks in the US have the highest prevalence ratio (PR) of disease (PR 2.29, 95% confidence interval [CI] 1.94–2.70).[18] Rates of treatment for chronic hepatitis C are also higher

Table 1. Race-conscious analysis tools employed in critical review.

Socioenvironmental theory[12]	Resource deprivation theory[13]
Socioenvironmental theory holds that racial residential segregation is central to racial and ethnic health disparities. According to this theory, racial/ethnic minority groups have considerably different levels of health risk due to the multiple social and environmental factors that detrimentally impact their health within the context of longstanding residential segregation and its deeply rooted socioeconomic disadvantages.	*Resource deprivation theory* holds that the longstanding deprivation of resources experienced by racial/ethnic minority groups is central to racial and ethnic disparities. Due to chronic deprivation, racial/ethnic minority groups lack the necessary infrastructure to support health. Resources are not restricted to material possessions; they include education, employment, housing, neighborhood safety, and psychological wellbeing. According to evidence-based interpretations of this theory, gap closure cannot be achieved through equal distribution of resources, but rather targeted differential distribution of resources that levels the playing field for racial/ethnic minority groups.

among Whites as compared to Black, Hispanic, and Asian individuals.[19] Direct-acting antivirals (DAA) became available in 2014 and are achieving greater than 90% cure rates.[20] Early research found that Black and Hispanic patients were less likely than Whites to benefit from DAA initiation (adjusted rate ratio [aRR] 0.7, 95% CI 0.7–0.8 and 0.8, 95% CI 0.7–0.9, respectively).[21] Follow-up data from a national cohort found that these racial-ethnic gaps had closed by 2016; however, more recent data is needed to determine whether equitable access has persisted beyond initial evidence-driven efforts.[20]

ED Actionable Steps: Increase access to HCV testing and referrals to DAA treatment.

Sexually Transmitted Infections

Disparities in sexually transmitted infections (STI) have been described extensively in the literature. Rates of primary and secondary syphilis, HIV/AIDS, chlamydia, and gonorrhea among Blacks range from 5.4 to 17.8 times the rates among Whites in the US.[22] The SDoH associated with increased STI prevalence have been discussed extensively, ranging from inequities in healthcare, income, incarceration, residential segregation, and substance use, among others.[23,24] Importantly, prevalence must be interpreted within the context of STI screening, the odds of which are higher among Black and Hispanic women than their White counterparts (adjusted odds ratio [aOR] 2.56, 95% CI 2.60–3.10 and 1.42, 95% CI 1.39–1.46, respectively).[25]

ED Actionable Steps: Increase access to STI testing and ED-based treatment.

Diarrheal Disease

An estimated 500,000 cases of shigellosis occur annually in the US.[26] Incidence rates of infection per 100,000 are greatest among Black (7.2) and Hispanic (5.6) individuals as compared to Whites (2.6).[26] Despite the preventable nature of shigellosis, an analysis of over 25,000 laboratory-confirmed cases reported to the CDC found a strong association between its incidence and residence in areas marked by US Census Tract-level poverty and household crowding. Racial and ethnic IR disparities, however, persisted even after controlling for these socioeconomic indicators,[26] and the rates of severe infection among adults are highest among Black persons.[27] Similarly, Black (vs non-Black) infants <6 months in age had higher rates of diarrhea-associated hospitalizations that persisted even after the introduction of the rotavirus vaccines in 2006.[28]

ED Actionable Steps: Educate patients and parents about transmission mechanisms and mitigation strategies (eg, hand hygiene, low-cost water treatment options, vaccination), and consider offering vaccination in the ED when necessary and reasonable.

Pandemic Respiratory Viral Infection

Disparities exist among pandemic respiratory viral infections, including influenza H1N1 and severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), resulting in higher disease incidence and mortality among minority groups.[29–31] Coronavirus disease 2019 (COVID-19) cases and hospitalization rates were 2.5-4.5 times higher among Black, Hispanic, and Native American populations than Whites. Through May 2021, COVID-19 deaths among Hispanic and Black populations were 17% and 10% greater, respectively, than expected by US population representation after controlling for age.[32] Elevated COVID-19 infection and death rates have also been observed in socially disadvantaged counties with larger proportions of BIPOC.[32,33] Among residents of a predominantly Black and Hispanic COVID-19 hotspot, very high and disparate positivity rates were observed among Black (68.5%) and Hispanic (65.3%) patients as compared to Whites (53%).[34] Higher hospitalization rates for Blacks (60.2%) and Hispanics (62.3%) as compared to Whites (47.7%) were also observed, although there were no differences in admission rates to the intensive care unit.[34]

Mortality rates among COVID-19 inpatients also show BIPOC disparities.[35,36] Recent CDC data shows higher mortality risk ratios for Native Americans (2.4), Hispanics

(2.3), and Blacks (1.9) compared to Whites.[37] There are several reasons cited to explain the higher out-of-hospital mortality rates, disease burden, and severity of illness among BIPOC.[36,38–40] Several authors have concluded that population-based disparities in COVID-19 hospital mortality are best explained by differential disease incidence, prevalence of comorbid conditions, and socioeconomic marginalization among Black and Hispanic individuals.[34,39,40]

Overall racial and ethnic disparities in COVID-19 risk, severity, morbidity, and mortality arise from a combination of social, economic, and health determinants.[36,38] Due to economic strain, BIPOC are more likely to live in crowded housing (multigenerational or communal households) and densely populated neighborhoods. They are also more likely to work in consumer-facing public service industries and rely on public transportation, increasing their exposure risk. Additionally, higher rates of comorbidities (eg, heart disease, diabetes, hypertension, and obesity) increase BIPOC's risk for severe COVID-19 disease. Barriers to health insurance and health services limit access to treatments and to accurate knowledge regarding SARS-CoV-2 transmission, prevention strategies, disease symptoms, and reasons for seeking care.[41–43] Interestingly, despite the positive impact of Medicaid expansion on healthcare access, mortality, and disparities, one study failed to find an association between COVID-19 mortality and expansion vs non-expansion,[44,45] likely reflecting a benefit negated by the heightened social risk of structural racism.

Disparities in vaccination coverage were evident by the end of April 2021. When all adult age groups were eligible, vaccination rates among Black (46.3%) and Hispanic (47.3%) adults were lower than among Whites (59%) and Asians (69.6%).[46] Despite policies to ensure equitable COVID-19 vaccine access, vaccination hesitancy—originating from distrust in the medical establishment and resulting from longstanding systemic racism in healthcare and research—required community partnerships and concerted efforts by trusted sources of information to overcome the slower rates of vaccination among BIPOC.[46]

ED Actionable Steps: Increase access to viral testing, educate patients and parents about transmission mechanisms and mitigation strategies (eg, masks, isolation, vaccination), and consider offering vaccination in the ED when necessary and reasonable.

Non-Communicable Conditions

Acute Coronary Syndrome and Acute Myocardial Infarction

Disparities in acute coronary syndrome (ACS) care have been well-documented. Compared to White patients with door-to-balloon (DTB) times of 103.4 minutes, Black and Hispanic patients experience significantly longer DTB times (122.3 and 114.8 minutes, respectively).[47] Over the last decade, DTB times have improved significantly across all groups; however, Black Americans have a lower likelihood of experiencing DTB times <90 minutes[48] and have experienced only a modest decline in recurrent hospitalization for acute myocardial infarction (AMI) compared to Whites.[49] Black patients experience worse AMI outcomes with a five-year mortality rate of 29% compared to 18% among Whites.[50]

ED Actionable Steps: Consider protocolized ED triage and early management of potential ACS/AMI-related complaints beyond chest pain.

Type 2 Diabetes Mellitus

Type 2 diabetes prevalence rates among Black (13.2%) and Hispanic (12.8%) Americans are similar and higher than rates among Whites (7.6%).[51] Well-controlled glycemia and hospitalization rates, quality indicators, are both worse among Black patients (37.6% and 26.5%, respectively) compared to Whites (44% and 16.1%, respectively).[51] The marker of glycemic control, hemoglobin A_{1c} ($HgbA_{1c}$), is statistically worse among Black vs White patients ($HgbA_{1c}$ $9.1 \pm 2.9\%$ vs. $8.5 \pm 2.2\%$, $P = 0.001$).[52] Black and Hispanic patients have higher odds of diabetes-related ED visits (odds ratio [OR] 1.84, 95% confidence interval [CI] 1.7–2.0 and 1.60, 95% CI 1.4–1.8, respectively) than Whites.[53]

ED Actionable Steps: Educate patients about the complications of poor glycemic control and consider navigation partnerships with primary care for expedited post-ED visit, outpatient follow-up of patients with diabetes-related chief complaints and complications.

Hypertension

Racial and ethnic disparities in hypertension are likely multifactorial related to upstream SDoH, including access to healthcare, affordable medications, low-sodium foods, and safe green spaces for physical activity.[54] Unique to Black patients, race-consciousness significantly increases diastolic blood pressure (BP), and the self-perception of having a lower social standing as a function of race is associated with medication non-adherence and higher systolic BP.[54] Research has also demonstrated that Black and Asian patients have higher odds of a high BP reading at their last clinic visit (OR 0.36, 95% CI 0.21–0.60 and 0.40, 95% CI 0.16–0.97, respectively) and Black and American Indian/Alaska Native patients have higher odds of an ED visit or hospitalization (OR 3.61, 95% CI 1.88–6.91 and 5.31, 95% CI 2.13–13.20, respectively).[55]

ED Actionable Steps: Educate patients about the complications of poor BP control and consider navigation partnerships with primary care for expedited post-ED visit, outpatient follow-up of patients with hypertension-related chief complaints and complications.

End-stage Renal Disease

Racial and ethnic disparities are profound in renal disease. Black patients experience higher IRs of end-stage renal disease (ESRD) in adolescence, greater probability of progression to advanced disease stages before initiation of dialysis, lower likelihood of peritoneal vs hemodialysis treatment, lower likelihood of transplant waitlist placement, and longer waiting times for transplantation.[56] Pediatric nephrology registry data found that among children who progressed to ESRD, 41.8% of White children received transplants compared to 16.3% and 27% of Black and Hispanic children, respectively, and 70% of White children were transplanted within two years of waitlist placement compared to 44% of Black pediatric patients.[57] Subsequent analyses confirm the persistence of these disparities with Black and Hispanic less likely than White children to receive preemptive transplants (8.7% and 14.2% vs 27.4%, respectively), and Black pediatric transplant recipients were less likely than White to experience allograft survival at five years (63% vs 80.8%, respectively).[58]

Similar disparities among non-White adult ESRD patients include lower rates of transplant referrals, delayed times to transplant waitlist placement, and longer wait times for transplant.[56] National mortality statistics indicate Blacks experience significantly higher death rates from ESRD than Hispanic and White Americans (24.6 vs 11.1 and 12.1 age-adjusted death rate per 100,000, respectively).[59]

ED Actionable Steps: Advocate for increased access to dialysis, particularly for the uninsured, and consider navigation partnerships with nephrology and local dialysis centers for expedited post-ED visit, outpatient follow-up of patients with ESRD-related chief complaints and complications.

Obesity

As a risk factor for heart disease, type 2 diabetes, hypertension, and other chronic conditions, obesity poses a real challenge to population health management efforts. National data demonstrates that the highest prevalence of adult obesity occurs among Black Americans (38.4%) followed by Hispanics (32.6%) and Whites (28.6%).[60] Much like hypertension, racial and ethnic disparities in obesity are multifactorial and require a multifaceted intervention to target social (food deserts), biological (hormone dysregulation secondary adverse childhood events), and behavioral (physical activity) determinants.[61] Research has revealed a high burden of fast- food establishments within predominantly Black communities.[62–64] Treatment disparities are also present with BIPOC demonstrating decreased responsiveness to weight-loss pharmacotherapy, decreased likelihood weight- loss center referral, and decreased likelihood of bariatric surgery.[65]

ED Actionable Steps: Consider partnerships with community programs focused on healthy lifestyle change and prescribe vouchers to patients whose health would benefit from weight loss.

Mental Health

Racial disparities in the management of psychiatric illness have also come to the forefront in recent years. Rates of depression treatment are lower among Black and Hispanic patients as compared to White patients, who are half as likely and a third as likely, respectively, to receive care than White patients.[66] According to the CDC, Black adults had the highest rates of mental health-related ED visits in 2018-2020, had longer ED wait times, and were less likely to be admitted or transferred to another hospital.[67] An analysis of national data found that Black patients presenting to the ED with a psychiatric emergency have a greater probability of chemical sedation than White patients.[68,69] Additionally, single- and multisite studies have found that Black[69–71] and Hispanic patients[71] are more likely to be physically restrained in the ED than White patients.

ED Actionable Steps: Use an equity lens to conduct a thorough review of policies related to restraint use, consider protocolized screening and management of agitation inclusive of early oral medication and withdrawal treatment, and consider navigation partnerships with hospital-based and community-based counseling services.

Injuries

Environmental Hazard-Related Injuries

Ambient fine-particulate matter exposure (PM 2.5) is a risk factor for a host of conditions including reactive airway disease, coronary artery disease, and cerebrovascular disease.[72] The inequitable distribution of hazardous sites, namely industrial facilities, utilities, and landfills, is one of the greatest concerns in the field of environmental justice. Extensive literature has demonstrated that non-Whites are more likely to reside near stationary sources of PM, with Black Americans experiencing a higher burden of PM exposure than Whites and the general population.[73]

Racial disparities in hazardous exposure burden are not a recent phenomenon. The 1987 groundbreaking study that first exposed the disproportionate co-location of toxic waste sites and minority communities found that three of every five Black and Hispanic Americans lived in such conditions.[74] The National Research Council conducted a study that observed greater prevalence of health problems—spontaneous abortions, birth defects, heart disease, gastric cancer, leukemia, and Hodgkin's lymphoma—among those living in proximity to highly toxic chemicals and carcinogens (eg, benzene, polychlorinated biphenyls, mercury, arsenic, and lead).[75] Geo-mapping of hazardous sites found that a disproportionate number of towns overburdened by toxic sources were also home to high proportions of BIPOC, a robust positive predictor of hazardous waste site locations.[76]

ED Actionable Steps: Increase syndromic surveillance collaborations with public health departments for early detection and community notification of hazardous conditions, and advocate for targeted policy interventions by highlighting the harmful health impacts on local communities.

Long-bone Fractures

Black and Hispanic patients are less likely to receive opioid analgesia for acute pain in the ED and opioid prescriptions at discharge compared to White counterparts.[77–79] Research shows that although average pain scores do not differ between White and non-White patients with long-bone fractures (LBF), White patients are more likely to receive opiates (70% vs 50%, $P < 0.001$).[78] Among children presenting for ED management of LBF, the data is similar: Black and Hispanic children were less likely to receive opioid analgesics (aOR 0.86, 95% CI 077–0.95 and 0.86, 95% CI 0.76–0.96, respectively) and less likely to achieve optimal pain reduction (aOR 0.78, 95% CI 0.67–0.90 and 0.80, 95% CI 0.67–0.95, respectively).[80]

ED Actionable Steps: Consider protocolized ED triage and early management of LBF, including adequate analgesia dosing schedules.

Firearm Injuries

Firearm violence is a public health epidemic in the US. In 2018, firearms were the leading method of homicide and suicide, major causes of premature death. Per the CDC, 39,707 Americans died from firearm violence in 2019, averaging 109 deaths per day and comprising 60% suicides, 35% homicides, and 1.4% law enforcement interventions.[81] While most firearm suicide deaths impact Whites and American Indian/Alaska Natives, homicides disproportionately plague Black Americans. In 2018, firearm homicides were highest among Blacks. Black males and females aged 20–34 years died by firearm homicide at nearly 17 times higher and nearly six times higher rates than their White counterparts, respectively. Among youth aged 0–19, Black males had the highest firearm homicide rate at 14 times higher than their White peers. American Indian/Alaska Native male youth had the second highest youth homicide rate. Black males are disproportionately killed by law enforcement intervention with firearms at a rate 1.71 times that of non-Hispanic White males.[82]

ED Actionable Steps: Remain informed of local firearm injury statistics and advocate for adequate policy responses by highlighting the harmful health impacts on local communities.

DISCUSSION

Across clinical pathology interests and in almost every area studied, BIPOC communities experience worse patient care and health outcomes. Contrary to historical medical teachings, there is no biological evidence for the concept of race as a genomic human subspecies to explain health disparities.[83,84] Rather, it is the social interpretation of people in a race-conscious society that disparately impacts health.[85] The system of structuring opportunity and assigning value, based on assumptions about groups of people with certain physical attributes, systematically privileges some while disadvantaging others and undergirds the deadly problem of structural racism. Compounding the well-recognized theory of resource deprivation among racially/ethnically segregated communities (eg, quality primary education, adequate housing, green space) is socioenvironmental theory, which points to acts of commission that inequitably pose health risks (eg, air pollution,[72,73] toxic waste,[74–76] and fast- food,[62–64] alcohol,[86] and tobacco outlets[87]).

Physicians must acknowledge the insidious health threat that implicit biases and structural racism pose. Disproportionate levels of socioeconomic disadvantage, social vulnerability, and poor health outcomes are manifestations of long-established and deeply entrenched racial segregation and racial deprivation. One could argue that the adverse health effects of structural racism over the centuries have created a far greater public health crisis than the COVID-19 pandemic, and yet beyond their identification, they have not received the attention they demand. Perhaps, in future years, our collective response to the volatile sociopolitical events of the last five years will be viewed as the force that changed the narrative. Many academic medical centers have created executive positions focused on equity, diversity, and inclusion and have worked to implement educational curricula aimed at dismantling structural racism.[88]

The question that remains today— how do we as individuals and collectively as an institution and specialty best advance social justice and health equity? —demands thoughtful actions and transformative policies. A recent scoping review found 37 published intervention papers with only a third including empirical research.[89] Clearly, the implementation science behind this massive multi-pronged process will take time to develop,[90] but there appears to be sufficient direction to propose potential actionable steps (Table 2) and practice recommendations.

LIMITATIONS

As critical reviews focus on advancing thought through conceptual innovation following an analysis of the literature, the methodology, by design, does not necessitate an exhaustive comprehensive review of the literature nor the same systematicity and quality assessment as in other more structured review approaches.[11] Additionally, the objective of the conceptual product of a critical review is to propose a new phase of research within the field in question,[11] and as a result, the actionable steps and practice recommendations

Table 2. Potential actionable steps for emergency physicians.

Communicable diseases	1. DPH-funded, community partnerships for pop-up screening clinics in the community designed to provide rapid testing and counseling regarding treatment initiation for HIV, hepatitis C, and STIs. 2. DPH-funded, community partnerships for pop-up vaccination clinics in the community designed to provide testing, vaccination, and transmission-mitigation education in the community. 3. Self-guided education and peer education about the increased risk for severe COVID-19 and other respiratory and diarrheal morbidity and mortality among ethnic and racially diverse populations. 4. Empower patients with a thorough understanding of communicable diseases, including natural course of illness, methods of transmission, transmission prevention, and reasons for returning; discharge counseling techniques may include discharge nursing teach-back or read-back of instructions. 5. DPH-medical-community partnerships designed to focus efforts in areas of high transmission risk when planning resource distribution of testing, treatment, and vaccination supplies related to COVID-19 and other pandemic-related illnesses.
Non-communicable conditions	1. Educate EPs about long-standing racial and ethnic gaps in ED-based care and health outcomes; and promote opportunities for implicit bias training. 2. Develop equity metrics, monitor clinical performance data on quality measures, identify inequities in clinical and research, and implement process and policy changes to close disparity gaps. 3. Support health equity initiatives at the individual, departmental, and organizational levels that aim to educate patients about certain medical conditions (eg, hypertension, diabetes), early warning signs of serious complications (eg, acute coronary syndrome, renal failure), and available treatment options; educational strategies may involve smart documents and waiting room video educational modules. 4. Support and partner with existing patient care navigator and community health worker programs to engage patients beyond the index ED visit and ensure medication and treatment plan adherence, outpatient follow-up scheduling, and regular assessments of any barriers to disease control. 5. Partner with local community organizations designed to promote healthy lifestyle (eg, smoking cessation, nutritional food planning, local farm food collaborative, reduced-fee gym memberships, etc).
Injuries	1. Consider the potential environmental determinants of lung inflammation and injury in BIPOC patients with difficult-to-control asthma symptoms; educate patients about PM and its relationship to asthma and counsel them on preventative measures and importance of maintenance medication adherence. 2. Support and advocate for state and federal legislation and policy aimed at prevention of toxic waste dumping, containment efforts, periodic testing of soil and water supplies, increased testing for environmental exposures among communities living in high-risk exposure areas, and investment in industrial waste decontamination, safer housing, and quality medical care for affected communities. 3. Self-guided education and peer education about the signs and symptoms of toxicity due to common hazardous waste contaminants, and the available treatments. 4. Provide opioid analgesia for acute severe pain in the ED based on likely diagnosis, objective measures of pain, and optimal pain reduction (at least a 2-level reduction in pain score for initial treatment). 5. Support epidemiologic and narrative research of firearm violence, both nonfatal injuries and deaths, to better understand risk and protective factors as the basis for intervention. 6. Use the results of epidemiologic and narrative research to partner with communities to develop and implement effective interventions especially targeted at high-risk youth and young adults of color. 7. Partner with existing programs and personnel that have operated trauma center resources for community and firearm violence to extend their inpatient work to reach a greater proportion of those in need by developing and implementing ED protocols to identify, counsel, and refer at-risk populations. 8. Educate EPs on the effective counseling of populations at disproportionate risk for community and firearm violence and incorporate smart discharge phrases into the electronic health record system. 9. Develop strong collaborations with community groups and social services to whom the ED could transition primary and secondary prevention; incorporate these referrals into discharge materials. 10. Encourage state and federal legislation and policy aimed at decreasing firearm homicides and nonfatal injuries (eg, decrease access to illegal firearms, increase federal funding for research on firearm violence, decrease the production of violent video games and media and replace them with games in which the protagonist must save lives rather than kill to win).

BIPOC, Black, indigenous and people of color; *DPH*, Department of Public Health; *ED*, emergency department; *EP*, emergency physician; *PM*, particulate matter; *STIs*, sexually transmitted infections.

made have yet to be proven effective but instead serve as a starting point for a new phase of implementation science.

CONCLUSION

The suggested actionable steps and following practice recommendations constitute the conceptual product of this critical review, demanding a new phase of implementation and evaluation research that identifies effective strategies and best practices for mitigating racial health inequities. Emergency physicians, as individuals and organizational leaders, can act from several positions in the social structure:

A. Societal members
   1. Participate in local, state, and federal government forums advocating for health through resources and advantages historically inaccessible to BIPOC:
      a. Affordable, safe housing
      b. Food security (ie, sufficient, safe, and nutritious sustenance)
      c. Firearm safety, neighborhood safety, and support for survivors of violence
      d. Health-promoting lifestyle (eg, green space and density restrictions on fast-food, tobacco, and alcohol outlets)
      e. Comprehensive community health centers with expanded hours of operations
   2. Develop meaningful individual and organizational partnerships with antiracist stakeholders and communities
      (ie, Black Lives Matter, White Coats for Black Lives, etc).
   3. Engage leadership and representatives of first responder agencies in upholding the value of every human life.

B. Stewards of medicine
   1. Engage medical leadership in changing organizational culture to one that consistently prioritizes equity, addresses inequities in clinical and professional spaces, and recognizes the systematic advantage of privilege.
   2. Create permanent positions accountable to equity, diversity, and inclusion initiatives[91] and ensure core leadership articulates diversity as an institutional priority and dialogues constructively with all relevant stakeholders.[92]
   3. Increase BIPOC representation within the pipeline and across all organizational strata.[93]
   4. Identify racial disparities and their sources within the system, conduct root cause analyses, and implement strategies to remedy inequities.[94] Describe, document, and proactively work to mitigate the health impact of racism.[95]
   5. Draft policies and enforce protocols for dealing with race-based aggression by patients and other staff.
   6. Educate medical personnel through multimodal continuous medical education on trauma-informed care, anti-racism practice, and cultural humility.[96]
   7. Offer medical education curricula and periodic trainings for students, residents, community physicians, and faculty that include the following:[93,97]
      a. SDoH: Although the prospective, patient-oriented outcome is sparse, many medical schools and residency programs have adopted SDoH curriculum, which may lead to measurable changes in the future[98] and is a stated priority of the Institute of Medicine.[99] Comprehensive training materials are free and available on the web.[100]
      b. Cultural humility training to address implicit bias, stereotypes, and prejudice.[101]
      c. Anti-racism and trauma-informed care training to improve patient care communication and bedside skills.
   8. Evaluate the impact of educational programs on patient care and health outcomes to curate efforts.[102] Disseminate evidence-based best practices.
   9. Endeavor as an institution and specialty to eliminate racialized conceptions of disease susceptibility (eg, casting Blacks as innately diseased and dehumanizing their suffering).[103]

C. ED staff
   1. Develop equity metrics, monitor clinical performance data, identify clinical and research gaps, and implement process and policy changes to eliminate health disparities.
   2. Abandon the practice of stating the patient's race in the narrative of the history and physical as it has minimal benefit, risks introducing bias, and is offensive to minority physicians.[104]
   3. Cease the use of correction formulas that use race as a proxy for pathology when their use furthers health inequities.[105]
   4. Make deliberate efforts to treat racial groups similarly on individual and population levels as a concrete first step in ameliorating racial health disparities. Although physicians undoubtedly carry implicit racial biases equal to the general population, there is some evidence that emergency physicians show less implicit racial bias than the general population.[106]
   5. Address racist patient attitudes professionally even when these cause moral distress.[107] Addressing

racism and attempting to rebuild therapeutic alliances is part of the leadership and professionalism that emergency physicians must emulate.

D. Hospital executives
Institutional leaders must assure appropriate ED ancillary staffing and address hospital policies (eg, inpatient census levels, direct and transfer admissions) that result in ED crowding, medical error, morbidity and mortality, and staff demoralization.[108] Emergency physicians are experts in rapid cognition or thin-slicing, but with that practice comes the expression of latent stereotypes and biases that require a deliberate "bias-check" pause to better understand the patient and, thus, achieve better outcomes.[109] Research has demonstrated that overstressing physicians beyond reasonable levels is associated with increases in implicit bias.[110]

E. Clinical caregivers
1. Employ a trauma-informed care approach with individual patient interactions.[111] The BIPOC communities suffer under the pervasiveness of historical and personal trauma as well as the psychological trauma inflicted by law enforcement killings of unarmed Blacks.[112] Moreover, BIPOC minorities are exposed daily to stressful and traumatic events at much great rates than the general population.[113] To adopt the trauma-informed care framework:
   a. Abandon power imbalances common in traditional, paternalistic doctor-patient dynamics.
   b. Empower patients to be partners in treatment decisions.
   c. Offer patients validation, explanation, and choice.
   d. Practice cultural humility, an orientation to care that is based on self-reflexivity, appreciation of patients' lay expertise, openness to sharing power and knowledge with patients, and desire to learn from patients.[114]
2. Recognize and counter potentially racist clinical decisions by doing the following:
   a. Follow evidence-based race-blind admission and surgical criteria.
   b. Provide professional peer-to-peer feedback with coaching on delivery of difficult conversations.[115]
   c. Build race-blind analgesia protocols.[116]
   d. Create policies to address interprofessional microaggressions and patient-to-clinician racism. Micro- and macroaggressions contribute to burnout and must be combated to ensure inclusion and career longevity.[117,118]

In conclusion, from a medical standpoint, there is only one race—the human race—and we must recognize and counter our implicit biases. As fellow humans, we must acknowledge that structural racism drives health inequities, and as emergency physicians we can choose to address it by employing any or all the actions and recommendations proposed herein.

Address for Correspondence: Wendy L Macias-Konstantopoulos, MD, Center for Social Justice and Health Equity, Department of Emergency Medicine, Massachusetts General Hospital and Harvard Medical School, 55 Fruit Street Zero Emerson, Suite 3B, Boston, Massachusetts 02114. Email: wmacias@mgh.harvard.edu

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.

REFERENCES

1. Center for Disease Control and Prevention. *Social Determinants of Health at CDC*. 2022. Available at: https://www.cdc.gov/about/sdoh/index.html. Accessed July 9, 2023.
2. Greenwald AG, Banaji MR. Implicit social cognition: attitudes, self-esteem, and stereotypes. *Psychol Rev.* 1995;102(1):4–27.
3. FitzGerald C, Hurst S. Implicit bias in healthcare professionals: a systematic review. *BMC Med Ethics*. 2017;18:19.
4. Qiao WP, Powell ES, Witte MP, et al. Relationship between racial disparities in ED wait times and illness severity. *Am J Emerg Med.* 2016;34(1):10–5.
5. Pines JM, Localio AR, Hollander JE. Racial disparities in emergency department length of stay for admitted patients in the United States. *Acad Emerg Med.* 2009;16(5):403–10.
6. Schrader CD, Lewis LM. Racial disparity in emergency department triage. *J Emerg Med.* 2013;44(2):511–8.
7. Zhang X, Carabello M, Hill T, et al. Trends of racial/ethnic differences in emergency department care outcomes among adults in the United States from 2005 to 2016. *Front Med.* 2020;7:300.
8. Green AR, Carney DR, Pallin DJ, et al. Implicit bias among physician and its prediction of thrombolysis decisions for Black and White patients. *J Gen Intern Med.* 2007;22(9):1231–8.

9. Johnson TJ, Hickey RW, Switzer GE, et al. The impact of cognitive stressors in the emergency department on physician implicit racial bias. *Acad Emerg Med.* 2016;23(3):297–305.
10. Dehon E, Weiss N, Jones J, et al. A systematic review of the impact of physician implicit racial bias on clinical decision making. *Acad Emerg Med.* 2017;24(8):895–904.
11. Grant MJ, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J.* 2009;26(2):91–108.
12. Williams DR, Collins C. Racial residential segregation: a fundamental cause of racial disparities in health. *Public Health Rep.* 2001;116(5):404–16.
13. Assari S. Unequal gain of equal resources across racial groups. *Int J Health Policy Manag.* 2018;7(1):1–9.
14. Chapin-Bardales J, Rosenberg ES, Sullivan PS. Trends in racial/ethnic disparities of new AIDS diagnoses in the United States, 1984–2013. *Ann Epidemiol.* 2017;27(5):329–34.e2.
15. Nosyk B, Krebs E, Zang X, et al. "Ending the epidemic" will not happen without addressing racial/ethnic disparities in the United States human immunodeficiency virus epidemic. *Clin Infect Dis.* 2020;71(11):2968–71.
16. Harris NS, Johnson AS, Huang Y-LA, et al. Vital signs: status of human immunodeficiency virus testing, viral suppression, and HIV preexposure prophylaxis — United States, 2013–2018. *MMWR Morb Mortal Wkly.* 2019;68(48):1117–23.
17. Beer L, Bradley H, Mattson CL, et al. Trends in racial and ethnic disparities in antiretroviral therapy prescription and viral suppression in the United States, 2009–2013. *J Acquir Immune Defic Syndr.* 2016;73(4):446–53.
18. Bradley H, Wall EW, Rosenthal EM, et al. Hepatitis C virus prevalence in 50 U.S. states and D.C. by sex, birth cohort, and race: 2013-2016. *Hepatol Commun.* 2020;4(3):355–70.
19. Vutien P, Hoang J, Brooks L, et al. Racial disparities in treatment rates for chronic hepatitis C. *Medicine.* 2016;95(22):e3719.
20. Jung J, Du P, Feldman R, et al. Racial/ethnic and socioeconomic disparities in use of direct-acting antivirals among Medicare beneficiaries with chronic hepatitis C, 2014-2016. *J Manag Care Spec Pharm.* 2019;25(11):1236–42.
21. Marcus JL, Hurley LB, Chamberland S, et al. Disparities in initiation of direct-acting antiviral agents for hepatitis C virus infection in an insured population. *Public Health Rep.* 2018;133(4):452–60.
22. Hogben M, Leichliter JS. Social determinants and sexually transmitted disease disparities. *J Sex Transm Dis.* 2008;35:S13–8.
23. Adimora AA, Schoenbach VJ. Social context, sexual networks, and racial disparities in rates of sexually transmitted infections. *J Infec Dis.* 2005;191(s1):S115–22.
24. Owusu-Edusei K, Chesson HW, Leichliter JS, et al. The association between racial disparity in income and reported sexually transmitted infections. *Am J Public Health.* 2013;103(5):910–6.
25. Parekh N, Donohue JM, Corbelli J, et al. Screening for sexually transmitted infections after cervical cancer screening guideline and Medicaid policy changes: a population-based analysis. *Med Care.* 2018;56(7):561–8.
26. Libby T, Clogher P, Wilson E, et al. Disparities in shigellosis incidence by census tract poverty, crowding, and race/ethnicity in the United States, FoodNet, 2004–2014. *Open Forum Infect Dis.* 2020;7(2):ofaa030.
27. McCrickard LS, Crim SM, Kim S, et al. Disparities in severe shigellosis among adults—Foodborne Diseases Active Surveillance Network, 2002-2014. *BMC Public Health.* 2018;18(1):221.
28. Yen C, Steiner CA, Barrett M, et al. Racial disparities in diarrhea-associated hospitalizations among children in five US States, before and after introduction of rotavirus vaccines. *Vaccine.* 2010;28(46):7423–6.
29. Yaya S, Yeboah H, Charles CH, et al. Ethnic and racial disparities in COVID-19-related deaths: counting the trees, hiding the forest. *BMJ Global Health.* 2020;5(6):e002913.
30. Smith AR. Emergency department visits for COVID-19 by race and ethnicity — 13 States, October–December 2020. *MMWR Morb Mortal Wkly Rep.* 2021;70(15):566–9.
31. Quinn SC, Kumar S, Freimuth VS, et al. Racial disparities in exposure, susceptibility, and access to health care in the US H1N1 influenza pandemic. *Am J Public Health.* 2011;101(2):285–93.
32. Khazanchi R, Beiter ER, Gondi S, et al. County-level association of social vulnerability with COVID-19 cases and deaths in the USA. *J Gen Intern Med.* 2020;35(9):2784–7.
33. Millet GA, Jones AT, Benkeser D, et al. Assessing differential impacts of COVID-19 on Black communities. *Ann Epidemiol.* 2020;47:37–44.
34. Kabarriti R, Brodin NP, Maron MI, et al. Association of race and ethnicity with comorbidities and survival among patients with COVID-19 at an urban medical center in New York. *JAMA Netw Open.* 2020;3(9):e2019795.
35. Centers for Disease Control and Prevention. *Excess Deaths Associated with COVID-19.* 2023. Available at: https://www.cdc.gov/nchs/nvss/vsrr/covid19/excess_deaths.htm. Accessed July 9, 2023.
36. Chen JT, Krieger N. Revealing the unequal burden of COVID-19 by income, race/ethnicity, and household crowding. *J Public Health Manag and Pract.* 2021;27(Suppl 1), COVID-19 and Public Health: Looking Back, Moving Forward: S43–56.
37. National Center for Health Statistics (NCHS) provisional death counts. Centers for Disease Control and Prevention. Published 2021. Available at: https://data.cdc.gov/NCHS/Provisional-Death-Counts-for-Coronavirus-Disease-C/pj7m-y5uh. Accessed June 10, 2021.
38. COVID-19 Racial and Ethnic health disparities. Centers for Disease Control and Prevention. Published 2020. Available at: https://www.cdc.gov/coronavirus/2019-ncov/community/health-equity/racial-ethnic-disparities/increased-risk-exposure.html#ref1. Accessed June 10, 2021.
39. Muñoz-Price LS, Nattinger AB, Rivera F, et al. Racial disparities in incidence and outcomes among patients with COVID-19. *JAMA Netw Open.* 2020;3(9):e2021892.

40. Yehia BR, Winegar A, Fogel R, et al. Association of race with mortality among patients hospitalized with coronavirus disease 2019 (COVID-19) at 92 US Hospitals. *JAMA Netw Open.* 2020;3(8):e2018039.
41. Alobuia WM, Dalva-Baird NP, Forrester JD, et al. Racial disparities in knowledge, attitudes and practices related to COVID-19 in the USA. *J Public Health.* 2020;42(3):470–8.
42. Alsan M, Stantcheva S, Yang D, et al. Disparities in coronavirus 2019 reported incidence, knowledge, and behavior among US adults. *JAMA Netw Open.* 2020;3(6):e2012403.
43. Jones J, Sullivan PS, Sanchez TH, et al. Similarities and differences in COVID-19 awareness, concern, and symptoms by race and ethnicity in the United States: cross-sectional survey. *J Med Internet Res.* 2020;22(7):e20001.
44. Guth M, Ammula M. Building on the evidence base: studies on the effects of Medicaid expansion, February 2020 to March 2021. Kaiser Family Foundation. Published 2021. Available at: https://files.kff.org/attachment/Report-Building-on-the-Evidence-Base-Studies-on-the-Effects-of-Medicaid-Expansion.pdf. Accessed August 23, 2021.
45. Liao TF, De Maio F. Association of social and economic inequality with coronavirus disease 2019 incidence and mortality across US counties. *JAMA Netw Open.* 2021;4(1):e2034578.
46. Kriss JL, Hung MC, Srivastav A, et al. COVID-19 vaccination coverage, by race and ethnicity—National Immunization Survey Adult COVID Module, United States, December 2020-November 2021. *MMWR Morb Mortal Wkly Rep.* 2022;71(23):757–63.
47. Bradley EH, Herrin J, Wang Y. Racial and ethnic differences in time to acute reperfusion therapy for patients hospitalized with myocardial infarction. *ACC Curr J Rev.* 2004;13(12):8.
48. Cavender MA, Rassi AN, Fonarow GC, et al. Relationship of race/ethnicity with door-to-balloon time and mortality in patients undergoing primary percutaneous coronary intervention for ST-elevation myocardial infarction: findings from Get with the Guidelines-Coronary Artery Disease. *Clin Cardiol.* 2013;36(12):749–56.
49. Chaudhry SI, Khan RF, Chen J, et al. National trends in recurrent AMI hospitalizations 1 year after acute myocardial infarction in Medicare beneficiaries: 1999–2010. *J Am Heart Assoc.* 2014;3(5):e001197.
50. Graham GN, Jones PG, Chan PS, et al. Racial disparities in patient characteristics and survival after acute myocardial infarction. *JAMA Netw Open.* 2018;1(7):e184240.
51. Ferdinand KC, Nasser SA. Racial/ethnic disparities in prevalence and care of patients with type 2 diabetes mellitus. *Curr Med Res Opin.* 2015;31(5):913–23.
52. Gary TL, Mcguire M, McCauley J, et al. Racial comparisons of health care and glycemic control for African American and White diabetic adults in an urban managed care organization. *Dis Manag.* 2004:7(1):25–34.
53. Menchine MD, Wiechmann W, Peter AL, et al. Trends in diabetes-related visits to US EDs from 1997 to 2007. *Am J Emerg Med.* 2012;30(5):754–8.
54. Doyle SK, Chang AM, Levy P, et al. Achieving health equity in hypertension management through addressing the social determinants of health. *Curr Hypertens Rep.* 2019;21(8):58.
55. Sripipatana A, Pourat N, Chen Z, et al. Exploring racial/ethnic disparities in hypertension care among patients served by health centers in the United States. *J Clin Hypertens.* 2019;21(4):489–98.
56. Minnick ML, Boynton S, Ndirangu J, et al. Sex, race, and socioeconomic disparities in kidney disease in children. *Semin Nephrol.* 2010;30(1):26–32.
57. NAPRTCS. 2007. *North American Pediatric Renal Transplant Cooperative Study (NAPRTICS) 2007 Annual Report*. Rockville, MD: The EMMES Corporation.
58. Patzer RE, Mohan S, Kutner N, et al. Racial and ethnic disparities in pediatric renal allograft survival in the United States. *Kidney Int.* 2015;87(3):584–92.
59. National Center for Health Statistics. *Health, United States, 2015: With Special Feature on Racial and Ethnic Health Disparities*. DHHS Publication No. 2016-1232. Hyattsville, MD: Centers for Disease Control and Prevention, U.S. Department of Health and Human Services; 2016. Available at: https://stacks.cdc.gov/view/cdc/39108. Accessed August 15, 2022.
60. Petersen R, Pan L, Blanck HM. Racial and ethnic disparities in adult obesity in the United States: CDC's tracking to inform state and local action. *Prev Chronic Dis.* 2019;16:E46.
61. Krueger PM, Reither EN. Mind the gap: race\ethnic and socioeconomic disparities in obesity. *Curr Diab Rep.* 2015;15(11):95.
62. Hilmers A, Hilmers DC, Dave J. Neighborhood disparities in access to healthy foods and their effects on environmental justice. *Am J Public Health.* 2012;102(9):1644–54.
63. Kwate NO, Yau CY, Loh JM, et al. Inequality in obesigenic environments: fast food density in New York City. *Health Place.* 2009;15(1):364–73.
64. Lewis LB, Sloane DC, Nascimento LM, et al. African Americans' access to health food options in South Los Angeles restaurants. *Am J Public Health.* 2005;95(4):668–73.
65. Byrd AS, Toth AT, Stanford FC. Racial disparities in obesity treatment. *Curr Obes Rep.* 2018;7(2):130–8.
66. McGregor B, Li C, Baltrus P, et al. Racial and ethnic disparities in treatment and treatment type for depression in a national sample of Medicaid recipients. *Psychiatr Serv.* 2020;71(7):663–9.
67. Peters ZJ, Santo L, Davis D, et al. Emergency department visits related to mental health disorders among adults, by race and Hispanic ethnicity: United States, 2018-2020. *Natl Health Stat Report.* 2023;(181):1–9.
68. Khatri UG, Delgado MK, South E, et al. Racial disparities in the management of emergency department patients presenting with psychiatric disorders. *Ann Epidemiol.* 2022;69:9–16.
69. Smith CM, Turner NA, Thielman NM, et al. Association of Black race with physical and chemical restraint use among patients undergoing emergency psychiatric evaluation. *Psychiatr Serv.* 2022;73(7):730–6.
70. Schnitzer K, Merideth F, Macias-Konstantopoulos W, et al. Disparities in care: the role of race on the utilization of physical restraints in the emergency setting. *Acad Emerg Med.* 2020;27(10):943–50.

71. Carreras Tartak J, Brisbon N, Wilkie S, et al. Racial and ethnic disparities in emergency department restraint use: a multicenter retrospective analysis. *Acad Emerg Med.* 2021;28(9):957–65.
72. Mikati I, Benson AF, Luben TJ, et al. Disparities in distribution of particulate matter emission sources by race and poverty status. *Am J Public Health.* 2018;108(4):480–5.
73. Tessum CW, Paolella DA, Chambliss SE, et al. PM2.5 polluters disproportionately and structurally affect people of color in the United States. *Sci Adv.* 2021;7(18):eabf4491.
74. Commission for Racial Justice. *Toxic Wastes and Race in the United States: A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Waste Sites*. New York, NY: United Church of Christ Commission for Racial Justice; 1987. Available at: https://www.nrc.gov/docs/ML1310/ML13109A339.pdf. Accessed August 15, 2022.
75. National Research Council. 1991. *Environmental Epidemiology: Volume I: Public Health and Hazardous Wastes*. National Research Council Committee on Environmental Epidemiology. Washington, DC: National Academies Press.
76. Faber DR, Krief EJ. Unequal exposure to ecological hazards: environmental injustices in the Commonwealth of Massachusetts. *Environ Health Perspect.* 2002;110(Suppl 2):277–88.
77. Lee P, Le Saux M, Siegel R, et al. Racial and ethnic disparities in the management of acute pain in US emergency departments: Meta-analysis and systematic review. *Am J Emerg Med.* 2019;37(9):1770–7.
78. Benzing AC, Bell C, Derazin M, et al. Disparities in opioid pain management for long bone fractures. *J Racial Ethn Health Disparities.* 2020;7(4):740–5.
79. Singhal A, Tien YY, Hsia RY. Racial-ethnic disparities in opioid prescriptions at emergency department visits for conditions commonly associated with prescription drug abuse. *PLoS One.* 2016;11(8):e0159224.
80. Goyal MK, Johnson TJ, Chamberlain JM, et al. Racial and ethnic differences in emergency department pain management of children with fractures. *Pediatrics.* 2020;145(5):e20193370.
81. Educational Fund to Stop Gun Violence. New CDC Data Reveals Persistently High Rates of U.S. Gun Deaths. 2019. Available at: https://efsgv.org/press/new-2019-cdc-data/. Accessed January 7, 2021.
82. Educational Fund to Stop Gun Violence. Gun Violence in America: An Analysis of 2018 CDC Data. 2020. Available at: https://efsgv.org/report/gun-violence-in-america-an-analysis-of-2018-cdc-data-february-2020/. Accessed January 7, 2021.
83. Smedley A, Smedley BD. Race as biology is fiction, racism as a social problem is real: anthropological and historical perspectives on the social construction of race. *Am Psychol.* 2005;60(1):16–26.
84. Nieblas-Bedolla E, Christophers B, Nkinsi NT, et al. Changing how race is portrayed in medical education: recommendations from medical students. *Acad Med.* 2020 Dec;95(12):1802–6.
85. Cooper RS. Race in biological and biomedical research. *Cold Spring Harb Perspect Med.* 2013;3(11):a008573.
86. Alaniz ML. Alcohol availability and targeted advertising in racial/ethnic minority communities. *Alcohol Health Res World.* 1998;22(4):286–9.
87. Lee JGL, Sun DL, Schleicher NM, et al. Inequalities in tobacco outlet density by race, ethnicity, and socioeconomic status, 2012, USA: results from the ASPiRE study. *J Epidemiol Community Health.* 2017;71(5):487–92.
88. Esquierdo-Leal JL, Houmanfar RA. Creating Inclusive and equitable cultural practices by linking leadership to systemic change. *Behav Anal Prac.* 2021;14(2):499–512.
89. Hassen N, Lofters A, Michael S, et al. Implementing anti-racism interventions in healthcare settings: a scoping review. *Int J Environ Res Public Health.* 2021;18(6):2993.
90. Brownson RC, Kumanyika SK, Kreuter MW, et al. Implementation science should give higher priority to health equity. *Implement Sci.* 2021;16(1):18.
91. Parker RB, Stack SJ, Schneider SM, et al. Why diversity and inclusion are critical to the American College of Emergency Physicians' future success. *Ann Emerg Med.* 2017;69(6):714–7.
92. Campbell KM, Tumin D. Mission matters: association between a medical school's mission and minority student representation. Zweigenthal VEM, ed. *PLoS One.* 2021;16(2):e0247154.
93. Lewis JH, Lage OG, Grant BK, et al. Addressing the social determinants of health in undergraduate medical education curricula: a survey report. *Adv Med.* 2020;11:369–77.
94. Eslava-Schmalbach J, Garzón-Orjuela N, Elias V, et al. Conceptual framework of equity-focused implementation research for health programs (EquIR). *Int J Equity Health.* 2019;18(1):80.
95. Bailey ZD, Feldman JM, Bassett MT. How structural racism works—racist policies as a root cause of US racial health inequalities. *N Engl J Med.* 2020;384(8):768–73.
96. Curtis E, Jones R, Tipene-Leach D, et al. Why cultural safety rather than cultural competency is required to achieve health equity: a literature review and recommended definition. *Int J Equity Health.* 2019;18(1):1–17.
97. Heron SL, Lovell EO, Wang E, et al. Promoting diversity in emergency medicine: summary recommendations from the 2008 Council of Emergency Medicine Residency Directors (CORD) Academic Assembly Diversity Workgroup. *Acad Emerg Med.* 2009;16(5):450–3.
98. Lewis NM, Friedrichs M, Wagstaff S, et al. Disparities in COVID-19 incidence, hospitalizations, and testing, by area-level deprivation–Utah, March 3–July 9, 2020. *MMWR Morb Mortal Wkly Rep.* 2020;69(38):1369–73.
99. Institute Of Medicine (U.S.). Committee on Educating Health Professionals to Address the Social Determinants of Health; Board on Global Health; Institute of Medicine; National Academies of Sciences, Engineering, and Medicine. 2016. *A Framework for Educating Health Professionals to Address the Social Determinants of Health*. Washington, DC: National Academies Press (US).

100. Neff J, Holmes SM, Knight KR, et al. Structural competency: curriculum for medical students, residents, and interprofessional teams on the structural factors that produce health disparities. *MedEdPORTAL.* 2020;16:10888.
101. Ogunyemi D. Defeating unconscious bias: the role of a structured, reflective, and interactive workshop. *J Grad Med Educ.* 2021;13(2):189–94.
102. Horvat L, Horey D, Romios P, et al. Cultural competence education for health professionals. *Cochrane Database System Rev.* 2014;(5):CD009405.
103. Bailey RK, Saldana AM, Saldana AM. Richard Allen Williams, MD: a career fighting disparities and fostering equity. *J Racial Ethn Health Disparities.* 2021;8(3):566–9.
104. Olufadeji A, Dubosh NM, Landry A. Guidelines on the use of race as patient identifiers in clinical presentations. *J Natl Med Assoc.* 2021;113(4):428–30.
105. Diao JA, Wu GJ, Taylor HA, et al. Clinical implications of removing race from estimates of kidney function. *JAMA.* 2021;325(2):184–6.
106. Cleveland Manchanda EC, Macias-Konstantopoulos WL. Tackling gender and racial bias in academic emergency medicine: the perceived role of implicit bias in faculty development. *Cureus.* 2020;12(11):e11325.
107. Huffman A. When race becomes an issue in emergency department treatment. *Ann Emerg Med.* 2018;71(1):A16–8.
108. Kelen GD, Wolfe R, D'Onofrio G, et al. Emergency department crowding: the canary in the health care system. *NEJM Catalyst*, 2021. Available at: https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0217. Accessed August 14, 2022.
109. Gladwell M. 2013. *Blink: The Power of Thinking Without Thinking*. New York, NY: Back Bay Books.
110. Johnson TJ, Hickey RW, Switzer GE, et al. the impact of cognitive stressors in the emergency department on physician implicit racial bias. Gerson L, ed. *Acad Emerg Med.* 2016;23(3):297–305.
111. Agboola IK, Coupet E Jr, Wong AH. "The coats that we can take off and the ones we can't": the role of trauma-informed care on race and bias during agitation in the emergency department. *Ann Emerg Med.* 2021;77(5):493–8.
112. Bor J, Venkataramani AS, Williams DR, et al. Police killings and their spillover effects on the mental health of Black Americans: a population-based, quasi-experimental study. *Lancet.* 2018;392(10144):302–10.
113. Gillespie CF, Bradley B, Mercer K, et al. Trauma exposure and stress-related disorders in inner city primary care patients. *Gen Hosp Psychiatry.* 2009;31(6):505–14.
114. Lekas HM, Pahl K, Fuller Lewis C. Rethinking cultural competence: shifting to cultural humility. *Health Serv Insights.* 2020;13:117863292097058.
115. Stone D, Heen S. 2015. *Thanks for the Feedback: The Science and Art of Receiving Feedback Well (even when it is off base, unfair, poorly delivered, and frankly, you're not in the mood).* New York, NY: Portfolio Penguin.
116. Tamayo-Sarver JH, Hinze SW, Cydulka RK, et al. Racial and ethnic disparities in emergency department analgesic prescription. *Am J Public Health.* 2003;93(12):2067–73.
117. Sudol NT, Guaderrama NM, Honsberger P, et al. Prevalence and nature of sexist and racial/ethnic microaggressions against surgeons and anesthesiologists. *JAMA Surg.* 2021;156(5):e210265.
118. Molina MF, Landry AI, Chary AN, et al. Addressing the elephant in the room: microaggressions in medicine. *Ann Emerg Med.* 2020;76(4):387–91.

From the Editors – Future Directions to Strengthen the Emergency Department Safety Net

Rama A. Salhi, MD, MHS, MSc*
Wendy L. Macias-Konstantopoulos, MD, MPH, MBA*
Caitlin R. Ryus, MD, MPH**

*Massachusetts General Hospital, Department of Emergency Medicine, Boston, Massachusetts
**Yale School of Medicine, Department of Emergency Medicine, New Haven, Connecticut

Section Editor: Mark Langdorf, MD, MHPE
Submission history: Submitted April 17, 2023; Revision received May 31, 2023; Accepted June 1, 2023
Electronically published August 8, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.60719

Emergency medicine as a specialty prides itself on being the safety net for the communities we serve. Always open, we provide care to all comers, regardless of insurance status or ability to pay, often on the worst days of their lives. Over time, we have come to appreciate that this can mean fractured limbs, cardiac arrest, or a cancer diagnosis; but just as frequently we care for individuals who are suffering the ramifications of the innumerable ways in which our system has failed them. This includes poverty, structural racism, lack of housing, food insecurity, community violence, and widely disparate incarceration rates.[1–3]

We acknowledge several fundamental truths:

1. Discrimination by age, race, gender identity, sexual orientation, housing status, psychiatric illness (and the list goes on) exists.
2. Our patients, colleagues, and communities grapple with discrimination and its health ramifications every day.
3. Implicit biases and discriminatory practices are not static. We continue to see the impact of past practices, and our current decisions will impact many decades to come.
4. Emergency clinicians are uniquely positioned and privileged to contribute to advancing equity.

As we strive to understand more fully the health impact of these social inequities and injustices, our clinical specialty has seen the rapid expansion of social emergency medicine. Increasingly recognized as a subspecialty, social emergency medicine has established a growing foundation of knowledge replete with peer-reviewed literature, academic journal special issues, textbooks, research and educational conferences, fellowships, and representation within our professional societies.[4–6] The burgeoning multidisciplinary work of social emergency medicine is a testament to the nuance with which we must understand social and structural determinants of health. This level of nuance is required to even begin to understand our role as emergency physicians, administrators, educators, researchers, and ultimately advocates in their solutions.

Despite these advances, the body of literature that constitutes the foundation of social emergency medicine is still being built. Many of the social determinants of health that we seek to address can be difficult to quantitatively study due to small or inaccessible populations, discrimination and mistrust, or failure to screen and identify. Here is where we find the value of case studies, qualitative studies, hypothesis-generating studies, and narrative reviews. Showcased in this *Western Journal of Emergency Medicine* special issue are studies by authors who endeavored to contribute to our growing foundation of knowledge and cover a broad range of topics.

As emergency physicians, we bear witness daily to the health impacts of social inequities and injustices on the individuals and communities we serve. Although the structural solutions needed to address our most vexing social problems may not lie squarely within our control as a specialty, we have both the responsibility and the opportunity to create, inform, and participate in change. Systematically investigating the compounding health effects of complex and interrelated social problems allows us to fulfill our promise to our communities: No matter who you are, no matter your problem, we are here 24 hours a day, 365 days a year.

Address for Correspondence: Rama A. Salhi, MD MHS MSc, Massachusetts General Hospital, Department of Emergency Medicine, 125 Nashua St., Suite 920, Boston, Massachusetts 02114. Email: rsalhi@mgh.harvard.edu

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.

REFERENCES

1. Darby A, Cleveland Manchanda EC, Janeway H, et al. Race, racism, and antiracism in emergency medicine: A scoping review of the literature and research agenda for the future. *Acad Emerg Med*. 2022;29(11):1383–98.
2. Salhi BA, White MH, Pitts SR, et al. Homelessness and emergency medicine: a review of the literature. *Acad Emerg Med*. 2018;25(5):577–93.
3. Wulz A. Emergency department visits by incarcerated adults for nonfatal injuries — United States, 2010–2019. *Morb Mortal Wkly Rep*. 2023;72.
4. Alter HJ. Foreword to conference proceedings, inventing social emergency medicine. *Ann Emerg Med*. 2019;74(5):S1–S2.
5. Alter HJ, Dalawari P, Doran KM, et al. *Social Emergency Medicine: Principles and Practice*. London, UK:Springer Nature; 2021.
6. Goldberg L, Urquhart S, DesCamp R, et al. Training future leaders: social emergency medicine fellowships. *AAEM - Common Sense*. 2021. Available at: https://www.aaem.org/UserFiles/SocialPopulationJulyAugust2021.pdf. Accessed April 14, 2023.

Charcot Neuroarthropathy of the Foot and Ankle in the Acute Setting: An Illustrative Case Report and Targeted Review

Kian Bagheri, BA* *Campbell University, School of Osteopathic Medicine, Lillington, North Carolina
Albert T. Anastasio, MD† †Duke University Hospital, Department of Orthopedic Surgery, Durham, North Carolina
Alexandra Krez, BA‡ ‡Duke University, School of Medicine, Durham, North Carolina
Lauren Siewny, MD§ §Duke University Hospital, Department of Emergency Medicine, Durham, North Carolina
Samuel B. Adams, MD†

Section Editors: Juan Acosta, DO, MS, and Edward Michelson, MD
Submission history: Submitted January 9, 2023; Revision received July 14, 2023; Accepted July 18, 2023
Electronically published August 30, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59833

Charcot neuroarthropathy (CN) is a rare but serious sequela of diabetes and other diseases that cause peripheral neuropathy. It is most commonly characterized by degeneration of the foot and/or ankle joints leading to progressive deformity and altered weight-bearing. If left untreated, the deformities of CN lead to ulceration, infection, amputation, and even death. Because of the associated peripheral neuropathy and proprioception deficits that accompany CN, patients typically do not perceive the onset of joint destruction. Moreover, in the hands of the untrained clinician, the initial presentation of CN can easily be mistaken for infection, osteoarthritis, gout, or inflammatory arthropathy. Misdiagnosis can lead to the aforementioned serious sequelae of CN. Thus, an early accurate diagnosis and off-loading of the involved extremity, followed by prompt referral to a specialist trained in the care of CN are crucial to prevent the late-term sequelae of the disease. The purpose of this article was to create an opportunity for enhanced understanding between orthopedic surgeons and emergency physicians, to improve patient care through the optimization of diagnosis and early management of CN in the emergent setting. [West J Emerg Med. 2023;24(5)921–930.]

Keywords: *Charcot neuroarthropathy; Charcot foot; diabetes mellitus; midfoot collapse; emergency.*

INTRODUCTION

Due to the progressive loss of protective sensation in advanced cases of diabetes mellitus (DM), identifying DM-related foot and ankle pathology in the early stages is a challenge for both patients and clinicians. One increasingly common complication of advanced DM is Charcot neuroarthropathy (CN), a progressive, destructive pathology of the bone and joints of the foot. Safavi et al estimated that CN has a prevalence of up to 13% in poorly controlled diabetic patients.[1] Once thought to be a rare complication, this diagnosis has become increasingly common as the global incidence of DM continues to rise.

Diagnosing diabetic CN is challenging, and even the most experienced clinicians can struggle to differentiate the disease from pathologies that masquerade as CN. Limited specificity with regard to physical examination, imaging, and lab work findings in CN can cloud the diagnosis. Moreover, when CN presents as an acutely inflamed foot, it often presents similarly to much more common pathologies of the foot and ankle, such as cellulitis, osteomyelitis, or gout. Delayed treatment results in the development of foot and ankle deformities, which increases the risk of ulceration, infection, and amputation.[2–5]

This case illustration and review, authored by orthopedic surgeons and emergency physicians, focuses on the early clinical presentation, diagnosis, and management of CN, particularly in the emergent and outpatient setting. While many authors have provided review articles on CN,[2–5] none to date have provided a manuscript specifically geared toward the facilitation of cross-talk between the involved specialties to aid in differentiating this challenging diagnosis from other similar pathologies. As the incidence of poorly controlled DM grows, the ability to distinguish the subtle presentation of CN from other more common foot

pathologies takes on unprecedented importance. We advocate for enhanced collaboration between orthopedic surgeons and emergency physicians to better understand our respective roles in the early diagnosis and treatment of CN, and to ultimately improve the care of patients with this condition.

ETIOLOGY AND PATHOPHYSIOLOGY OF CHARCOT NEUROARTHROPATHY

Early recognition of the complications of DM such as CN is critical in preventing damaging, long-term outcomes. In patients with poorly controlled DM, lack of protective sensation facilitates repetitive microtrauma, perpetuating a damaging feedback loop that is thought to contribute to the CN pathologic process. Some degree of CN exists in greater than 80% of patients who have poorly controlled DM for more than 10 years.[2] However, it is essential to emphasize that diabetes alone is not the sole predisposing factor for the development of CN. Any condition that causes sensory or autonomic neuropathy can lead to CN. Examples include syphilis, in which degeneration and demyelination of the dorsal columns and roots can lead to progressive sensory ataxia, chronic alcoholism, in which nutritional deficiency (especially thiamine) and oxidative stress can lead to free radical damage to nerves,[6] and spinal cord injury in which the somatosensory system is damaged.[7]

The exact pathogenesis of CN is not entirely understood, but there are two theories of what is believed to contribute to the pathogenesis of the disease.[2] The neurovascular theory postulates that increased blood flow to the bones, which is a result of damage to the "trophic nerves," leads to bone resorption and weakening. These pathophysiologic changes predispose patients to increased susceptibility to fractures and deformities. Alternatively, the neuro-traumatic theory states that repetitive trauma can cause fractures and deformation during healing.

PATIENT CASE REPORT

A 75-year-old woman with longstanding, poorly controlled type 2 DM with peripheral neuropathy to the mid-calf region presented to the emergency department (ED) with complaints of right foot deformity and pain for nine days. While the patient did not recall any specific injury, she attributed the appearance and symptoms to an ankle sprain. She was initially evaluated by her primary care physician, where the diagnosis of cellulitis was made and she was told to go to the ED for further evaluation. At the time of presentation, her erythrocyte sedimentation rate (ESR) was 103, her white blood cell count (WBC) was within normal limits, and her vital signs were within normal limits. Physical exam revealed a swollen, diffusely erythematous foot with diminished sensation to fine touch. No standard foot and ankle radiographs were obtained, but she underwent magnetic resonance imaging (MRI) that showed a fluid collection posterior to the ankle joint, which was drained and yielded a clear, serous fluid that did not grow any organisms of culture. A diagnosis of cellulitis was made, and the patient was placed on intravenous clindamycin and admitted to the hospital. She was discharged on oral antibiotics five days later. There were no limitations placed on her weight-bearing status.

Shortly after discharge, the patient traveled across the country, bearing weight on the involved foot. After a week, her foot swelling and redness progressed in severity. She re-presented to a different ED. A repeat MRI at that time was concerning for osteomyelitis, and she was started on cefepime and vancomycin. During this presentation, her lab values were within normal limits and she was again afebrile. She was admitted to the hospital and later discharged on vancomycin via a peripherally inserted central catheter. No standard foot and ankle radiographs were obtained during this admission. Three weeks after that admission, her creatinine increased to 4.41 and her vancomycin trough was found to be 16.8 micrograms per microliter (mcg/mL) (reference range: 5–15 mcg/mL). Subsequently, the patient was admitted to the hospital, this time for acute renal failure secondary to vancomycin therapy.

Physical exam at the time revealed a fixed abduction deformity of the foot with a severe equinus contracture of the Achilles tendon. She did not have protective sensation to Semmes-Weinstein monofilament testing with 5.07. Finally, radiographic imaging was obtained, which demonstrated severe midfoot and hindfoot collapse with hindfoot valgus alignment and forefoot abduction (Figure 1). Her talus was nearly in a vertical plantar flexed position. Advanced imaging in the form of computed tomography (CT) further demonstrated these findings, with advanced stage CN, with degenerative change at the talonavicular joint and midfoot (Figure 2).

She was eventually diagnosed with CN as well as end-stage renal disease, requiring chronic hemodialysis. After the correct diagnosis of CN had been made, the patient followed up in the orthopedic surgery clinic at our institution, where she received further care, including osteotomy with medial and lateral column fixation (Figure 3).

Case Summation

This case highlights the importance of early recognition of CN in an acutely inflamed foot in patients with DM, especially in the presence of advanced neuropathy. Despite careful attention from various clinicians, no standard radiographs were obtained and the diagnosis of CN was missed, contributing to kidney injury in addition to increased destructive changes of the foot from CN that may have been avoided with prompt diagnosis. In the case of our patient, no individual clinician on the care team was at fault; CN can be a challenging diagnosis to make due to the number of pathologies with which it can be easily confused. Orthopedic

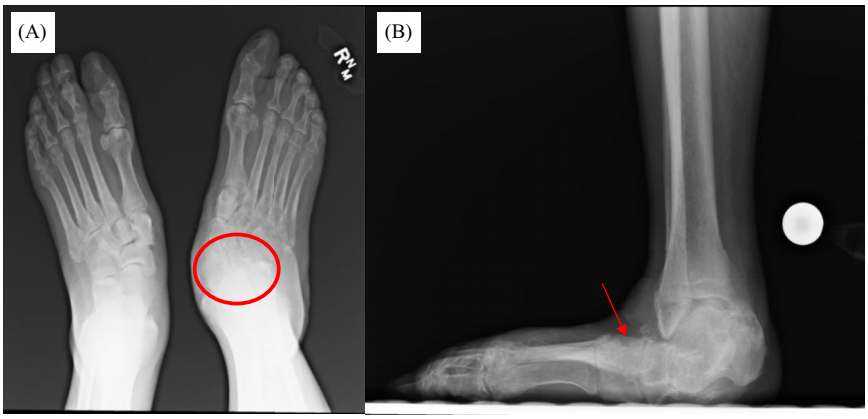


Figure 1. Weight-bearing radiographs: (A) Bilateral anterior-posterior. (B) Lateral radiographs 1.5 years after the patient's initial presentation to the emergency department. There is evidence of degenerative changes at the talonavicular joint (A – red circle) in addition to midfoot collapse (B – red arrow).

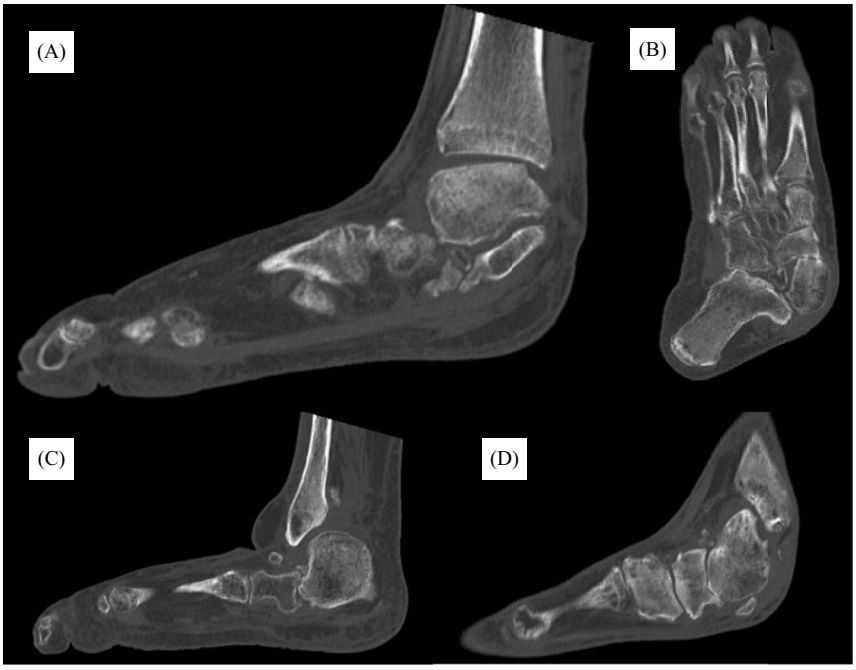


Figure 2. Computed tomography with (A,C,D) multiple sagittal cuts, and (B) a coronal cut after follow-up in orthopedic clinic demonstrating findings consistent with advanced stage Charcot joint with marked pes planus, mid-foot collapse, and hindfoot valgus.

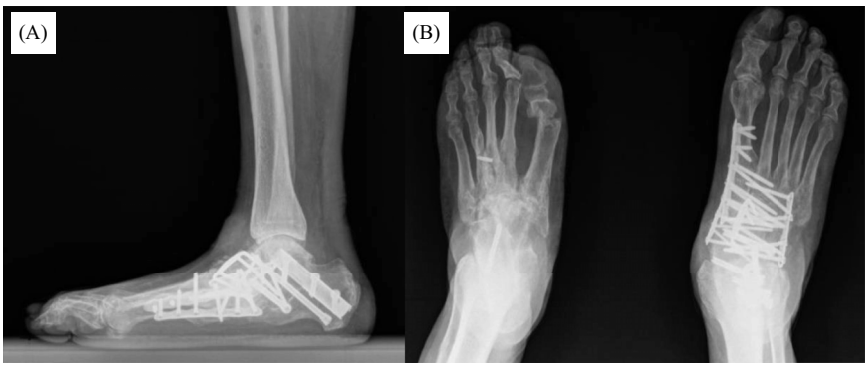


Figure 3. Most recent radiographs at final follow-up. (A) Lateral radiograph. (B) Bilateral anterior-posterior radiograph, revealing restoration of the arch of the foot, through the use of multiple osteotomy sites and internal fixation with a variety of plate, screw, and beam constructs.

surgeons receive specific training on differentiating CN from other conditions during foot and ankle subspecialty training, but the breadth of knowledge required for other specialties may preclude extensive awareness of CN. Thus, our goal with this review was to discuss the differential diagnosis of a patient with peripheral neuropathy and swelling to the foot and ankle and to expand upon the initial diagnosis and early treatment options of CN. Our ultimate aim is to facilitate understanding between orthopedic surgeons, emergency physicians, and primary care physicians to optimize the care of the diabetic patient with CN.

Clinical Presentation in the Emergent Setting

The typical patient presenting to the ED with CN is an individual with poorly controlled diabetes, usually 50 years of age or older, with signs of advanced disease such as peripheral neuropathy, retinopathy, or chronic kidney disease. A clinician may encounter the frequent scenario of a patient with previous trauma to the foot, such as a fall, that re-presents weeks or months later with persistent swelling and pain. However, patients often do not recall any specific trauma, which makes prompt diagnosis challenging.

In the early phase of CN, pain is an uncommon finding. However, if present, pain is usually insidious in onset, progressing over days or weeks. Between 25–50% of patients recall no trauma or inciting event.[3] A clinical exam will reveal unilateral warmth and an erythematous foot with soft tissue swelling. It is often difficult for the patient to fit the affected foot into normal shoes. A low threshold should be maintained for referral to orthopedic surgery.

Without treatment, early CN can progress to a chronic stage, where unfortunately most cases of CN are diagnosed. Late diagnosis increases the likelihood of bony destruction and resorption, which eventually leads to foot deformities, ulceration, and subsequent infection, often warranting amputation.[5,8] In a systematic review by Safavi et al in 2021, the average time from symptom onset to a final diagnosis of CN was 84.8 days, and 48% of patients experienced a misdiagnosis.[1] A systematic review by Korst et al in 2022 found similar results; the duration from symptom onset to correct diagnosis was 86.9 days, and 53.2% of cases of CN were initially misdiagnosed.[9] These alarming statistics highlight the challenge in making the diagnosis of CN, which calls attention to the importance of accurate diagnosis and prompt treatment.

Differential Diagnosis

Charcot neuroarthropathy shares many overlapping features with other common pathologies of the foot and ankle, which can complicate prompt and accurate diagnosis. Thus, we discuss common pathologies of the foot and ankle that can mislead clinicians to overlook the diagnosis of CN and offer clinical "pearls" that can help differentiate one from the other (Table 1).

Infection: Cellulitis, Septic Arthritis, and Osteomyelitis

The diagnosis that is the most commonly made over CN is foot and ankle infection, including cellulitis, septic arthritis, and osteomyelitis. This is because acute CN causes foot swelling and erythema. In general, an acutely infected foot is often painful and accompanied by a fever, whereas CN may present with minimal pain and an afebrile status. However, varying presentations of more indolent infectious etiologies in afebrile patients who may lack peripheral sensation and pain symptoms can mislead the diagnosis. These patients also tend to have poorly controlled blood glucose levels due to elevated cortisol, which antagonizes the action of insulin,[10] further causing the potential for misdiagnosis.

Charcot neuroarthropathy should always be considered in patients with recurrent cellulitis without systemic signs, symptoms, or findings that suggest infection on laboratory analysis.[3] Specifically, cellulitis can be accompanied by signs of systemic toxicity such as leukocytosis and elevated inflammatory markers. The lack of these findings in the presence of erythema may indicate an early stage of CN. A common orthopaedic teaching point regarding the differentiation of CN from infectious etiologies involves assessing the limb for improvement in erythema with elevation. After the involved foot has been elevated for 30 minutes, erythema should decrease in CN but will remain in the setting of infection.[3] Another distinguishing factor is laboratory markers. In CN, WBC count, C-reactive protein (CRP), and ESR may be normal, but these markers are almost always elevated to some extent in the setting of infection.[2,11]

Regarding specific infectious etiologies, osteomyelitis shares many overlapping features and can be concomitantly present with CN. Osteomyelitis should be suspected in the presence of ulcers and should be assumed in the setting of an ulcer that probes to bone.[12] The ESR may be elevated in both osteomyelitis and CN, but a downward trend with appropriate antibiotic therapy favors the diagnosis of osteomyelitis.[13] As a further differentiating factor, osteomyelitis often involves a single bone region, whereas CN involves multiple bones and joints.[14]

Imaging can further help delineate between CN and infectious etiologies of the foot and ankle. Plain radiography can be used to diagnose CN, but findings may not appear until two to three weeks after symptom onset. Moreover, it has been demonstrated that a 40–50% loss in bone mass in a patient with CN is required to note a difference from patients without CN.[12] Thus, MRI is a reasonable alternative to plain radiography. Unfortunately, several limitations to MRI for the diagnosis of CN exist, such as in the setting of recent surgery, retained hardware, or renal insufficiency that may preclude patients from receiving contrast. A bone biopsy, which has long been considered the gold standard for diagnosing osteomyelitis, can be done after a 14-day antibiotic-free period if the diagnosis of osteomyelitis is more

Table. 1 A summary of risk factors, physical exam, laboratory, and imaging findings, and treatment for Charcot neuroarthropathy (CN) and diseases that present similarly to CN.

Differential	Risk factors	Physical exam findings	Abnormal lab findings from initial evaluation	Imaging findings	Treatment
Charcot neuropathy	• Chronic alcohol use • Diabetic neuropathy • Heavy metal poisoning • Myelomeningocele • Leprosy • Syphilis • Syringomyelia • Vitamin B12 deficiency	• Commonly painless • Decreased range of motion • Edema • Erythema that may decrease with elevation • Peripheral neuropathy • Structural deformity • Warmth	• Elevated HbA1c or random serum glucose	• Plain radiograph: Delayed imaging with evidence of joint space narrowing, fragmentation of articular surfaces, coalescence of fragments, bone resorption, soft tissue calcification, deformity and remodeling of the fracture fragments • MRI: May detect subtle changes above in the earlier stages as well as periarticular edema	• Contact casting • Orthotics • Optimize underlying risk factors • Surgical management
Gout	• Chemotherapy • Chronic kidney disease • Excessive intake of ethanol, dietary purine or fructose • Hemolytic disorders • Inherited enzyme defects leading to purine overproduction • Lymphoproliferative disorders • Male sex • Myeloproliferative disorders • Obesity • Older age • Psoriasis • Use of medications associated with hyperuricemia	• Decreased range of motion • Edema • Erythema • Fever • Joint pain • Joint tenderness • Subcutaneous nodules • Sudden onset of symptoms • Warmth	• Elevated serum uric acid • Joint aspiration with negative birefringent monosodium urate crystals	• Plain radiograph: Periarticular erosion with sclerotic borders, joint space narrowing, soft tissue crystal deposition	• Nonsteroidal anti-inflammatory drugs • Colchicine • Corticosteroids • Allopurinol • Optimize underlying risk factors
Deep vein thrombosis	• Chronic inflammatory states • Heart failure • Obesity • Older age • Male gender • Malignancy • May-Thurner syndrome • Myeloproliferative disorders • Pregnancy or postpartum status • Previous deep vein thrombosis • Prolonged immobilization • Recent trauma or surgery • Tobacco use • Use of oral contraceptives or hormone replacement therapy	• Edema • Erythema • Increased visible skin veins • Pratt's sign • Sigg's sign • Unilateral pain and edema most commonly in calf • Warmth	• Elevated D-dimer	• Ultrasound: Noncompressible vein positive for thrombus	• Anticoagulants • Optimize underlying risk factors

(*Continued on next page*)

Table. 1 Continued.

Differential	Risk factors	Physical exam findings	Abnormal lab findings from initial evaluation	Imaging findings	Treatment
Osteoarthritis	• Female gender • History of joint trauma or overuse • Obesity • Older age • Muscle weakness	• Bone overgrowth or deformity • Decreased range of motion • Gradual onset of symptoms • Joint instability • Joint tenderness • May be polyarticular • Morning stiffness ≤30 minutes • Pain with movement and relieved with rest		• Plain radiographs: Joint space narrowing, presence of osteophytes, and subchondral sclerosis	• Nonsteroidal anti-inflammatory drugs • Physical therapy • Optimize underlying risk factors • Surgical management
Osteomyelitis	• Diabetes • Injection drug use • Immunocompromised • Indwelling catheter • Older age • Orthopedic hardware • Peripheral neuropathy • Poor vascular supply • Recent trauma • Sickle cell	• Decreased range of motion • Draining sinus tract • Gradual onset of symptoms • Fever • Erythema • Edema • Tenderness • Pain • Presence of ulcers • Warmth	• Elevated erythrocyte sedimentation rate and C-reactive protein Positive bone culture • Leukocytosis	• Plain radiograph: After 2 weeks may observe bone loss and periosteal reaction • MRI: In addition to finding on plain radiograph,T2 bone and soft tissue edema and a penumbra sign may be present	• Antibiotics • Irrigation and debridement • Optimize underlying risk factors • Amputation
Cellulitis	• Diabetes • Injection drug use • Lymphatic drainage disruption • Obesity • Peripheral artery disease • Recent surgery • Saphenous vein harvest • Skin barrier disruption • Skin inflammation • Venous insufficiency	• Breach in skin barrier • Edema • Erythema without dissipation upon elevation of affected extremity • Fever • Tenderness • Warmth	• Elevated erythrocyte sedimentation rate and C-reactive protein • Leukocytosis	-	• Antibiotics
Septic arthritis	• Diabetes • End-stage renal disease • Immunocompromised • Indwelling catheters • Injection drug use • Older age • Recent surgery • Recent trauma • Skin or soft tissue infection	• Acute onset of symptoms • Decreased range of motion • Edema • Erythema without dissipation upon elevation of affected extremity • Fever • Joint pain • Tenderness • Warmth	• Elevated erythrocyte sedimentation rate and C-reactive protein • Leukocytosis • Positive synovial fluid gram stain and culture	• Plain radiographs: Joint space narrowing, joint effusion, periarticular osteopenia, destruction of subchondral bone	• Antibiotics • Surgical drainage

MRI, magnetic resonance imaging.

heavily favored than CN.[15] In summation, differentiating CN from infectious etiologies of the foot and ankle is a clinical challenge that involves careful consideration of a variety of clinical, laboratory, and imaging-based findings.

Gout

Gout most commonly manifests symptomatically in the foot and ankle, making this diagnosis easy to confuse with CN. Risk factors for gout and CN overlap, such as DM and obesity, but a few special considerations merit further discussion. For example, certain medications can precipitate gout, the most common of which are thiazide diuretics. Thus, we recommend a thorough medication reconciliation upon presentation in cases of suspected gout vs CN. Heavy alcohol use is another risk factor often associated with gout. However, chronic alcoholism has been shown to be a risk factor for the progression of CN,[16,17] and so the presence of heavy alcohol use does not necessarily favor one diagnosis over the other. An additional diagnostic clue is the presence or absence of peripheral neuropathy. The presence of peripheral neuropathy coupled with extensive alcohol consumption points more toward CN over gout, especially if the patient does not have a previous history of gouty flares.[18]

To further differentiate a gout flare from CN, pain and tenderness that dissipate over a short duration favor the diagnosis of gout over the more long-term, subacute pain seen with CN. Laboratory analysis may reveal nonspecific changes consistent with inflammation during a gout flare, and these elevations may also be present in CN. Uric acid levels are not consistently elevated in gout[19] and should not be used as a marker to distinguish gout from CN. If gout is suspected, synovial fluid testing with cell counts and differential white count, Gram stain and culture, and crystal examination under polarizing light microscopy is recommended.[20–22] The presence of monosodium urate crystals confirms the diagnosis of gout.

Deep Vein Thrombosis

Deep vein thrombosis (DVT), while more commonly relegated to the calf, may also present similarly to CN. One of the most reliable clinical signs of DVT is unilateral leg swelling that involves the calf.[23] Risk factors for DVT include recent surgery, pregnancy, smoking, cancer, and prolonged immobility, which are distinct from CN.[24] Furthermore, a D-dimer level has a high sensitivity for ruling out DVT. If the D-dimer is elevated, venous duplex ultrasonography becomes the imaging study of choice in patients with suspected DVT.[25,26] The result of this study will be normal in patients with CN.

Osteoarthritis

Osteoarthritis is a chronic condition that progressively worsens over the course of a patient's life.[27] Pain is the cardinal symptom of osteoarthritis, which may or may not always be present in CN, given loss of protective sensation. However, the pain in osteoarthritis is classically exacerbated by activity and improved by rest.[28] Osteoarthritis also has characteristic findings on radiographs, such as joint space narrowing, the presence of osteophytes, and subchondral sclerosis.[29,30] In addition, bony fragmentation and callus formation are not seen in osteoarthritis but can be seen in CN.

Diagnosis

Diagnostic delays in diabetic CN are common but avoidable if clinicians maintain a high index of suspicion in patients with risk factors for CN. We encourage clinicians to always consider CN in their differential diagnosis when a diabetic patient with peripheral neuropathy presents with foot edema, redness, and warmth, especially in the absence of pain. Diagnosis of CN includes a thorough history and physical exam, imaging, and laboratory evaluation.

Physical Exam

Diagnosis of CN begins with a complete physical exam. Vital signs should be assessed for evidence of systemic illness, such as the presence of fever, tachycardia, or hypotension. In addition, the patient's feet should be inspected for the presence of ulcers or breaks in the skin. Although gross sensation testing in patients at risk of neuropathy is simple and rapid in the emergent setting, it is unreliable for assessing diabetic patients at risk of CN.[31] Semmes-Weinstein monofilament testing has long been considered the gold standard for detecting clinically relevant neuropathy in diabetic patients.[31] This non-invasive, low-cost, and rapid test is the most sensitive indicator of CN.[32] In addition to sensation testing, skin texture, bony deformities, signs of vascular or neurologic compromise, and details of footwear should be recorded.[2] Finally, elevating the affected foot for 30 minutes is a simple yet effective way of narrowing the differential diagnosis in the emergent setting. Redness will decrease in CN but not in the setting of infection.[3]

Laboratory Testing

Laboratory testing in patients suspected of CN should include a complete blood count (CBC), WBC with differential, and testing of renal function (via blood urea nitrogen and creatinine). Patients should also be screened for diabetes, even if they do not have a history of the disease or its presenting risk factors. Depending on the clinical setting, this can be achieved by assessing fasting glucose, hemoglobin A1c (HbA1c), or random blood glucose levels. The ESR and CRP can also be helpful, as elevations in these values are seen more commonly in other conditions, such as osteomyelitis or infection.

Imaging

Imaging is also helpful to help establish the diagnosis of CN; however, it is imperative to emphasize that normal radiographs do not rule out CN. Radiographs are often unremarkable in the early stages of the disease and are not a reliable indicator of disease progression. Nonetheless, plain film radiographs must be obtained because they serve as a baseline and allow for the detection of subtle changes that may portend instability.[3]

In instances where the radiograph is negative, but there remains a high index of suspicion for CN, MRI can be used for further evaluation. Magnetic resonance imaging is more sensitive in detecting subtle changes in the early phase of the disease and can help rule out other overlapping pathologies such as osteomyelitis.[32] In instances when MRI is contraindicated or cannot effectively distinguish CN from other pathologies, nuclear medicine studies such as leukocyte-labeled bone scans are highly specific for distinguishing between CN and infection.[33] In this process, WBCs are removed from the patient, tagged with a radioisotope such as indium-111, and injected intravenously back into the patient. The tagged leukocytes then localize to areas of relatively new infection.

Treatment

Immobilization

Charcot neuroarthropathy is a medical emergency that can lead to irreversible skeletal destruction and permanent deformities if not promptly addressed.[33] In patients with concomitant risk factors for CN, immobilization and non-weight bearing of the involved foot is recommended until the correct diagnosis is confirmed. Once the diagnosis of CN is established, it is vital to continue immobilization and non-weight bearing of the affected extremity.[32] At a minimum, the patient should be placed in a controlled ankle motion (CAM) boot. We caution against splinting or casting in the ED in case the patient gets lost to follow-up. A long-term splint or cast could lead to ulceration in the setting of decreased sensation. If an ulcer is present, the preferred method of immobilization is a total contact cast.[3,33] Full methodology for the application of total contact casting is outside the scope of this manuscript but generally includes a thin layer of cast padding to allow for weight distribution to offload points of ulceration and bony change. Total contact casting should continue until lower extremity edema and warmth resolve and serial radiography shows evidence of osseous consolidation.[3] This process typically occurs after three to four months but can take as long as 12 months. A CT or MRI can also be used to monitor the resolution of CN.

DISCUSSION

Charcot neuroarthropathy continues to emerge as a significant contributor to patient morbidity worldwide. In recognition of the importance of early diagnosis of this condition, a number of authors have reported on various interventions aimed to improve the detection of CN. A study by Foltz et al looked at the vascular and neurologic findings that were the most helpful in differentiating factors between patients with and without CN.[34] They found that simple neurologic testing combined with a comprehensive patient history were the most beneficial tools to determine patients at high risk of developing CN. They found statistically significant associations for history of retinopathy, nephropathy, and previous foot ulcer in addition to the neurologic physical exam findings of vibratory sensation, deep tendon reflexes, and Semmes-Weinstein monofilament testing with CN. Notably, vascular examinations were not predictive of CN. These findings have important implications for emergency physicians who are considering a diagnosis of CN.

Another study by Chantelau et al assessed the clinical course of acute CN in 24 patients without evidence of definite fractures on the initial radiograph after the onset of symptoms.[35] Alarmingly, 19 of the 24 patients in this study had been misdiagnosed prior to referral, highlighting the difficulty in achieving an accurate diagnosis of CN. The most common misdiagnosis among these patients was an ankle sprain, followed by cellulitis. Fourteen of the patients progressed to definite fractures of either all tarsometatarsal joints or of the talonavicular joint. This study emphasizes the importance of early diagnosis, treatment, and referral of CN to prevent the progression of the disease.

If CN is promptly diagnosed, early treatment has shown excellent success at mitigating its possible long-term ramifications. A study by Parisi et al in 2013 looked at the radiographic and functional results in the treatment of the early stages of CN with a CAM boot and immediate weight-bearing.[36] The study included 22 patients with type 2 diabetes. American Orthopedic Foot and Ankle Society scores showed statistically significant improvement at the termination of the study. These authors conclude that the utilization of a CAM boot in conjunction with immediate weight-bearing for CN showed good functional outcomes and halted the progression of deformity on radiographic assessment. In contrast, when the diagnosis of CN is delayed and patients present to the ED with the presence of a Charcot-related foot wound, outcomes can be much worse. A study by Wukich et al found that the presence of a Charcot-related foot wound at presentation increased the likelihood of a major lower extremity amputation by a factor of six.[37]

CONCLUSION

Charcot neuroarthropathy is a highly complex disorder, and its pathophysiology is not fully understood. While once a rare diagnosis, as obesity and diabetes rates rise, CN is becoming more common. Even experienced clinicians may struggle to diagnose CN, given the large number of other

conditions that can present similarly. It should always be on the differential in a diabetic patient with peripheral neuropathy and signs of foot edema, redness, and warmth, especially in the absence of pain. If CN is suspected, immediate immobilization and non-weight bearing are recommended until orthopedic follow-up. A multidisciplinary approach should be emphasized in the care of patients with CN, with enhanced collaboration between emergency physicians and orthopedic surgeons to ensure the best outcome for patients with this complex condition.

Address for Correspondence: Kian Bagheri, BA, Duke University Hospital, 200 Trent Drive, Durham, North Carolina 27710. Email: k_bagheri1204@email.campbell.edu

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.

REFERENCES

1. Shazadeh Safavi K, Janney C, Shazadeh Safavi P, et al. Inappropriate antibiotic administration in the setting of Charcot arthropathy: a case series and literature review. *Prim Care Diabetes* 2022;16(1):202–06.
2. Trieb K. The Charcot foot: pathophysiology, diagnosis and classification. *Bone Joint J* 2016;98-B(9):1155–9.
3. Marmolejo VS, Arnold JF, Ponticello M, et al. Charcot foot: clinical clues, diagnostic strategies, and treatment principles. *Am Fam Physician* 2018;97(9):594–99.
4. Al-Busaidi IS, Mason R, Lunt H. Diabetic Charcot neuroarthropathy: The diagnosis must be considered in all diabetic neuropathic patients presenting with a hot, swollen foot. *N Z Med J* 2015;128(1423):77–80. [published Online First: 20151016]
5. Goldsmith L, Barlow M, Evans PJ, et al. Acute hot foot: Charcot neuroarthropathy or osteomyelitis? Untangling a diagnostic web. *BMJ Case Rep* 2019;12(5). [published Online First: 20190513]
6. Chopra K, Tiwari V. Alcoholic neuropathy: possible mechanisms and future treatment possibilities. *Br J Clin Pharmacol* 2012;73(3):348–62.
7. Chambel SS, Tavares I, Cruz CD. Chronic pain after spinal cord injury: Is there a role for neuron-immune dysregulation? *Front Physiol* 2020;11:748. [published Online First: 20200707]
8. Fauzi AA, Chung TY, Latif LA. Risk factors of diabetic foot Charcot arthropathy: a case-control study at a Malaysian tertiary care centre. *Singapore Med J* 2016;57(4):198–203.
9. Korst GS, Ratliff HT, Torian J, et al. Delayed diagnosis of Charcot foot: a systematic review. *J Foot Ankle Surg* 2022;61(5):1109–13. [published Online First: 20220223]
10. Butler SO, Btaiche IF, Alaniz C. Relationship between hyperglycemia and infection in critically ill patients. *Pharmacotherapy* 2005;25(7):963–76.
11. Carro GV, Ricci A, Torterola I, et al. Differential diagnosis of Charcot neuroarthropathy in subacute and chronic phases: unusual diseases. *Int J Low Extrem Wounds* 2021:15347346211054326. [published Online First: 20211115]
12. Womack J. Charcot arthropathy versus osteomyelitis: evaluation and management. *Orthop Clin North Am* 2017;48(2):241–7. [published Online First: 20170201]
13. Bury DC, Rogers TS, Dickman MM. Osteomyelitis: diagnosis and treatment. *Am Fam Physician* 2021;104(4):395–402.
14. Marcus CD, Ladam-Marcus VJ, Leone J, et al. MR imaging of osteomyelitis and neuropathic osteoarthropathy in the feet of diabetics. *Radiographics* 1996;16(6):1337–48.
15. Donegan R, Sumpio B, Blume PA. Charcot foot and ankle with osteomyelitis. *Diabet Foot Ankle* 2013;4 [published Online First: 20131001]
16. Arapostathi C, Tentolouris N, Jude EB. Charcot foot associated with chronic alcohol abuse. *BMJ Case Rep* 2013;2013 [published Online First: 20130405]
17. Shibuya N, La Fontaine J, Frania SJ. Alcohol-induced neuroarthropathy in the foot: a case series and review of literature. *J Foot Ankle Surg* 2008;47(2):118–24.
18. Liote F. [Diagnosis of crystal-induced arthritis]. *Presse Med* 2011;40(9 Pt 1):869–76. [published Online First: 20110803]
19. Pittman JR, Bross MH. Diagnosis and management of gout. *Am Fam Physician* 1999;59(7):1799–806, 810.
20. Hainer BL, Matheson E, Wilkes RT. Diagnosis, treatment, and prevention of gout. *Am Fam Physician* 2014;90(12):831–6.
21. Sivera F, Andres M, Quilis N. Gout: Diagnosis and treatment. *Med Clin (Barc)* 2017;148(6):271–76. [published Online First: 20161205]
22. Dalbeth N, Merriman TR, Stamp LK. Gout. *Lancet* 2016;388 (10055):2039–52. [published Online First: 20160421]
23. Hansrani V, Khanbhai M, McCollum C. The diagnosis and management of early deep vein thrombosis. *Adv Exp Med Biol* 2017;906:23–31.
24. Goldhaber SZ. Risk factors for venous thromboembolism. *J Am Coll Cardiol* 2010;56(1):1–7.
25. Barrosse-Antle ME, Patel KH, Kramer JA, et al. Point-of-care ultrasound for bedside diagnosis of lower extremity DVT. *Chest* 2021;160(5):1853–63. [published Online First: 20210713]
26. Katz DS, Hon M. Current DVT imaging. *Tech Vasc Interv Radiol* 2004;7(2):55–62.
27. Becker JA, Daily JP, Pohlgeers KM. Acute monoarthritis: diagnosis in adults. *Am Fam Physician* 2016;94(10):810–6.
28. Taruc-Uy RL, Lynch SA. Diagnosis and treatment of osteoarthritis. *Prim Care* 2013;40(4):821–36, vii. [published Online First: 20130926]

29. Roemer FW, Demehri S, Omoumi P, et al. State of the art: imaging of osteoarthritis-revisited 2020. *Radiology* 2020;296(1):5–21. [published Online First: 20200519]
30. Braun HJ, Gold GE. Diagnosis of osteoarthritis: imaging. *Bone* 2012;51(2):278–88. [published Online First: 20111203]
31. Obolensky L, Trimble K. Importance of close surveillance for Charcot arthropathy in diabetic patients presenting to the emergency department with low-energy foot injuries. *Emerg Med J* 2010;27(6):484–5.
32. Vopat ML, Nentwig MJ, Chong ACM, et al. Initial diagnosis and management for acute Charcot neuroarthropathy. *Kans J Med* 2018;11(4):114–9. [published Online First: 20181129]
33. Mascarenhas JV, Jude EB. The Charcot foot as a complication of diabetic neuropathy. *Curr Diab Rep* 2014;14(12):561.
34. Foltz KD, Fallat LM, Schwartz S. Usefulness of a brief assessment battery for early detection of Charcot foot deformity in patients with diabetes. *J Foot Ankle Surg* 2004;43(2):87–92.
35. Chantelau EA, Richter A. The acute diabetic Charcot foot managed on the basis of magnetic resonance imaging–a review of 71 cases. *Swiss Med Wkly* 2013;143:w13831. [published Online First: 20130729]
36. Parisi MC, Godoy-Santos AL, Ortiz RT, et al. Radiographic and functional results in the treatment of early stages of Charcot neuroarthropathy with a walker boot and immediate weight bearing. *Diabet Foot Ankle* 2013;4. [published Online First: 20131029]
37. Wukich DK, Sadoskas D, Vaudreuil NJ, et al. Comparison of diabetic charcot patients with and without foot wounds. *Foot Ankle Int* 2017;38(2):140–8. [published Online First: 20161024]

A Shorter Door-In-Door-Out Time Is Associated with Improved Outcome in Large Vessel Occlusion Stroke

Adam Sigal, MD* [*]
Derek L. Isenberg, MD† [†]
Chadd K. Kraus, DO, DrPH‡ [‡]
Daniel Ackerman, MD§ [§]
Joseph Herres, DO‖ [‖]
Ethan S. Brandler, MD¶ [¶]
Alexander Kuc, MD# [#]
Jason T. Nomura, MD** [**]
Derek R. Cooney, MD†† [††]
Michael T. Mullen, MD‡‡ [‡‡]
Huaqing Zhao, PhD§§ [§§]
Nina T. Gentile, MD† [†]

*Reading Hospital, Department of Emergency Medicine, West Reading, Pennsylvania
†Lewis Katz School of Medicine at Temple University, Department of Emergency Medicine, Philadelphia, Pennsylvania
‡Geisinger Health, Department of Emergency Medicine, Danville, Pennsylvania
§St. Luke's Health System, Department of Neurology, Bethlehem, Pennsylvania
‖Einstein Health System, Department of Emergency Medicine, Philadelphia, Pennsylvania
¶State University of New York-Stony Brook, Department of Emergency Medicine, Stony Brook, New York
#Cooper University Healthcare, Department of Emergency Medicine, Camden, New Jersey
**Christiana Care, Department of Emergency, Newark, Delaware
††State University of New York-Upstate, Department of Emergency Medicine, Syracuse, New York
‡‡Lewis Katz School of Medicine at Temple University, Department of Neurology, Philadelphia, Pennsylvania
§§Lewis Katz School of Medicine at Temple University, Center for Biostatistics and Epidemiology, Philadelphia, Pennsylvania

Section Editor: Shadi Lahham, MD
Submission history: Submitted September 27, 2022; Revision received April 21, 2023; Accepted April 18, 2023
Electronically published August 30, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.58946

Introduction: Endovascular thrombectomy (EVT) significantly improves outcomes in large vessel occlusion stroke (LVOS). When a patient with a LVOS arrives at a hospital that does not perform EVT, emergent transfer to an endovascular stroke center (ESC) is required. Our objective was to determine the association between door-in-door-out time (DIDO) and 90-day outcomes in patients undergoing EVT.

Methods: We conducted an analysis of the Optimizing Prehospital Stroke Systems of Care-Reacting to Changing Paradigms (OPUS-REACH) registry of 2,400 LVOS patients treated at nine ESCs in the United States. We examined the association between DIDO times and 90-day outcomes as measured by the modified Rankin scale.

Results: A total of 435 patients were included in the final analysis. The mean DIDO time for patients with good outcomes was 17 minute shorter than patients with poor outcomes (122 minutes [min] vs 139 min, $P = 0.04$). Absolute DIDO cutoff times of ≤60 min, ≤90 min, or ≤120 min were not associated with improved functional outcomes (46.4 vs 32.3%, $P = 0.12$; 38.6 vs 30.6%, $P = 0.10$; and 36.4 vs 28.9%, $P = 0.10$, respectively). This held true for patients with hyperacute strokes of less than four-hour onset. Lower baseline National Institutes of Health Stroke Scale (NIHSS) score (11.9 vs 18.2, $P = <.001$) and younger age (62.5 vs 74.9 years ($P < .001$) were associated with improved outcomes. On multiple regression analysis, age (odds ratio [OR] 1.71, 95% confidence interval [CI] 1.45–2.02) and baseline NIHSS score (OR 1.67, 95% CI 1.42–1.98) were associated with improved outcomes while DIDO time was not associated with better outcome (OR 1.13, 95% CI 0.99–1.30).

Conclusion: Although the DIDO time was shorter for patients with a good outcome, this was non-significant in multiple regression analysis. Receipt of intravenous thrombolysis and time to EVT were not associated with better outcomes, while male gender, lower age, arrival by private vehicle, and lower NIHSS score portended better outcomes. No absolute DIDO-time cutoff or modifiable factor was associated with improved outcomes for LVOS. This study underscores the need to streamline DIDO times but not to set an artificial DIDO time benchmark to meet. [West J Emerg Med. 2023;24(5)931–938.]

INTRODUCTION

Endovascular thrombectomy (EVT) significantly improves outcomes in patients with large vessel occlusion stroke (LVOS).[1] Time to thrombectomy is a major determinant of neurologic outcome with shorter times associated with better functional outcomes at 90 days.[2,3] Key components in managing LVOS include identifying the LVOS, determining eligibility for thrombolytics and EVT, and optimizing management until reperfusion occurs.[4] Many hospitals in the United States do not have EVT capabilities and must transfer LVOS patients to endovascular stroke centers (ESC) for EVT.[5]

It is not clear how the length of time spent at the transferring non-ESC impacts patient outcomes. Time spent at non-ESC hospitals prior to transfer is defined as the door-in-door-out time (DIDO). Longer DIDO times at the non-ESC may worsen outcomes by delaying recanalization and reperfusion.[6] However, there is a paucity of evidence on the relationship between DIDO and functional outcomes. In this study, we examined the relationship between DIDO times and 90-day functional outcomes in a multicenter registry. We hypothesized that longer DIDO times would be associated with worse functional outcomes at 90 days.

Population Health Research Capsule

What do we already know about this issue?
Door-in-door-out (DIDO) time (the time spent in the ED at a transferring hospital) is used as a benchmark in stroke patients transferred to a higher level of care.

What was the research question?
What is the association between DIDO time and outcomes in patients undergoing endovascular therapy?

What was the major finding of the study?
The mean time for patients with good outcomes was 122 minutes vs 139 minutes for patients with poor outcomes ($P = 0.04$).

How does this improve population health?
This study underscores the need to streamline DIDO times but not to set an artificial DIDO-time benchmark for transferring hospitals to meet.

METHODS

This study was conducted by the Optimizing Prehospital Stroke Systems of Care-Reacting to Changing Paradigms (OPUS-REACH) consortium. The OPUS-REACH is a consortium of nine health systems in the Northeast US. The structure of the OPUS-REACH consortium has been previously described.[7] The OPUS-REACH registry includes all patients who underwent EVT at one of the nine ESCs between January 1, 2015–December 31, 2020. An ESC was defined as a thrombectomy-capable stroke center or comprehensive stroke center capable of performing EVT 24 hours a day on an emergency basis. We included all patients who initially presented to a non-ESC and were later transferred to an ESC for EVT. We excluded patients from analysis if their stroke occurred after arrival at the hospital, their 90-day functional outcome was unknown, or if DIDO time at the non-ESC was not available.

We extracted all information from the electronic health records (EHR) at the individual hospitals and submitted to Temple University that serves as the central repository for OPUS-REACH data. Trained research associates or nurses at each of the nine sites used a standardized case report form to abstract data from the EHR. The principal investigator at each of the nine sites verified the data prior to submission to University. The data abstracted were explicit variables without need for interpretation. Missing data was not imputed except for missing 90-day modified Rankin Scale (mRS) scores.

The mRS score was obtained from documentation in the EHR or by estimation by the site investigator using the EHR. If no 90-day mRS score was documented in the EHR or in the hospital's stroke registry, the site investigator at each ESC reviewed the EHR to identify a clinician note from the 90-day time frame. This could have been a note from neurology, emergency medicine, primary care, physical therapy, or any other licensed clinician. Using this note, the site investigator estimated whether the patient had a good (mRS 0–2) or poor (mRS 3–6) functional outcome. For example, if the EHR reflected that the patient needed care in a skilled nursing faculty this would be coded as a poor outcome while if the note reflected the patient had minimal neurological deficits and walked without assistance, the patient would be assigned a good outcome. This estimation of the mRS score has been previously shown to have good correlation with in-person derived mRS values.[8] We collected and managed study data using REDCap electronic data capture tools hosted at Temple University.[1,2] REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies.

The primary outcome was 90-day functional outcome as assessed by the mRS.[10–13] A mRS score of 0–2 was considered a good outcome while a mRS score of 3–6 was considered a poor outcome.

Descriptive summary statistics are presented as means (SD) for continuous variables and as frequencies with percentages for categorical variables. We used the

two-sample *t*-test to compare continuous variables and chi-square test to compare categorical variables between good and poor outcomes. Univariate logistic regression was performed to establish potential factors that may contribute to good outcomes. A priori, we defined a *P*-value of <0.05 as significant in the univariate analysis. Multiple variable logistic regression was conducted to determine the association of variables to estimate an odds ratio of a good outcome. We performed statistical analyses with SAS Statistics Software, SAS 9.4 (SAS Institute Inc, Cary, NC). Univariate analysis was performed using *t*-tests to obtain a *P*-value. A priori, we defined *a P-value* of <0.05 as significant. We conducted multiple logistic regression to determine the association of variables to estimate an odds ratio. The institutional review boards of all nine participating institutions approved this study.

RESULTS

Of the 2,139 patients in the OPUS-REACH registry, we included 434 in the final analysis (Figure 1). Patients were predominantly White with an even distribution by gender. The median age was 71 years (Table 1). Of the 378 patients for whom the time of vascular imaging was known, 56% of patients had vascular imaging performed at the transferring hospital.

We found that 33% of patients had a good outcome (mRS 0–2). Patients who had favorable 90-day outcomes had a lower baseline NIHSS score than those with poor outcomes (NIHSS 11.9 vs 18.2, $P < 0001$). Patients with better outcomes were more likely to arrive by private transport than by emergency medical services (EMS) (56.5 vs 30.6%, $P = 0.004$). Overall, patients with good outcomes had a 17-minute faster DIDO time than patients with poor outcomes (122.6 minutes [min] vs 139.8 min, $P = 0.037$). This trend, however, did not meet statistical significance when analyzed with DIDO cutoff times of ≤60, ≤90, or ≤120 min (Table 2).

We performed a subgroup analysis for patients who arrived at the non-ESC within four hours of the onset of their strokes (hyperacute stroke). Here, we saw no difference in the mean DIDO times between the group with good outcomes and the group with poor outcomes (Table 3). Again, lower age and lower initial NIHSS score portended better outcomes. On multiple variable analysis, we found that age and lower baseline NIHSS score were the only variables associated with improved outcomes in LVOS patients. There

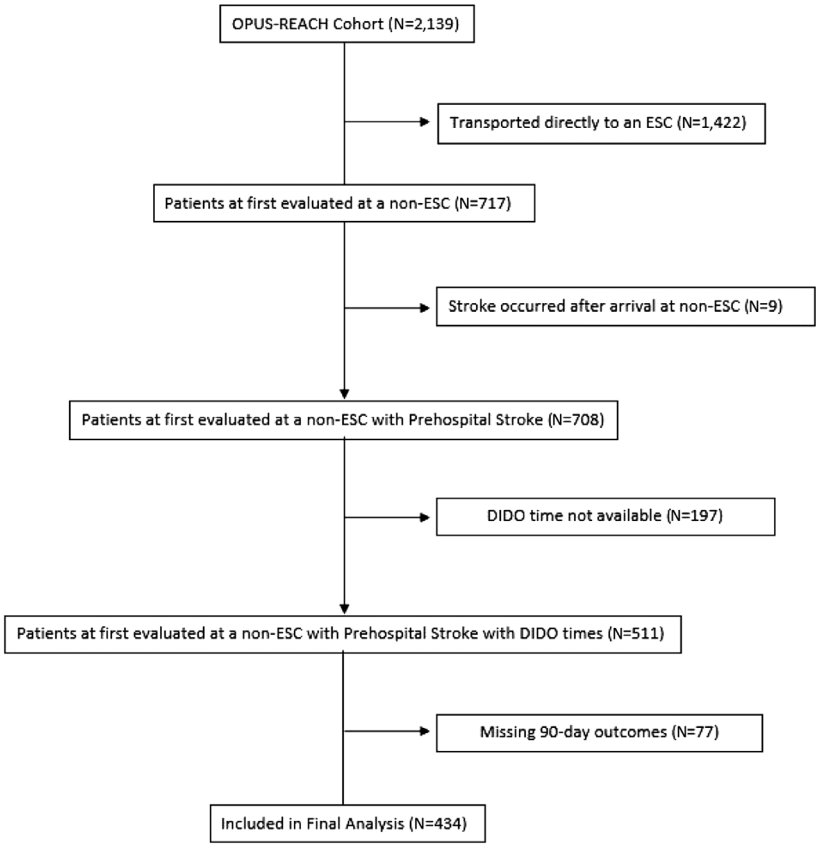


Figure 1. Enrollment diagram. Of the initial cohort of 2,129 patients, 434 were included in the final analysis based on complete DIDO times and neurologic outcomes.
ESC, endovascular stroke center.

Table 1. Demographics.

Demographic	N = 434 (%)
Race	
American Indian/Alaska Native	1 (0.2)
Black or African American	62 (15.0)
White	347 (83.8)
Asian/Native Hawaiian/Pacific Islander	2 (0.5)
Other	2 (0.5)
Unknown	22 (5.0)
Hispanic ethnicity	
Yes	16 (3.7)
No	416 (96.3)
Unknown	4 (0.9)
Age	
Mean (SD)	70.7 (16.2)
Range	25–103
Gender	
Male	211 (48.4)
Female	225 (51.6)
Baseline Patient Characteristics	
Mean initial NIHSS (SD)	16.1 (8.1)
Mean time from last known well to arrival at non-ESC in minutes (SD)	276 (325)
Mean time from last known well to EVT in minutes (SD)	505 (344)

NIHSS, National Institutes of Health Stroke Scale; *EVT,* endovascular thrombectomy.

were no modifiable factors associated with improved outcomes. (Table 4).

DISCUSSION

Although patients with good outcome had slightly faster DIDO times overall, we could find no specific DIDO threshold up to 120 min that was associated with improved outcomes at 90 days whether early or late in the stroke process. The initial NIHSS score and the patient's age were more predictive than DIDO time for favorable outcome. We found some surprising factors that were not associated with outcomes among our patients. Arrival by EMS was significantly associated with improved outcomes in our cohort. Arrival by EMS was closely linked to a higher NIHSS score. Therefore, EMS arrival was not significant on multiple variable analysis. Receipt of intravenous thrombolysis (IVT) was borderline significant on univariate analysis. This may be related to a small sample size or to the fact that the mean arrival time to the non-ESC was greater than 4.5 hours, making many patients ineligible for IVT.

Most interesting, time to EVT was not associated with better outcomes, despite prior research showing delays to EVT were associated with worse outcomes. For example, Jahan et al found that each 15-min delay to EVT was associated with worse outcomes.[14] However, this effect only persisted up to 270 min. Therefore, the longer time to EVT in our cohort may have diluted effects of time to EVT. Although DIDO time is linked to EVT time, there are many more time intervals involved in stroke onset to EVT. It may be that time from hospital arrival to EVT or time from imaging to EVT are more important factors in outcomes after LVOS.

The model for transferring patients to higher levels of care and concern that delays may impact long-term function is an adaptation of the models developed for managing acute ST-elevation myocardial infarction (STEMI). Among STEMI transfer patients, those with prolonged DIDO times had increased mortality at 30 days.[15] Transferred patients with DIDO times <30 min had both shorter perfusion times and lower in-hospital mortality, with the odds ratio of 1.56 for those with times >30 min.[16]

In one metanalysis of nearly 16,000 patients, the authors found that those with DIDO time of <30 min had a 2.8% 30-day mortality compared to 6.0% for patients with DIDO times of >30 min.[17] However, DIDO times for transferred patients undergoing primary percutaneous intervention rarely meet the recommended 30-min goal.[18,19] Common delays in transfer include transport delays, diagnostic uncertainty, and clinical instability prior to transfer.[20]

As regional stroke systems of care develop, DIDO has been proposed as a metric for transferring hospitals to follow. Choi et al demonstrated that a primary stroke center can achieve median DIDO times of <60 min.[21] However, compared to the STEMI transfer process, the diagnosis of LVOS is more complex. Whereas a STEMI diagnosis can be made based on a 12-lead electrocardiogram and an abbreviated history, the diagnosis of an LVOS requires a thorough neurologic exam, advanced computed tomography, radiologic interpretation, and consultation with a neurologist. Currently the American Heart Association (AHA) makes no recommendations as to an optimal DIDO time for LVOS.[1] While the benefit of EVT is time dependent early on in LVOS, and systems of care should prioritize rapid transfer of LVOS patients to an ESC, more research is needed to identify a clinically meaningful DIDO threshold, prior to adopting national benchmarks. From our data, we cannot recommend a specific DIDO time for LVOS patients in an analogous manner to STEMI patients.

LIMITATIONS

Our study has several limitations. As it was a retrospective study, we did not have complete data on all the patients transferred to thrombectomy centers for EVT. We were missing DIDO times for 197 patients largely because of

Table 2. Univariate analysis of entire cohort.

Variable	Overall (N = 434)	Good (N = 144)	Poor (N = 290)	*P*-value
	434	144	290	
Mean DIDO time at non-ESC (SD)	**134.1 (86.7)**	**122.6 (74.0)**	**139.8 (91.9)**	**0.04**
Means of arrival to non-ESC (n = 415)				**<.001**
EMS	369 (88.9)	113 (30.6)	256 (69.4)	
Private Vehicle	46 (11.1)	26 (56.5)	20 (43.5)	
Received IVT				0.08
No	263 (60.6)	79 (30.0)	184 (70.0)	
Yes	171 (39.4)	79 (38.0)	106 (62.0)	
Vascular imaging performed at non-ESC (n = 324)				0.73
No	141 (43.5)	46 (32.6)	95 (67.4)	
Yes	183 (56.5)	63 (34.4)	120 (65.6)	
Level of non-ESC (n = 434)				0.90
Not certified	59 (13.6)	20 (33.9)	39 (66.1)	
PSC	375 (86.4)	124 (33.1)	251 (66.9)	
Race (n = 412)				0.55
American Indian	1 (0.2)	0	1 (100.0)	
Asian/Pacific Islander	2 (0.5)	0	1 (100.0)	
Black	62 (15.1)	23 (37.1)	39 (62.9)	
White	345 (83.7)	111 (32.2)	234 (67.8)	
Other	2 (0.5)	0	2 (100.0)	
Hispanic ethnicity (n = 430)				0.57
No	415 (96.5)	137 (33.0)	278 (67.0)	
Yes	15 (3.5)	6 (40.0)	9 (60.0)	
Mean age (SD)	70.8 (15.1)	62.5 (15.0)	74.9 (13.5)	**<.001**
Gender				**0.02**
Female	224 (51.5)	63 (28.1)	161 (71.9)	
Male	211 (48.5)	81 (38.4)	130 (61.6)	
DIDO time at non-ESC				
≤60 minutes (min)	28 (6.5)	13 (46.4)	15 (53.6)	0.12
>60 min	406 (93.6)	131 (32.3)	275 (67.7)	
≤90 min	140 (32.3)	54 (38.6)	86 (61.4)	0.10
>90 min	294 (67.7)	90 (30.6)	204 (69.4)	
≤120 min	247 (56.9)	90 (36.4)	157 (63.6)	0.10
>120 min	187 (43.1)	54 (28.9)	133 (71.1)	
LKW to arrival at non-ESC (n = 401)				0.31
Mean time in minutes (SD)	278.83 (330.1)	254.63 (300.1)	290.57 (343.6)	
LKW to arrival at non-ESC in <4 hours (n = 266)		88 (33.1)	178 (66.9)	0.80
LKW to EVT (n = 394)				0.28
Mean time in minutes (SD)	497.4 (334.8)	471.4 (307.5)	510.4 (347.5)	
Initial NIHSS score (n = 430) [SD]	16.1 (8.1)	11.9 (7.3)	18.2 (7.7)	**<.001**

DIDO, door-in-door-out; *ESC*, endovascular stroke center; *EMS*, emergency medical services; *IVT*, intravenous thrombolysis; *PSC*, primary stroke center; *LKW*, last known well; *EVT*, endovascular thrombectomy; *NIHSS* National Institutes of Health Stroke Scale.

Table 3. Univariate analysis of patients with hyperacute stroke presentation (onset to arrival of non-endovascular stroke center of <240 minutes).

Variable	Total	Good outcome	Poor outcome	*P*-value
	265	87	178	
Mean DIDO time (SD)	126.3(71.2)	116.6 (62.4)	131.1 (74.9)	0.12
Means of arrival to Nnon-ESC (n = 254)				
EMS	227 (89.4)	67 (29.5)	160 (70.5)	<**.001**
Private vehicle	27 (10.6	15 (55.6)	12 (44.4)	
Received IVT				
No	106 (40.0)	28 (26.4)	78 (73.6)	0.07
Yes	159 (60.0)	59 (37.1)	100 (62.9)	
Vascular imaging performed at non-ESC (n = 200)				
No	88 (44.0)	28 (31.8)	60 (68.2)	0.82
Yes	112 (56.0)	34 (30.4)	78 (69.6)	
Level of non-ESC	265			
Not certified	41 (15.5)	13 (31.7)	28 (68.3)	0.87
PSC	224 (84.5)	74 (33.0)	150 (67.0)	
Race (n = 249)	249			
American Indian	1 (0.4)	0	1 (100)	0.83
Asian or Pacific Islander	1 (0.4)	0	1 (100)	
Black	32 (12.9)	11 (34.4)	21 (65.6)	
White	214 (85.9)	68 (31.8)	146 (68.2)	
Other	1 (0.4)	0	2 (100)	
Hispanic ethnicity (n = 263)				
No	252 (95.8)	84 (33.3)	168 (66.7)	0.68
Yes	11 (4.2)	3 (27.3)	8 (72.7)	
Mean age				<**.001**
Mean (SD)	70.87 (15.14)	62.86 (14.83)	74.78 (13.71)	
Gender (n = 245)				**0.04**
Female	146 (55.1)	40 (27.4)	106 (72.6)	
Male	119 (44.9)	47 (39.5)	72 (60.5)	
DIDO time at non-ESC				
≤60 minutes (min)	16 (6.0)	6 (37.5)	10 (62.5)	0.68
>60 min	406 (93.6)	131 (32.3)	275 (67.7)	
≤90 min	91 (34.3)	34 (37.4)	57 (62.6)	0.26
>90 min	294 (67.7)	90 (30.6)	204 (69.4)	
≤120 min	158 (59.6)	57 (36.1)	101 (63.9)	0.17
>120 min	187 (43.1)	54 (28.9)	133 (71.1)	
LKW to arrival at non-ESC				0.35
Mean (SD)	79.31 (53.2)	74.95 (53.4)	81.43 (53.1)	
LKW to EVT (n = 260)				0.97
Mean (SD)	301.13 (114.2)	300.69 (114.9)	301.35 (114.1)	
Initial mean NIHSS score (SD) [n = 263]	263			

DIDO, door-in-door-out; *ESC*, endovascular stroke center; *IVT*, intravenous thrombolysis; *EMS*, emergency medical services; *PSC*, primary stroke center; *LKW*, last known well; *EVT*, endovascular thrombectomy.

Table 4. Multiple regression analysis for entire cohort.

	Odds ratio	95% Confidence limits	
DIDO	1.13	0.99	1.30
Not in same hospital system	1.98	1.18	3.31
NIHSS	1.67	1.42	1.98
Age	1.71	1.45	2.02

Hyperacute Stroke Presentation (onset to arrival of non-ESC of <240 minutes)

	Odds ratio	95% Confidence limits	
DIDO	1.22	0.99	1.50
Not in same hospital system	3.02	1.49	6.11
NIHSS score	1.76	1.41	2.20
Age	1.80	1.43	2.25

DIDO, door-in-door-out; *NIHSS*, National Institutes of Health Stroke Scale.

missing data from the transferring hospitals. As data was collected retrospectively, records from the transferring hospital were sometimes missing from the EHR of the ESC. In addition, the three-month outcome was based on a mRS score that at times was estimate-based. Prior studies have validated this methodology, however.[8]

In addition, we included patients cared for by nine health systems and over 100 non-ESCs. Although most followed standard AHA/American College of Cardiology stroke guidelines for care and are designated as ESCs, there are variations in prehospital EMS communications, transfer processes, initial imaging, and thrombolysis process at the initial hospitals from which they receive patients. However, the inclusion of many health systems in a wide contiguous geographic region improves generalizability and provides information about outcomes in routine clinical practice, rather than clinical trials. All patients in our study were known to have LVOS and underwent EVT. We do not know the DIDO times for patients who were transferred but did not undergo EVT.

CONCLUSION

Although the mean door-in-door-out time is shorter for patients with good functional outcomes after large vessel occlusion stroke there is no absolute DIDO cutoff time up to 120 minutes that improved 90-day functional outcome for patients with an LVOS undergoing endovascular thrombectomy. Before establishing DIDO metrics for referring hospitals, more research is needed on factors that improve clinical outcomes. The most important predictor of 90-day outcomes is the patient's age and initial NIHSS score. Non-endovascular stroke centers should focus on following AHA/American Stroke Association guidelines for initial stroke care, including intravenous thrombolysis administration, and appropriate transfer to an ESC.

Address for Correspondence: Derek Isenberg, MD, Lewis Katz School of Medicine at Temple University, Department of Emergency Medicine, 1316 West Ontario Street, 10th Floor, Philadelphia, Pennsylvania 19140. Email: derek.isenberg@tuhs.temple.edu

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. Dr. Derek Isenberg and Dr. Jason T. Nomura received a grant from the American Heart Association to support OPUS-REACH. The authors disclosed no conflicts of interest.

REFERENCES

1. Adeoye O, Nyström KV, Yavagal DR, et al. Recommendations for the establishment of stroke systems of care: a 2019 update. *Stroke.* 2019;50(7):e187–210.
2. Jahan R, Saver JL, Schwamm LH, et al. Association between time to treatmente with endovascular reperfusion therapy and outcomes in patients with acute ischemic stroke treated in clinical practice. *JAMA.* 2019;322(3):252–63.
3. Saver JL, Goyal M, van der Lugt A, et al. Time to treatment with endovascular thrombectomy and outcomes from ischemic stroke: a meta-analysis. *JAMA.* 2016;316(12):1279.
4. McTaggart RA, Ansari SA, Goyal M, et al. Initial hospital management of paitents with emergent large vessel occlusion (ELVO): report of the standards and guidelines committeeof the Society of NeuroInternventional Surgery. *J NeuroInterv Surg.* 2017;9:316–23.
5. Jauch EC, Schwamm LH, Panagos PD, et al. Recommendations for Regional Stroke Destination Plans in Rural, Suburban and Urban Communities From the Prehospital Stroke System of Care Consensus Conference: A Consensus Statement From the American Academy of Neurology, American heart Association/American Stroke Association, American Society of Neuroradiology, National Association of EMS Physicians, National Association of State EMS Officials, Society of NeuroInterventional Surgery and Society of Vascular and Interventional Neurology: Endorsed by the Neurocritical Care Society. *Stroke.* 2021;52(5):e133–52.
6. McTaggart RA, Modovan K, Oliver LA, et al. Door-in-door-out time at primary stroke centers may predict outcome for emergent large vessel occlusion patients. *Stroke.* 2018;49(12):2969–74.
7. Isenberg DL, Henry KA, Sigal A, et al. Optimizing Prehospital Stroke Systems of Care - Reacting to Changing Paradigms (OPUS-REACH): a

pragmatic registry of large vessel occlusion stroke patients to create evidence-based stroke systems of care and eliminate disparities in access to stroke care. *BMC Neurology.* 2022;22(1):132.

8. Isenberg D, Prus N, Ramsey F, NT G. The Modified Rankin Scale can accurately be derived from the electronic medical record. *Transformative Medicine.* 2022;1(2):31–5.
9. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap) - a metadata-driven methodology and workflow process for providing translational research informatics support *J Biomed Inform.* 2009;42(2):377–81.
10. Rankin J. Cerebral vascular accidents in patients over the age of 60. I. General considerations. *Scott Med J.* 1957;2(4):127–36.
11. Rankin J. Cerebral vascular accidents in patients over the age of 60. II. Prognosis. *Scott Med J.* 1957;2(5):200–15.
12. Rankin J. Cerebral vascular accidents in patients over the age of 60. III. Diagnosis and treatment. *Scott Med J.* 1957;2(6):254–68.
13. van Swieten JC, Koudstaal PJ, Visser MC, et al. Interobserver agreement for the assessment of handicap in stroke patients. *Stroke.* 1988;19(5):604–7.
14. Jahan R, Saver JL, Schwamm LH, et al. Association between time to treatment with endovascular reperfusion therapy and outcomes in patients with acute ischemic stroke treated in clinical practice. *JAMA.* 2019;322(3):252–63.
15. Shi O, Khan AM, Rezai MR, et al. Factors associated with door-in to door-out delays among ST-segment elevation myocardial infarction (STEMI) patients transferred to primary percutaneous coronary intervention: a population-based cohort study in Ontario, Canada. *BMC Cardiovascular Disorders.* 2018;18(1):1–9.
16. Wang TY, Nallamothu BK, Krumholz HM, et al. Association of door-in to door-out time with reperfusion delays in outcomes among patients transferred for primary percutaneous coronary intervention. *JAMA.* 2011;305(24):2540–7.
17. Yamaguchi J, Matoba T, Kikuchi M, et al. Effects of door-in to door-out time on mortality among ST-segment elevation myocardial infarction patients transferred for primary percutaneous coronary intervention - systemic review and meta-analysis. *Circ Rep.* 2022;4(3):109–15.
18. Herrin J, Miller LE, Turkmani DF, et al. National performance on door-in to door-out time among patients transferred for primary percutaneous coronary intervention. *Arch Intern Med.* 2011;171(21):1879–86.
19. Lambert LJ, Brown KA, Boothroyd LJ, et al. Transfer of patients with ST-elevation myocardial infarction for primary percutaneous coronary intervention. *Circulation.* 2014;129(25):2653–60.
20. Miedema MD, Newell MC, Duval S, et al. Causes of delay and associated mortality in patients transferred with ST-segment-elevation myocardial infarction. *Circulation.* 2011;124:1636–44.
21. Choi PMC, Tsoi AH, Pope AL, et al. Door-in-door-out time of 60 minutes for stroke with emergent large vessel occlusion at a primary stroke center. *Stroke.* 2019;50:2829–34.

Treatment of Factor-Xa Inhibitor-associated Bleeding with Andexanet Alfa or 4 Factor PCC: A Multicenter Feasibility Retrospective Study

Adam J. Singer, MD*
Mauricio Concha, MD, MHS†
James Williams, DO‡
Caitlin S. Brown, PharmD§
Rafael Fernandes, MS*
Henry C. Thode Jr., PhD*
Marylin Kirchman, MSN, RN, SCRN†
Alejandro A. Rabinstein, MD‖

*Renaissance School of Medicine at Stony Brook University, Department of Emergency Medicine, Stony Brook, New York
†Sarasota Memorial Hospital, Department of Neuroscience, Sarasota, Florida
‡Meritus Health, Department of Emergency Medicine, Hagerstown, Maryland
§Mayo Clinic-Rochester, Department of Pharmacy, Rochester, Minnesota
‖Mayo Clinic-Rochester, Department of Neurosurgery, Rochester, Minnesota

Section Editor: Mark Langdorf, MD, MHPE
Submission history: Submitted March 31, 2023; Revision received July 6, 2023; Accepted July 20, 2023
Electronically published August 22, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.60587

Background: There are no randomized trials comparing andexanet alfa and 4 factor prothrombin complex concentrate (4F-PCC) for the treatment of factor Xa inhibitor (FXa-I)-associated bleeds, and observational studies lack important patient characteristics. We pursued this study to demonstrate the feasibility of acquiring relevant patient characteristics from electronic health records. Secondarily, we explored outcomes in patients with life-threatening FXa-I associated bleeds after adjusting for these variables.

Methods: We conducted a multicenter, chart review of 100 consecutive adult patients with FXa-I associated intracerebral hemorrhage (50) or gastrointestinal bleeding (50) treated with andexanet alfa or 4F-PCC. We collected demographic, clinical, laboratory, and imaging data including time from last factor FXa-I dose and bleed onset.

Results: Mean (SD) age was 75 (12) years; 34% were female. Estimated time from last FXa-I dose to bleed onset was present in most cases (76%), and patients treated with andexanet alfa and 4F-PCC were similar in baseline characteristics. Hemostatic efficacy was excellent/good in 88% and 76% of patients treated with andexanet alfa and 4F-PCC, respectively ($P = 0.29$). Rates of thrombotic events within 90 days were 14% and 16% in andexanet alfa and 4F-PCC patients, respectively ($P = 0.80$). Survival to hospital discharge was 92% and 76% in andexanet alfa and 4F-PCC patients, respectively ($P = 0.25$). Inclusion of an exploratory propensity score and treatment in a logistic regression model resulted in an odds ratio in favor of andexanet alfa of 2.01 (95% confidence interval 0.67–6.06) for excellent/good hemostatic efficacy, although the difference was not statistically significant.

Conclusion: Important patient characteristics are often documented supporting the feasibility of a large observational study comparing real-life outcomes in patients with FXa-I-associated bleeds treated with andexanet alfa or 4F-PCC. The small sample size in the current study precluded definitive conclusions regarding the safety and efficacy of andexanet alfa or 4F-PCC in FXa-I-associated bleeds. [West J Emerg Med. 2023;24(5)939–949.]

INTRODUCTION

The use of factor Xa inhibitors (FXa-I) has rapidly increased over the last decade due to their improved pharmacokinetic properties, efficacy, and safety compared with oral vitamin K antagonists.[1–4] As a result, the number of patients requiring treatment for life-threatening bleeding associated with FXa-I use has also increased.[5] Prior to the availability of a specific reversal agent for bleeding secondary to the FXa-I, these bleeds were treated with 4-factor prothrombin complex concentrates (4F-PCC) containing coagulation factors II, VII, IX and X,[6,7] but because patients treated with the FXa-I are not deficient in these coagulation factors, the mechanistic rationale for their use has been questioned.[8] Andexanet alfa (more recently known as coagulation factor Xa [recombinant], inactivated-zhzo) is a specifically designed recombinant factor Xa decoy molecule.[9] Due to its high affinity to the FXa-I, andexanet alfa binds with apixaban and rivaroxaban releasing native FXa and resulting in thrombin generation, clot formation, and hemostasis.

The efficacy and safety of andexanet alfa in patients treated with FXa-I presenting with life-threatening bleeds is supported by the ANNEXA-4 clinical trial.[10] However, ANNEXA-4 was a single arm trial. An ongoing randomized clinical trial (RCT), ANNEXA-I, is comparing andexanet alfa head to head with coagulation factor replacement strategy (anticipated to mostly be 4F-PCC) for factor FXa-I-related intracerebral hemorrhage (ICH) (ClinicalTrials.gov NCT03661528). Yet the results of this trial are not anticipated for at least 1–2 years, and it will only provide results for intracerebral bleeds.

While a number of studies have described the use of 4F-PCC for treatment of life-threatening bleeds in patients treated with a FXa-I,[6,7] relatively few studies have compared 4F-PCC to andexanet alfa and none have been RCTs.[11–16] Direct comparison of patients treated with 4F-PCC and andexanet alfa is challenging due to differences in patient populations and endpoints. A retrospective review of electronic health records (EHR) from 45 hospitals compared outcomes of 3,030 patients hospitalized with major bleeding related to FXa-I and treated with andexanet alfa or 4F-PCC. In this study, treatment with andexanet alfa was associated with the lowest hospital mortality across different bleed types.[14] However, this study did not collect critical baseline information such as time from last FXa-I dose and did not control for confounding variables, limiting its conclusions. Furthermore, this study was limited to hospital outcomes only with no longer term outcomes.

Another retrospective study of 322 patients treated with andexanet alfa from the ANNEXA-4 study[10] that were propensity score matched (PSM) with 88 patients from the ORANGE study[15] found lower 30-day adjusted mortality rates in patients treated with andexanet alfa.[13] This study is also limited since patients included in the ANNEXA-4 study were generally less severely ill than those included in the ORANGE study. In contrast, other retrospective comparisons of patients treated with andexanet alfa or 4F-PCC have not shown clear differences in outcomes.[11,12,16,17] Importantly, these studies often failed to control their analyses for relevant patient characteristics that are potential confounding variables, such as timing from last FXa-I dose, timing from onset of bleeding episode, initial ICH volume, time from ICH onset to first head CT, or severity of illness.[18]

Our objective in this current feasibility study was to conduct a multicenter retrospective chart review to determine whether data regarding important patient characteristics was generally documented in the EHR and to explore the association between 4F-PCC or andexanet alfa and outcomes in patients with primary ICH and gastrointestinal bleeds (GIB) associated with use of apixaban or rivaroxaban.

METHODS

Study Design

We performed a structured, retrospective chart review, consistent with the recommended methodology of Kaji et al.[19] Our study also followed the Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines for cross-sectional studies.[20] Because of the retrospective design, we received institutional review board (IRB) approval with waiver of informed consent. Due to the nature of this study as a feasibility and exploratory pilot, no sample size calculations were made.

Patients and Settings

We included all adult patients presenting with an ICH (50) or GIB (50) event who received reversal with andexanet alfa (50) or replacement with 4F-PCC (50). We chose to include 50 patients in each treatment group and bleeding type a priori since we felt that this number would be adequate to determine the feasibility of a larger study. We excluded patients who were treated with both agents as well as patients treated with andexanet alfa plus other coagulation factor concentrates. We also excluded patients transferred to one of the study sites from another hospital. The study period was from May 2018 (when the US Food and Drug Administration [FDA] approved andexanet alfa) until December 2021. Consecutive patients were enrolled in reverse chronological order starting with the most recent date (based on each institution's IRB approval) until the required number of patients were identified. The study sites included two large academic medical centers and two large community settings. Initially, each hospital was requested to contribute cases equally. However, due to imbalances in number of patients treated, the final number of study patients from each site was not equal. One site did not have andexanet alfa on formulary and only contributed cases treated with

4F-PCC. At the other three sites andexanet alfa was added to the formulary in June 2018.

Decision on high or low dose followed the standard recommendations. No patient in the study had repeated doses. Andexanet alfa was used in patients who reported last dose of apixaban or rivaroxaban within 18 hours and met the following indications: i) acute, overt major or life-threatening bleeding episode; ii) acute bleeding in a critical area or organ, such as pericardial, intracranial, or intraspinal; iii) signs or symptoms of significant hemodynamic compromise despite aggressive fluid and blood product resuscitation; iv) patients with ICH must have had a Glasgow Coma Score (GCS) ≥7 and an estimated intracerebral hematoma volume of 60 milliliters as assessed by computed tomography (CT) or magnetic resonance imaging. During the study period, prescription of andexanet alfa was restricted to neurology, neurosurgery, hematology, emergency medicine, and trauma surgery. The 4F-PCC prescription was not restricted by specialty, and dose was weight-based. The decision to treat patients and the selection of the reversal agent was at the discretion of the treating physician.

Data Collection

Structured data collection was performed by physicians, pharmacists or trained research assistants using a HIPPA-compliant encrypted database (REDCap, hosted at Vanderbilt University, Nashville, TN). We developed a library of the definitions of data collected (Supplement 1). Data collected included demographic, clinical, laboratory, and imaging data on patient presentation and throughout their entire hospital admission and extending to 90 days after discharge. The presence of comorbidities was determined by chart review. Among the variables collected we specifically searched all EHRs for time of bleeding onset, time from last dose of oral FXa-I, time from presentation to imaging, clinical risk scores (GCS for ICH and albumin level <3.0 grams per deciliter, international normalized ratio [INR] >1.5, altered mental status, systolic blood pressure less than 90 millimeters of mercury, and age >65 years [AIMS65] for GIB)[21,22] and concomitant treatments including blood products, reversal agents, and procedures. (See Supplements 2–4 for data collection tools.) Thrombotic events were collected during index hospitalization and at 30 and 90 days after discharge. We defined thrombotic events as deep vein thrombosis (DVT), pulmonary embolism (PE), ischemic stroke, myocardial infarction, or other arterial or venous thromboembolic events. Door to needle time was defined as time from hospital presentation to receipt of reversal agent. Onset to CT time was calculated using the difference between initial CT and time of bleeding onset, where they both existed; onset to CT time for the remainder of cases was determined by combining categorical onset to presentation time (<6, 6–12, 12–24, 24–48, and >48 hours), using the median time for each category, with door to CT time. We defined all study data and variables prior to initiating the study and trained our data abstractors using a library of definitions (see Supplement 1). We periodically monitored data collection and provided feedback to the data abstractors during and after data collection and entry regarding missing, conflicting, or obviously erroneous data. The number of data abstractors at each institution varied from 1–3. The data abstracters were not blinded to therapy.

Outcomes

We developed all study outcomes a priori. The primary outcomes were presence of estimated times from last dose of FXa-I and time from bleeding onset to administration of 4F-PCC or andexanet alfa. Secondary outcomes were hemostatic efficacy as defined by the ANEXXA-4 criteria,[23] survival to hospital discharge, thrombotic events during the index hospitalization and at 30 and 90 days, and rebleeding events such as ICH, rectal bleeding, melena, or hematemesis.

Data Analysis

We used descriptive statistics to summarize the data. Categorical data are presented as numbers or percentages and compared between groups using chi-square or Fisher exact tests as appropriate. Continuous variables are presented with means and standard deviations or medians and interquartile ranges (IQR) based on their distribution and compared with *t*-tests or the Mann-Whitney U tests, as appropriate. Because this was a pilot study, no formal sample size calculation was performed. We chose to include 25 patients in each of the four study subgroups: ICH treated with andexanet alfa; ICH treated with 4F-PCC; GIB treated with andexanet alfa, and GIB treated with 4F-PCC. An exploratory PSM model was constructed to estimate the odds of excellent/good hemostatic efficacy in patients treated with andexanet alfa or 4F-PCC adjusting for age, gender, comorbidities, time from last dose of FXa-I, time from bleed onset to treatment, and indication for anticoagulation.

RESULTS

General Characteristics and Feasibility

In total, the study enrolled 100 patients who were treated with either andexanet alfa or 4F-PCC for reversal of life-threatening bleeds after taking apixaban or rivaroxaban (Table 1). As intentionally designed, half of the patients had an ICH and half had a GIB. Within the two groups of patients, half were treated with andexanet alfa while the other half were treated with 4F-PCC. Mean (SD) age of all patients was 75 (12) years, and 34% were female. Most patients were on apixaban (72%), and the rest were on rivaroxaban. Common comorbidities included hypertension (78%) and diabetes (25%). Antiplatelet agents were used in about half of the patients, mostly aspirin (40%) followed by

Table 1. Comparison of patients with intracerebral hemorrhage and gastrointestinal bleeding. Results are presented as numbers (%) unless otherwise specified.

	Number (%) unless otherwise specified		
	All cases (N = 100)	**ICH (n = 50)**	**GIB (n = 50)**
Mean (SD) age, years	75 (12)	75 (15)	75 (10)
Gender			
Female	34 (34)	15 (30)	19 (38)
Male	66 (66)	35 (70)	31 (62)
Ethnicity			
Non-Hispanic	95 (95)	48 (96)	47 (94)
Hispanic	3 (3)	1 (2)	2 (4)
Unknown	2 (2)	1 (2)	1 (2)
Race			
White	91 (91)	47 (94)	44 (88)
Black	2 (2)	1 (2)	1 (2)
Asian	2 (2)	0	2 (4)
Native Hawaiian/Pacific Islander	1 (1)	0	1 (2)
Unknown	4 (4)	2 (4)	2 (4)
Mean height (SD), cm*	170 (13)	173 (10)	167 (15)
Mean weight (SD), kg	84 (24)	84 (20)	85 (27)
Mean BMI*	30 (15)	28 (6)	31 (21)
Code status at presentation			
Full code	62 (62)	31 (62)	31 (62)
DNR/DNI	10 (10)	5 (10)	5 (10)
DNR	2 (2)	2 (4)	0
Unspecified	26 (26)	12 (24)	14 (28)
Comorbidities			
None	3 (3)	0	3 (6)
Hypertension	78 (78)	44 (88)	34 (68)
Diabetes mellitus	25 (25)	11 (22)	14 (28)
Liver	4 (4)	2 (4)	2 (4)
Chronic kidney disease	13 (13)	2 (4)	11 (22)
Alcohol abuse	8 (8)	3 (6)	5 (10)
Prior bleed	16 (16)	3 (6)	13 (26)
Prior stroke	18 (18)	9 (18)	9 (18)
Factor Xa inhibitor			
Apixaban	72 (72)	36 (72)	36 (72)
Rivaroxaban	28 (28)	14 (28)	14 (28)
Bleed type			
Traumatic	5 (5)	4 (8)	1 (2)
Spontaneous	94 (94)	46 (92)	48 (96)
Unspecified	1 (1)	0	1 (2)
Indications for anticoagulation			
Atrial fibrillation	68 (68)	33 (66)	35 (70)
Deep vein thrombosis	28 (28)	15 (30)	13 (26)
Pulmonary embolism	15 (15)	6 (12)	9 (18)
Prophylaxis of VTE	0	0	0
Other	6 (6)	4 (8)	2 (4)
Antiplatelet agents			
None	52 (52)	24 (48)	28 (56)
Aspirin	40 (40)	23 (46)	17 (34)
Clopidogrel	9 (9)	4 (8)	5 (10)
Ticagrelor	2 (2)	1 (2)	1 (2)
Treatments			
Andexanet alfa	50 (5)	25 (50)	25 (50)
4F-PCC	50 (50)	25 (50)	25 (50)
Number of 4F-PCC doses			
1	43 (86)	19 (76)	24 (96)
2	7 (14)	6 (24)	1 (4)
Vitamin K	12 (12)	9 (18)	3 (6)
Fresh frozen plasma	8 (8)	0	8 (16)
Packed red blood cells	38 (38)	0	38 (76)
Platelets	22 (22)	11 (22)	11 (22)
Factor IX	5 (5)	2 (4)	3 (6)
Desmopressin	7 (7)	6 (12)	1 (2)
Cryoprecipitate pooled 5-pack status	1 (1)	0	1 (2)
Intravenous fluids	59 (59)	31 (62)	28 (56)
Other	7 (7)	3 (6)	4 (8)
Outcomes			
Thrombotic events in-hospital	11 (11)	5 (10)	6 (12)
Hemostatic efficacy			
Excellent	62 (62)	35 (71)	27 (55)
Good	16 (16)	5 (10)	11 (22)
Poor	20 (20)	9 (18)	11 (22)
Unknown	2 (2)	1 (2)	1 (2)
Rebleed in-hospital	7 (7)	1 (2)	6 (12)
Survival (to discharge)	83 (83)	42 (84)	41 (82)

*9 cases missing height and body mass index.
ICH, intracerebral; *GIB*, gastrointestinal bleed; *BMI*, body mass index; *VTE*, venous thromboembolism; *DNR*, do not resuscitate.

(*Continued on next column*)

clopidogrel (9%) and ticagrelor (2%). Overall hemostatic efficacy was excellent in 62% and good in an additional 16%. Mortality at hospital discharge was 16%, and the overall rates of thrombosis and rebleeding were 15% and 7%, respectively.

While the exact timing of last dose of FXa-I and bleed onset was rarely available, estimated ranges of time (in 6–12-hour intervals) from last dose and bleed onset were available in the EHR in most cases. Of those with ICH, 96% of patients who received andexanet alfa and 80% of those who received 4F-PCC had documentation of an estimated time from last FXa-I. In patients with GIB, the documentation of last FXa-I was present in 92% of those receiving 4F-PCC and in 68% of those receiving andexanet alfa.

Intracerebral Hemorrhage

A comparison of baseline characteristics of patients with ICH based on reversal agent is presented in Table 2. Overall, the two study groups were fairly well balanced for the variables measured. More patients in the 4F-PCC group had a prior stroke and intraventricular extension. The most common sites of bleeding were lobar and the deep white matter. Median (IQR) initial GCS in patients treated with andexanet alfa and 4F-PCC were 14 (12–15) and 14 (13–15), respectively.

In both groups, over two thirds of patients presented within six hours of the onset of bleeding. The proportion of patients presenting within six and within 12 hours of their last dose of oral Fxa-I among those treated with andexanet alfa were 28% and 52%, respectively, as compared with 4% and 44% among those treated with 4F-PCC ($P = 0.06$). Initial hematoma volumes in patients treated with andexanet alfa and 4F-PCC were 15 +/−23 ml and 28+/−37 ml, respectively, $P = 0.07$. Time to imaging and time to administration of the reversal agent were relatively short and comparable.

Hemostatic efficacy was excellent in 80% of those treated with andexanet alfa and 60% among patients treated with 4F-PCC. Survival to hospital discharge among those treated with andexanet alfa and 4FPCC were 92% and 76%, respectively ($P = 0.25$). Of the five thrombotic events that occurred in-hospital, three were in patients treated with andexanet alfa (one ischemic stroke, one DVT, and one PE), and two were in patients treated with 4F-PCC (two DVTs). The rate of additional thrombotic events beyond the index hospitalization among patients treated with andexanet alfa and 4F-PCC were 0% and 5% at 30 days and 0% and 5% at 90 days, respectively.

Gastrointestinal Bleeding

Of 50 patients with GIB, 25 (50%) had an upper source of GIB, 16 (32%) had a lower source of GIB and in nine (18%) patients, the source was unknown. A comparison of baseline characteristics of patients with GIB based on treatment strategy is presented in Table 3. Overall, the two study groups

Table 2. Andexanet alfa vs 4F-PCC in patients with intracerebral hemorrhage. Results are presented as numbers (%) unless otherwise specified.

	Andexanet alfa (n = 25)	4F-PCC (n = 25)	*P*-value
Gender			0.54
Female	9 (36)	6 (24)	
Male	16 (64)	19 (76)	
Mean (SD) age, years	77 (12)	73 (17)	0.38
Ethnicity			0.35
Non-Hispanic	23 (92)	25 (100)	
Hispanic	1 (4)	0	
Unknown	1 (4)	0	
Race			0.22
White	23 (92)	24 (96)	
Black	0	1 (4)	
Asian	0	0	
Native Hawaiian/Pacific Islander	0	0	
Unknown	2 (8)	0	
Comorbidities			
None	0	0	-
Hypertension	23 (92)	21 (84)	0.67
Diabetes mellitus	8 (32)	3 (12)	0.17
Liver disease	0	2 (8)	0.49
Chronic kidney disease	1 (4)	1 (4)	1.00
Alcohol abuse	1 (4)	2(8)	1.00
Prior bleed	0	3 (12)	0.24
Prior stroke	1 (4)	8 (32)	0.02
Indications for anticoagulation			
Atrial fibrillation	17 (68)	16 (64)	1.00
Deep vein thrombosis	8 (32)	7 (28)	1.00
Pulmonary embolism	4 (16)	2 (8)	0.67
Other	1 (4)	3 (12)	0.61
ICH location			
Deep white matter	9 (36)	8 (32)	1.00
Lobar	11 (44)	13 (52)	0.78
Brainstem	2 (8)	0	0.49
Cerebellum	3 (12)	3 (12)	1.00
Intraventricular extension	1 (4)	7 (28)	0.049
Hematoma volume, mean (SD), ml	15 (23)	28 (37)	0.07
Estimated time from last dose of apixaban/rivaroxaban to presentation			0.06
<6 hrs.	7 (28)	1 (4)	
7–12 hrs.	13 (52)	11 (44)	

(*Continued on next page*)

Table 2. Continued.

	Andexanet alfa (n = 25)	4F-PCC (n = 25)	*P*-value
8–18 hrs.	4 (16)	5 (20)	
19–24 hrs.	0	1 (4)	
>24 hrs.	0	2 (8)	
Unknown	1 (4)	5 (20)	
Estimated time from bleed onset to presentation			0.26
<6 hrs.	18 (72)	17 (68)	
7–12 hrs.	1 (4)	4 (16)	
8–18 hrs.	2 (12)	0	
19–24 hrs.	1 (4)	2 (8)	
>24 hrs.	1 (4)	2 (8)	
Unknown	1 (4)	0	
Median (IQR) GCS	14 (12–15)	14 (13–15)	0.40
Door to CT time (median ([IQR]), hrs.	0.45 (0.22–1.22)	0.53 (0.26–1.16)	0.89
Estimated time from bleed onset to CT*, (median [IQR]), hrs.	4.5 (3.2–6.9)	2.5 (1.1–7.2)	0.25
Door to needle time, median (IQR), hrs.	1.8 (1.4–3.0)	1.7 (1.5–2.6)	0.99
Outcomes			
Thrombotic event inpatient	3 (12)	2 (8)	1.00
Hemostatic efficacy			0.50
Excellent	20 (80)	15 (60)	
Good	2 (8)	3 (12)	
Poor	3 (12)	6 (24)	
Unknown	0	1 (4)	
Grouped hemostatic efficiency			0.29
Excellent/Good	22 (88)	18 (76)	
Fair/Poor	3 (12)	6 (24)	
Rebleed	0	1 (4)	1.00
Survival (to hospital discharge)	23 (92)	19 (76)	0.25
Interventions			
Endotracheal intubation	2 (8)	11 (44)	0.10
Craniotomy	0	8 (32)	0.11
External ventricular drain	0	3 (12)	0.24
Diagnostic angiography	1 (4)	0	
Angiographic repair	0	1(4)	

*Estimated time from bleed onset to CT imaging was calculated by adding the median of the estimated time interval from bleed onset to presentation to the time from door to CT imaging.
ICH, intracerebral; *IQR*, interquartile range; *CT*, computed tomography.

Table 3. Andexanet alfa v. 4F-PCC in patients with gastrointestinal bleeding. Results are presented as numbers (%) unless otherwise specified.

	Andexanet alfa (n = 25)	4F-PCC (n = 25)	*P*-value
Gender			1.00
Female	9 (36)	10 (40)	
Male	16 (64)	15 (60)	
Mean (SD) age, years	72 (11)	78 (9)	0.049
Ethnicity			0.22
Non-Hispanic	23 (92)	24 (96)	
Hispanic	2 (8)	0	
Unknown	0	1 (4)	
Race			0.39
White	21 (84)	23 (92)	
Black	0	1 (4)	
Asian	2 (8)	0	
Native Hawaiian/Pacific Islander	1 (4)	0	
Unknown	1 (4)	1 (4)	
AIM65 criteria			
Albumin < 3 g/dL	10 (48)	10 (42)	0.77
INR > 1.5	10 (43)	9 (39)	1.00
Altered mental status	6 (24)	4 (17)	0.73
SBP < 90 mm Hg	9 (36)	7 (29)	0.76
Age > 65 years	19 (76)	23 (92)	0.25
Median (IQR) AIMS65 score	2 (1–2)	2 (2–2)	0.90
Comorbidities			
None	2 (8)	1 (4)	1.00
Hypertension	16 (64)	18 (72)	0.76
Diabetes mellitus	7 (28)	7 (28)	1.00
Liver disease	0	2 (8)	0.49
Chronic kidney disease	6 (24)	5 (20)	1.00
Alcohol abuse	2 (8)	3 (12)	1.00
Prior bleed	5 (20)	8 (32)	0.52
Prior stroke	4 (16)	5 (20)	1.00
Indications for anticoagulation			
Atrial fibrillation	15 (60)	20 (80)	0.22
Deep vein thrombosis	6 (24)	7 (28)	1.00
Pulmonary embolism	5 (20)	4 (16)	1.00
Other	2 (8)	0	0.49
Estimated time from last dose of apixaban/rivaroxaban to treatment			<0.001
<6 hrs.	4 (16)	9 (36)	
7–12 hrs.	1 (4)	6 (24)	
8–18 hrs.	3 (12)	7 (28)	

(*Continued on next page*)

Table 3. Continued.

	Andexanet alfa (n = 25)	4F-PCC (n = 25)	*P*-value
19–24 hrs.	1 (4)	1 (4)	
Unknown	16 (64)	2 (8)	
Estimated time from bleed onset to presentation			0.10
<6 hrs.	10 (40)	13 (52)	
7–12 hrs.	0	2 (8)	
8–18 hrs.	0	3 (12)	
19–24 hrs.	3 (12)	2 (8)	
>24 hrs.	4 (16)	3 (12)	
Unknown	6 (32)	2 (8)	
Door to needle time, median (IQR)	3.6 (2.2–16.0)	3.3 (1.3–7.0)	0.22
Outcomes			
Thrombotic event in-hospital	4 (16)	2 (8)	0.67
Hemostatic efficacy			0.40
Excellent	16 (64)	11 (44)	
Good	4 (16)	7 (28)	
Poor	5 (20)	6 (24)	
Unknown	0	1 (4)	
Grouped hemostatic efficiency			0.74
Excellent/Good	20 (80)	18 (76)	
Fair/Poor	5 (20)	6 (24)	
Rebleed in-hospital	5 (20)	1 (4)	0.09
Survival (to hospital discharge)	19 (76)	22 (88)	0.46
Interventions			
Mean (SD) units PRBC over 24 hours	1.6 (1.8)	2.2 (1.6)	0.26
Endoscopy	14 (56)	21 (84)	0.06
Interventional radiology	1 (4)	2 (8)	1.00
Surgery	2 (8)	1 (4)	1.00

INR, International normalized ratio; *SBP*, systolic blood pressure; *IQR*, interquartile range; *PRBC*, packed red blood cells.

were fairly well balanced for the variables that were measured. Median (IQR) initial AIMS65 scores in patients treated with andexanet alfa and 4F-PCC were 2 (1–2) and 2 (2–2), respectively. Most patient in both groups had hypertension or diabetes.

The percentages of patients presenting within 6 or 12 hours of bleeding onset among those treated with andexanet alfa were 40% and 0%, while the percentages of patients presenting within 6 or 12 hours of bleeding were 52% and 8%, respectively, among patients treated with 4F-PCC. The time from bleeding onset to presentation was greater than 24 hours or unknown in 16% and 32% in patients treated with andexanet alfa and 12% and 8% in patients treated with 4F-PCC, respectively. The time of the last dose of Fxa-I was 12 hours or less in 20% and 60% in patients treated with andexanet alfa and 4F-PCC, respectively. Median [IQR] times from arrival to ED to administration of the treatment drug were also relatively short and comparable in patients treated with andexanet alfa and 4F-PCC (3.6 [2.2–16.0] vs 3.3 [1.3–7.0], respectively).

Hemostatic efficacy was excellent in 64% and 44% of those treated with andexanet alfa and 4F-PCC, respectively ($P = 0.40$). Survival to hospital discharge among those treated with andexanet alfa and 4F-PCC were 76% and 88%, respectively ($P = 0.46$). The rate of thrombotic events among patients treated with andexanet alfa and 4F-PCC were 8% in each group. Of the six thrombotic events that occurred in-hospital, four were in patients treated with andexanet alfa (two DVTs, and two other) and two were in patients treated with 4F-PCC (two ischemic strokes).

Thrombotic Events

There were 15 cases with recorded thrombotic events (Tables 4 and 5). Of these, 11 cases had in-hospital thrombotic events, three had thrombotic events at 30 days, and one event occurred between 30-90 days of index bleed. Of all thrombotic events, seven occurred in patients treated with andexanet alfa and eight occurred in patients treated with 4F-PCC. Of the 15 patients who had a thrombotic event 10 patients were restarted on anticoagulation prior to the

Table 4. Outcomes by treatment when bleeding types are combined. Numbers (percent).

	Andexanet alfa (n = 50)	4F-PCC (n = 50)	*P*-value
Hemostatic efficacy			0.26
Excellent	36 (72)	26 (52)	
Good	6 (12)	10 (20)	
Poor	8 (16)	12 (24)	
Grouped hemostatic efficiency			0.32
Excellent/good	42 (84)	36 (72)	
Fair/poor	8 (16)	12 (24)	
Rebleeding events in hospital	5 (10)	2 (4)	0.26
Survival to hospital discharge	42 (84)	41 (82)	1.00
In-hospital thrombotic events	7 (14)	4 (8)	0.53
Total thrombotic events through day 90	7 (14)	8 (16)	0.80

Table 5. Summary of thrombotic events.

	Bleed site	In-hospital event	30 days	90 days
Andexanet alfa	ICH	3 (1 DVT, 1 stroke, 1 PE)	0	0
	GIB	4 (2 DVT, 2 other*)	0	0
4F-PCC	ICH	2 (2 DVT)	1 (DVT)	1 (DVT)
	GIB	2 (2 strokes)	2 (2 DVT)	

*Acute left lower extremity arterial thrombosis with ischemia (n = 1); bowel infarction and splenic infarcts (n = 1).
ICH, intracerebral hemorrhage; *DVT*, deep vein thrombosis; *PE*, pulmonary embolism; *GIB*, gastrointestinal bleeding.

thrombotic event. A breakdown of thrombotic events by site of bleeding and therapy is presented in Table 5.

Propensity Score Matched Model

Outcomes in patients treated with andexanet alfa and 4F-PCC when all study patients were compared regardless of site of bleeding are summarized in Table 4. There were no statistically significant differences in any of the study outcomes between the two treatment groups. Using all cases combined (98, excludes two missing hemostatic efficacy) and for the endpoint of hemostatic efficacy, categorized into excellent/good and poor, a propensity score was determined using age, gender, comorbidities, time from last dose, time from bleeding onset, and indication for anticoagulation. Inclusion of the propensity score and treatment in a logistic regression model resulted in an odds ratio (OR) in favor of andexanet alfa of 2.01 (95% confidence interval CI, 0.67–6.06) for the endpoint of excellent/good hemostatic efficacy.

Additional Exploratory Analyses for Hemostatic Efficacy

For the 49 ICH cases (one with missing data excluded) and for the outcome of hemostatic efficacy, categorized into excellent/good and poor, a propensity score was determined using age, hematoma volume categorized into <30 vs ≥30 milliliters, GCS score categorized into <13 vs ≥13, time from last dose of FXa-I, and onset to CT time. Two cases were excluded (both 4F-PCC) because one did not have an initial CT time and one had initial CT time prior to hospital presentation. Inclusion of the propensity score and treatment in a logistic regression model resulted in an OR of andexanet alfa to 4F-PCC of 3.30 (95% CI 0.59–18.52) in predicting excellent/good hemostatic efficacy.

For 49 GIB cases (one with missing data excluded) and for the outcome of hemostatic efficacy, categorized into excellent/good and poor, a propensity score was determined using age, time from last FXa-I dose, time of bleed onset, and AIMS65 categorized into <2 vs ≥2. Inclusion of the propensity score and treatment in a logistic regression model resulted in an OR of andexanet alfa to 4F-PCC of 1.67 (95% CI 0.29–9.71) in predicting excellent/good hemostatic efficacy.

DISCUSSION

Our multicenter study demonstrates that a comparative study of patients with ICH and GIB treated with andexanet alfa or 4F-PCC can be adequately conducted by collecting and analyzing data routinely available in the EHR retrospectively. We were able to acquire information on many important factors affecting outcomes, including several that had been consistently missing from previous studies.[18] For example, documentation of estimated ranges of time from last FXa-I does were present in 80–96% of patients with ICH and in 68%–92% of patients with GIB. These results suggest that a reliable study evaluating real-life practice in patients undergoing FXa-I reversal with andexanet alfa or 4F-PCC after ICH or GIB should be feasible in a much larger cohort of patients in centers like those included in the study.

Current literature on reversal strategies for FXa-I has major limitations. There have been only non-randomized cohort studies evaluating andexanet alfa and 4F-PCC.[24–26] Most of these studies have been single-arm, single-center, or both.[6,7,11,12,16,27–35] Some use historical rather than contemporary controls, or at best indirectly compared two independent datasets trying to account for major baseline differences by using a suboptimal PSM.[13] Other studies used propensity score treatment weighting rather than PSM and were able to account for bleed size/volume, which was not captured in the ORANGE indirect comparison.[36,37] None has included all pertinent variables to sufficiently reduce the risk of confounding bias.[18] Even ANNEXA-4,[10,23] a prospective study that served to support the FDA approval of andexanet alfa for reversal of anticoagulation with FXa-I in patients with life-threatening bleeding, had a single arm and failed to control for crucial factors, such as time from ICH onset to first head CT— a key variable because the risk of hematoma expansion is much greater in patients presenting early after ICH onset.[38] Other pertinent variables often missed in most previous studies include time between ICH onset and hospital presentation, time between last dose of FXa-I and hospital presentation, precise hematoma volume and location, measures of severity of GIB, concomitant administration of antiplatelet agents, detailed accounting of comorbidities, restrictions in the level of medical care, and functional outcomes.[18] Up-to-date assays to measure level of anticoagulation in patients treated with FXa-I are not commercially available. In the absence of information on the intensity of anticoagulation, time variables (eg, time from last dose of anticoagulant) become key surrogates in a controlled analysis of hemostatic efficacy.

One of the major advantages of RCTs is that the act of randomization reduces the chance of between-group bias due to imbalances in measured and unmeasured confounding variables. Thus, any claims regarding the relative efficacy and safety of andexanet alfa vs 4F- PCC in patients with FXa-I bleeds will only be resolved with the completion of a RCT comparing these treatments head to head. That said, in the meantime real-world data can be useful if the studies adjust as much as possible for potential confounding variables.

Our four-center study was designed to determine the feasibility of collecting all relevant information from the EHR of multiple centers. Due to the small sample size, adjustment of covariates in a multivariate analysis was limited, and no definitive conclusions can be made regarding the relative efficacy and safety of andexanet alfa and 4F-PCC. Our exploratory analysis including PSM models suggested better hemostatic efficacy with andexanet alfa for both indications, ICH and GIB. However, these results were very imprecise (as indicated by the wide 95% CIs) and should therefore be interpreted with great caution.

The strength of our study resides in the granularity of the data collection. Among patients with ICH, we were able to obtain information on time between last dose of FXa-I and symptom onset and the intervals between symptom onset and hospital presentation and first head CT. While exact times were not consistently documented (in fact, this information is often not known with precision in daily practice), estimated time ranges were available in nearly all patients. Clinical severity assessed by the GCS score and the use of concomitant antiplatelet agents were routinely available. Intracerebral hematoma volumes were also available since all patients with ICH had initial head CTs as well as repeat CTs within 6–24 hours, allowing precise calculation of hematoma volume and hematoma expansion. For patients with GIB, we were able to adjust for illness severity using the AIMS65 risk assessment score. The hemostatic efficacy in patients with GIB is typically determined by the need for blood transfusions and their effect on hemoglobin and hematocrit over the course of the first 12 hours. However, bleeding cessation often requires advanced interventions, such as endoscopic hemostasis or embolization by interventional radiology. Data on these advanced interventions are also important to report; however, many prior studies did not report on these interventions.

Of note, the mortality in the subgroup of patients with GIB in this study was considerably higher than previously reported,[39] suggesting that patients with GIB while taking FXa-I are a particularly high-risk group and require immediate and aggressive therapy. Existing risk prediction scores, such as the AIMS65,[40] do not account for ongoing use of FXa-I, yet this factor must be considered in the management patients with GIB. Due to the lack of RCTs and the small number of reported studies evaluating use of andexanet alfa for acute GIB the American College of Gastroenterology and the Canadian Association of Gastroenterology recommend against the use of andexanet alfa for reversing life-threatening gastrointestinal bleeds.[35] More data is needed to identify the ideal patient and reversal agent for FXa-I-associated GIB.

LIMITATIONS

This study has various limitations in addition to the small size of the four groups examined. Selection bias may have affected our findings, and the direction of this bias is difficult to infer from our data. In institutions where both andexanet alfa and 4-PCC are available, the treated groups become selectively different and so is their prognosis. For example, because of stricter criteria for the use of andexanet alfa the use of 4-PCC may be relegated to patients with worse bleeds and less favorable chances of recovery. On the other hand, andexanet alfa could have been preferentially used in patients deemed to be at higher risk of hematoma expansion. Thus, confounding by indication cannot be excluded. Studying a much larger cohort with adequate adjustment for covariates might be able to account for these issues.

Also, functional outcomes after discharge were available in only some of the participating centers. Information on thrombotic events was consistently available in the hospital but not after discharge. One of the participating centers did not have availability of andexanet alfa and consequently the other three centers had to contribute more cases treated with this agent. This may have introduced additional bias to our study. Identification of thrombotic events and deaths that occurred after hospital discharge may have been underestimated since some patients may have followed up at hospital sites other than the index hospital.

Due to the nature of the study being a feasibility pilot, data abstraction was performed by investigators who were not blinded to therapy. This may have introduced observer bias that may have affected the exploratory results. While overall documentation of important confounding variables at the four study sites was good to excellent, it is possible that other sites may have had less (or more) documentation of these variables. In this study we chose the AIMS65 score to control for gastrointestinal bleeding severity. We acknowledge that the AIMS65 has not been validated in lower GIB and may not be the best index of severity even in upper GIB. In addition, since the median AIMS65 score was relatively low in both study groups, our results may not be generalizable to more severe gastrointestinal bleeds.

Another limitation of our study is that it included mostly White patients and may not be as representative of other racial minority groups. While none of the patients received more than one dose of andexanet alfa, some of the patients received a second dose of 4F-PCC. However, it is unclear why a second dose was given. Finally, we have no

information regarding compliance with FXa-I after discharge from the hospital, which may contribute to a high rate of thrombotic events.

CONCLUSION

This feasibility study indicates that careful collection of information routinely available in the electronic health records of academic and community hospitals permits the development of adjustment models incorporating most of the factors that can influence the prognosis of patients with intracranial hemorrhage and gastrointestinal bleeds and confound the interpretation of the therapeutic effects of anticoagulation reversal with andexanet alfa or replacement with 4F-PCC. Until more definitive data from randomized controlled trials becomes available, a much larger study with more participating centers may produce comparative real-life experience that can help determine whether the treatment selected for reversal of FXa-I (ie, andexanet alfa vs 4F-PCC) has an impact on patient-centered outcomes in daily practice. Furthermore, our data has additional benefit since it reflects clinical practice where patients are not necessarily treated as in well controlled trials.

Address for Correspondence: Adam J. Singer, MD, Stony Brook University, Renaissance School of Medicine, Department of Emergency Medicine, HSC-L4-050, 101 Nicolls Road Stony Brook, New York 11794. Email: adam.singer@stonybrook.edu

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. Adam J. Singer and James Williams have served on an advisory board for Alexion and AstraZeneca and are on the speaker's bureau of Alexion and AstraZeneca. Research funding has been given by Alexion to the institutions of Adam J. Singer, Mauricio Concha, James Williams, and Alejandro A. Rabinstein.

REFERENCES

1. Barnes GD, Lucas E, Alexander GC, et al. National trends in ambulatory oral anticoagulant use. *Am J Med*. 2015;128:1300–5 e1302.
2. Lutsey PL, Walker RF, MacLehose RF, et al. Direct oral anticoagulants and warfarin for venous thromboembolism treatment: trends from 2012 to 2017. *Res Pract Thromb Haemost*. 2019;3:668–73.
3. Ziakas PD, Kourbeti IS, Poulou LS, et al. Medicare part D prescribing for direct oral anticoagulants in the United States: cost, use and the "rubber effect." *PLoS ONE*. 2018;13:e0198674.
4. Yao X, Abraham NS, Sangaralingham LR, et al. Effectiveness and safety of dabigatran, rivaroxaban, and apixaban versus warfarin in nonvalvular atrial fibrillation. *J Am Heart Assoc*. 2016;5.
5. Geller AI, Shehab N, Lovegrove MC, et al. Emergency visits for oral anticoagulant bleeding. *J Gen Intern Med*. 2020;35:371–3.
6. Majeed A, Agren A, Holmstrom M, et al. Management of rivaroxaban- or apixaban-associated major bleeding with prothrombin complex concentrates: a cohort study. *Blood*. 2017;130:1706–12.
7. Schulman S, Gross PL, Ritchie B, et al. Prothrombin complex concentrate for major bleeding on factor Xa inhibitors: a prospective cohort study. *Thromb Haemost*. 2018;118:842–51.
8. Lu G, Lin J, Bui K, et al. Andexanet versus prothrombin complex concentrates: differences in reversal of factor Xa inhibitors in in vitro thrombin generation. *Res Pract Thromb Haemost*. 2020;4:1282–94.
9. Yeh CH, Fredenburgh JC, Weitz JI. The real decoy: an antidote for factor Xa-directed anticoagulants. *Circ Res*. 2013;113:954–7.
10. Connolly SJ, Crowther M, Eikelboom JW, et al. Full study report of andexanet alfa for bleeding associated with factor Xa inhibitors. *N Engl J Med*. 2019;380:1326–35.
11. Ammar AA, Ammar MA, Owusu KA, et al. Andexanet alfa versus 4-factor prothrombin complex concentrate for reversal of factor Xa inhibitors in intracranial hemorrhage. *Neurocrit Care*. 2021;35:255–61.
12. Barra ME, Das AS, Hayes BD, et al. Evaluation of andexanet alfa and four-factor prothrombin complex concentrate (4F-PCC) for reversal of rivaroxaban- and apixaban-associated intracranial hemorrhages. *J Thromb Haemost*. 2020;18:1637–47.
13. Cohen AT, Lewis M, Connor A, et al. Thirty-day mortality with andexanet alfa compared with prothrombin complex concentrate therapy for life-threatening direct oral anticoagulant-related bleeding. *J Am Coll Emerg Physicians Open*. 2022;3:e12655.
14. Coleman CI, Dobesh PP, Danese S, et al. Real-world management of oral factor Xa inhibitor-related bleeds with reversal or replacement agents including andexanet alfa and four-factor prothrombin complex concentrate: a multicenter study. *Future Cardiol*. 2021;17:127–35.
15. Green L, Tan J, Morris JK, et al. A three-year prospective study of the presentation and clinical outcomes of major bleeding episodes associated with oral anticoagulant use in the UK (ORANGE study). *Haematologica*. 2018;103:738–45.
16. Pham H, Medford WG, Horst S, et al. Andexanet alfa versus four-factor prothrombin complex concentrate for the reversal of apixaban- or rivaroxaban-associated intracranial hemorrhages. *Am J Emerg Med*. 2022;55:38–44.
17. Troyer C, Nguyen W, Xie A, et al. Retrospective review of andexanet alfa versus 4-factor prothrombin complex concentrate for reversal of DOAC-associated intracranial hemorrhage. *J Thromb Thrombolysis*. 2023;55(1):149–55.
18. Concha M, Cohen AT. Recommendations for research assessing outcomes for patients with anticoagulant-related intracerebral bleeds. *Stroke*. 2021;52:1520–6.
19. Kaji AH, Schriger D, Green S. Looking through the retrospectoscope: reducing bias in emergency medicine chart review studies. *Ann Emerg Med*. 2014;64:292–8.

20. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Ann Intern Med*. 2007;147:573–7.
21. Saltzman JR, Tabak YP, Hyett BH, et al. A simple risk score accurately predicts in-hospital mortality, length of stay, and cost in acute upper GI bleeding. *Gastrointest Endosc*. 2011;74:1215–24.
22. Thandassery RB, Sharma M, John AK, et al. Clinical application of AIMS65 scores to predict outcomes in patients with upper gastrointestinal hemorrhage. *Clin Endosc*. 2015;48:380–4.
23. Connolly SJ, Milling TJJr, Eikelboom JW, et al. Andexanet alfa for acute major bleeding associated with factor Xa Inhibitors. *N Engl J Med*. 2016;375:1131–41.
24. Nederpelt CJ, Naar L, Krijnen P, et al. Andexanet alfa or prothrombin complex concentrate for factor Xa inhibitor reversal in acute major bleeding: a systematic review and meta-analysis. *Crit Care Med*. 2021;49:e1025–36.
25. Shrestha DB, Budhathoki P, Adhikari A, et al. Efficacy and safety of andexanet alfa for bleeding caused by factor Xa Inhibitors: A Systematic Review and Meta-Analysis. *Cureus*. 2021;13:e20632.
26. Gomez-Outes A, Alcubilla P, Calvo-Rojas G, et al. Meta-analysis of reversal agents for severe bleeding associated with direct oral anticoagulants. *J Am Coll Cardiol*. 2021;77:2987–3001.
27. Brown CS, Scott RA, Sridharan M, et al. Real-world utilization of andexanet alfa. *Am J Emerg Med*. 2020;38:810–4.
28. Castillo R, Chan A, Atallah S, et al. Treatment of adults with intracranial hemorrhage on apixaban or rivaroxaban with prothrombin complex concentrate products. *J Thromb Thrombolysis*. 2021;51:151–8.
29. Giovino A, Shomo E, Busey KV, et al. An 18-month single-center observational study of real-world use of andexanet alfa in patients with factor Xa inhibitor associated intracranial hemorrhage. *Clin Neurol Neurosurg*. 2020;195:106070.
30. Rauch S, Muller HP, Dreyhaupt J, et al. Andexanet alfa for reversal of factor Xa inhibitors in intracranial hemorrhage: Observational Cohort Study. *J Clin Med*. 2022;11.
31. Vestal ML, Hodulik K, Mando-Vandrick J, et al. Andexanet alfa and four-factor prothrombin complex concentrate for reversal of apixaban and rivaroxaban in patients diagnosed with intracranial hemorrhage. *J Thromb Thrombolysis*. 2022;53:167–75.
32. Parsels KA, Seabury RW, Zyck S, et al. Andexanet alfa effectiveness and safety versus four-factor prothrombin complex concentrate (4F-PCC) in intracranial hemorrhage while on apixaban or rivaroxaban: A single-center, retrospective, matched cohort analysis. *Am J Emerg Med*. 2022;55:16–9.
33. Panos NG, Cook AM, John S, et al, Neurocritical Care Society Pharmacy Study G. Factor Xa inhibitor-related intracranial hemorrhage: results from a multicenter, observational cohort receiving prothrombin complex concentrates. *Circulation*. 2020;141:1681–9.
34. Bradshaw PG, Keegan S, Foertsch M, et al. Andexanet alfa after 4-factor PCC administration for intracranial hemorrhage: a case series. *J Thromb Thrombolysis*. 2022;54:295–300.
35. Abraham NS, Barkun AN, Sauer BG, et al. American College of Gastroenterology-Canadian Association of Gastroenterology Clinical Practice Guideline: Management of Anticoagulants and Antiplatelets During Acute Gastrointestinal Bleeding and the Periendoscopic Period. *Am J Gastroenterol*. 2022;117:542–58.
36. Costa OS, Connolly SJ, Sharma M, et al. Andexanet alfa versus four-factor prothrombin complex concentrate for the reversal of apixaban- or rivaroxaban-associated intracranial hemorrhage: a propensity score-overlap weighted analysis. *Crit Care*. 2022;26:180.
37. Huttner HB, Gerner ST, Kuramatsu JB, et al. Hematoma expansion and clinical outcomes in patients with factor-Xa inhibitor-related atraumatic intracerebral hemorrhage treated within the ANNEXA-4 trial versus real-world usual care. *Stroke*. 2022;53:532–43.
38. Brouwers HB, Greenberg SM. Hematoma expansion following acute intracerebral hemorrhage. *Cerebrovasc Dis*. 2013;35:195–201.
39. Stanley AJ, Laine L. Management of acute upper gastrointestinal bleeding. *BMJ*. 2019;364:l536.
40. Kim MS, Choi J, Shin WC. AIMS65 scoring system is comparable to Glasgow-Blatchford score or Rockall score for prediction of clinical outcomes for non-variceal upper gastrointestinal bleeding. *BMC Gastroenterol*. 2019;19:136.

Influence of Body Mass Index on the Evaluation and Management of Pediatric Abdominal Pain in the Emergency Department

Carly A. Theiler, MD*
Morgan Bobb Swanson*
Ryan Squires, MD†
Karisa K. Harland, MPH, PhD*

*University of Iowa, Department of Emergency Medicine, Iowa City, Iowa
†Indiana University, Department of Emergency Medicine, Bloomington, Indiana

Section Editor: WestJEM Publishing Office
Submission history: Submitted October 28, 2022; Revision received March 14, 2023; Accepted April 28, 2023
Electronically published August 8, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59287

Introduction: Childhood obesity is a serious concern in the United States, with over one third of the pediatric population classified as obese. Abdominal pain is one of the most common chief complaints among pediatric emergency department (ED) visits. We hypothesized that overweight and obese children being evaluated in the ED for abdominal pain would have higher resource utilization than their normal and underweight peers.

Methods: This was a retrospective review of pediatric patients <18 years who presented with abdominal pain to the ED of a tertiary care center from January 1, 2014–September 3, 2020. Patients were excluded if they did not have both a height and weight recorded. We categorized patients as underweight (body mass index [BMI] <5th percentile); normal weight (BMI 5th to <85th percentile), overweight (BMI 85th to <95th percentile); or obese (BMI ≥95th percentile). Descriptive statistics were used to examine the study population. We used chi-square tests to examine the differences in patient characteristics between normal/underweight patients and overweight/obese patients. The Kruskal-Wallis test was completed for examining differences in the medians. We used multivariable logistic regression to examine visit characteristics associated with overweight/obese patients, including ED interventions, testing, and length of stay (LOS).

Results: Of the 184 subjects included in the analysis, nine (4.9%) were underweight, 108 (58.7%) were normal weight, 21 (11.4%) were overweight, and 46 (25.0%) were obese. Patients with a BMI of ≥85th percentile were older (median 15 vs 13 years, $P = 0.01$). They were otherwise similar in demographics. There was no significant difference between normal/underweight and overweight/obese subjects in disposition (37% vs 43% discharge, $P = 0.38$), 72-hour return (7% vs 6%, $P = 0.82$), ED LOS (median 4.42 vs 3.95 hours, $P = 0.195$), or inpatient LOS (median 42.0 vs 34.2 hours, $P = 0.06$). There were no statistically significant differences in total number of ED tests or interventions received by overweight/obese patients compared to normal/underweight patients, and each subject received a median of six tests (interquartile range [IQR] 4–7) and two interventions (IQR 1–3).

Conclusion: Among pediatric patients presenting to the ED with abdominal pain, we found that patient characteristics and ED resource utilization (including testing, intervention, disposition, and LOS) did not differ significantly across BMI categories. [West J Emerg Med. 2023;24(5)950–955.]

INTRODUCTION

Childhood obesity is a serious concern in the United States, with over one third of the pediatric population classified as overweight/obese.[1,2] A body mass index (BMI) elevated above normal has been associated with numerous illnesses in childhood and higher healthcare

utilization/expenditures, including increased outpatient visits, prescription drug use, and emergency department (ED) visits, as well as a higher likelihood of hospital admission.[3,4] In addition, overweight and obese children are more likely than their normal-weight peers to receive their routine medical care in an ED rather than a primary care setting.[5]

Abdominal pain is a common chief complaint among pediatric ED visits.[6] Patients with an elevated BMI have been found to have higher rates of functional gastrointestinal (GI) disorders including constipation, gastroesophageal reflux disease, irritable bowel syndrome, encopresis, and functional pain.[7,8] Obese pediatric patients also have higher rates of persistent pain with functional GI disorders, and higher rates of overall pain reporting in the outpatient setting.[9,10] Obesity may also limit the accuracy of a physical exam and is a comorbidity that may contribute to missed or delayed diagnosis.[11,12] In addition, in children who present to the ED with appendicitis, there is increased likelihood of non-diagnostic ultrasound and need for further imaging in obese children.[13,14]

We hypothesized that overweight and obese children being evaluated in the ED for abdominal pain would have higher resource utilization than their normal and underweight peers. To date, no study to our knowledge has examined these factors in the pediatric abdominal pain population.

METHODS

This was a retrospective review of pediatric patients seen in the ED at a midwestern academic center with a freestanding tertiary children's hospital, with an annual pediatric ED census of approximately 15,000 patients. This was an institutional review board-approved study. We abstracted data from the electronic health record (EHR) for ED visits between September 1, 2014–September 3, 2020. Patients were included who were <18 years of age and presented to the ED with a chief complaint of abdominal pain. Because both height and weight are required to calculate BMI, we excluded patients if they did not have a recent height recorded in the EHR. Once patients were identified using this simple criterion, a single physician completed templated chart abstraction and recorded objective demographic and visit-level data directly into a secure RedCap database hosted at University of Iowa.[1,2] REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies. A second blinded abstractor randomly reviewed 10% of charts to ensure interrater reliability; there were no discrepancies.

Pediatric BMI cutoffs are defined using a BMI-for-age percentile; therefore, we calculated BMI as a percentile using the US Centers for Disease Control and Prevention age-based calculator.[15] Patients were categorized as underweight (BMI <5th percentile); normal weight (BMI 5th to <85th percentile); overweight (BMI 85th to <95th percentile), or obese (BMI ≥95th percentile). We defined ED interventions as pediatric gastroenterology consult, pediatric surgery consult, or administration of antiemetic, intravenous fluids, or pain medications, and we defined ED testing as bloodwork (basic metabolic panel, liver function test, lipase, complete blood count, C-reactive protein, erythrocyte sedimentation rate), enteric panel, urinalysis or urine culture, abdominal radiograph, abdominal ultrasound, or other advanced imaging (computed tomography abdomen or magnetic resonance imaging abdomen).

Descriptive statistics were used to examine the study population, and we used chi-square tests to examine the differences in patient characteristics between normal/underweight patients (BMI <85th percentile) and overweight/obese patients (BMI ≥85th percentile), with $P < 0.05$ considered statistically significant. The Kruskal-Wallis test was completed for examining differences in the medians. We used multivariable logistic regression to examine visit characteristics associated with overweight/obese patients, controlling for age. All statistical analyses were performed using Statistical Analysis Software version 9.3 (SAS Institute Inc, Cary, NC).

RESULTS

We included a total of 184 patient encounters in the analysis. Of the 184 subjects, nine (4.9%) were underweight (BMI <5th percentile), 108 (58.7%) were normal weight (BMI 5th to <85th percentile); 21 (11.4%) were overweight (BMI 85th to <95th percentile); and 46 (25.0%) were obese (BMI ≥95th percentile). Demographic characteristics of the study population are shown in Table 1. Patients with a BMI of ≥85th percentile were older (median 15 years vs 13 years, $P = 0.01$) but were otherwise similar in demographics including gender, race, and triage level.

Table 2 shows visit characteristics including ED interventions and testing, with adjusted odds of these after controlling for age. Overall, 112 patients (61%) were admitted to inpatient from the ED, and 12 patients (7%) returned to the ED within 72 hours. There was no significant difference between normal/underweight and overweight/obese subjects in disposition (37 vs 43% discharge from the ED, $P = 0.38$) or 72-hour return rates (7 vs 6%, $P = 0.82$). The overall median ED LOS was 4.09 hours (IQR 3.08–5.53), with no significant difference between normal/underweight and overweight/obese subjects (median 4.42 vs 3.95 hrs, $P = 0.20$). Among the 112 patients who were admitted, the median inpatient LOS was 37.7 hrs (20.9–76.7 hrs), with no significant difference between normal/underweight and overweight/obese subjects (median 42.0 vs 34.2 hrs, $P = 0.06$).

There was no statistically significant difference in total numbers of ED tests or interventions received by overweight/

Table 1. Characteristics of study population.

Variable	Level	N	Overall N = 184	BMI <85% percentilen = 117	BMI ≥85% percentilen = 67	*P*-Value	Metrics
Age (years)		184	13.64 (9.63, 16.44)	13.02 (8.5, 15.87)	15.08 (11.67, 16.7)	0.01	Median (Q1, Q3)
	13–18	184	103 (55.98%)	59 (50.43%)	44 (65.67%)	0.13	N (%)
	2–6		27 (14.67%)	19 (16.24%)	8 (11.94%)		N (%)
	7–12		54 (29.35%)	39 (33.33%)	15 (22.39%)		N (%)
BMI		184	73 (39, 94.5)	47 (26, 72)	96 (94, 99)	<.001	Median (Q1, Q3)
Height (cm)		184	157.5 (134, 167.6)	152.4 (130, 165.1)	161.3 (149.9, 167.6)	0.02	Median (Q1, Q3)
Weight (kg)		184	52.55 (30.1, 70.25)	46.7 (25, 56.4)	75.3 (59.5, 93.2)	<.001	Median (Q1, Q3)
Gender	Female	184	109 (59.24%)	68 (58.12%)	41 (61.19%)	0.68	N (%)
	Male		75 (40.76%)	49 (41.88%)	26 (38.81%)		N (%)
Race	Asian	184	4 (2.17%)	3 (2.56%)	1 (1.49%)	0.31	N (%)
	Black or African Am		16 (8.70%)	7 (5.98%)	9 (13.43%)		N (%)
	Missing		22 (11.96%)	13 (11.11%)	9 (13.43%)		N (%)
	White		142 (77.17%)	94 (80.34%)	48 (71.64%)		N (%)
Mode of transfer	Air ambulance	63	2 (3.17%)	1 (2.44%)	1 (4.55%)	0.89	N (%)
	Ground ambulance		50 (79.37%)	33 (80.49%)	17 (77.27%)		N (%)
	Private vehicle		11 (17.46%)	7 (17.07%)	4 (18.18%)		N (%)
Mode of arrival	Ambulance	183	6 (3.28%)	3 (2.59%)	3 (4.48%)	0.76	N (%)
	Private vehicle/Public transportation		114 (62.30%)	72 (62.07%)	42 (62.69%)		N (%)
	Transfer from another facility		63 (34.43%)	41 (35.34%)	22 (32.84%)		N (%)
Triage level	Emergent	184	28 (15.22%)	20 (17.09%)	8 (11.94%)	0.35	N (%)
	Non-urgent		2 (1.09%)	2 (1.71%)	0 (0.00%)		N (%)
	Urgent		154 (83.70%)	95 (81.20%)	59 (88.06%)		N (%)

BMI, body mass index; *cm*, centimeter; *kg*, kilogram; *Am*, American.

obese patients compared to normal/underweight patients. Each subject received a median of six ED tests (IQR 4–7) and two ED interventions (IQR 1–3). There was no difference in the number of ED interventions ($P = 0.20$) or ED tests ($P = 0.618$) by BMI group. On bivariate analysis, overweight/obese subjects were less likely than normal/underweight subjects to have an abdominal radiograph (22 vs 38%, $P = 0.03$) and less likely to have a pediatric surgery consult (33 vs 49%, $P = 0.04$); however, after controlling for age, this finding was not found to be statistically significant for either abdominal radiograph (aOR 0.51, 95% confidence interval [CI] 0.26–1.03) or pediatric surgery consult (aOR 0.58, 95% CI 0.31–1.11). There were no significant differences in the rate of other individual tests or interventions between the two groups.

DISCUSSION

Our results did not show a significant difference in ED resource use (testing or intervention) or LOS for overweight/obese pediatric patients presenting to the ED with abdominal pain compared to normal/underweight patients. We analyzed 184 pediatric patients presenting to the ED with a chief complaint of abdominal pain. Of these, 4.9% were underweight, 58.7% normal weight, 11.4% overweight, and 25.0% were obese. Patients with a BMI of ≥85th percentile were older (median 15 years vs 13 years, $P = 0.01$) but otherwise similar in demographics.

There was no significant difference between normal/underweight and overweight/obese subjects in disposition (37 vs 43% discharge from the ED, $P = 0.38$); 72-hour return (7 vs 6%, $P = 0.82$), ED LOS (median

Table 2. Visit characteristics.

Variable	Level	Overall N = 184	BMI <85% percentile n = 117	BMI ≥85% percentile n = 67	P-Value	aOR (95% CI)[1]
Disposition	Admit	112 (60.87%)	74 (63.25%)	38 (56.72%)	0.38	1.02 (0.52, 1.97)
	DC to home	72 (39.13%)	43 (36.75%)	29 (43.28%)		1.00 (ref)
72-hour return	N	172 (93.48%)	109 (93.16%)	63 (94.03%)	0.82	1.00 (ref)
	Y	12 (6.52%)	8 (6.84%)	4 (5.97%)		0.91 (0.26, 3.21)
ED LOS (hrs)		4.09 (3.08, 5.53)	4.42 (3.33, 5.57)	3.95 (2.58, 5.2)	0.20	−0.45 (−1.17, 0.28)[2]
Inpt LOS (hrs)		37.7 (20.9, 76.7)	42.0 (26.7, 88.2)	34.2 (18.9, 44.1)	0.06	−7.2 (−23.6, 9.2)[2]
Intervention – Antiemetics	Y	88 (47.83%)	59 (50.43%)	29 (43.28%)	0.35	0.77 (0.42, 1.42)
	N	96 (52.17%)	58 (49.57%)	38 (56.72%)		1.00 (ref)
Intervention – Ped GI	Y	12 (6.52%)	7 (5.98%)	5 (7.46%)	0.70	1.39 (0.41, 4.70)
	N	172 (93.48%)	110 (94.02%)	62 (92.54%)		1.00 (ref)
Intervention – Ped surgery	Y	79 (42.93%)	57 (48.72%)	22 (32.84%)	0.04	0.58 (0.31–1.11)
	N	105 (57.07%)	60 (51.28%)	45 (67.16%)		1.00 (ref)
Intervention – IV fluids	Y	128 (69.57%)	84 (71.79%)	44 (65.67%)	0.39	0.90 (0.46, 1.75)
	N	56 (30.43%)	33 (28.21%)	23 (34.33%)		1.00 (ref)
Intervention – Pain meds	Y	59 (32.07%)	37 (31.62%)	22 (32.84%)	0.87	1.04 (0.54, 2.01)
	N	125 (67.93%)	80 (68.38%)	45 (67.16%)		1.00 (ref)
Any bloodwork	N	18 (9.78%)	15 (12.82%)	3 (4.48%)	0.07	1.00 (ref)
	Y	166 (90.22%)	102 (87.18%)	64 (95.52%)		3.48 (0.95, 12.7)
Enteric panel	Y	16 (8.70%)	8 (6.84%)	8 (11.94%)	0.24	2.17 (0.75, 6.27)
	N	168 (91.30%)	109 (93.16%)	59 (88.06%)		1.00 (ref)
Urinalysis/Urine culture	Y	143 (77.72%)	90 (76.92%)	53 (79.10%)	0.73	0.95 (0.45, 2.02)
	N	41 (22.28%)	27 (23.08%)	14 (20.90%)		1.00 (ref)
Abdominal radiograph	Y	60 (32.61%)	45 (38.46%)	15 (22.39%)	0.03	0.51 (0.26, 1.03)
	N	124 (67.39%)	72 (61.54%)	52 (77.61%)		1.00 (ref)
Any abdominal ultrasound	N	96 (52.17%)	64 (54.70%)	32 (47.76%)	0.37	1.00 (ref)
	Y	88 (47.83%)	53 (45.30%)	35 (52.24%)		1.44 (0.78, 2.66)
Any advanced imaging	N	131 (71.20%)	82 (70.09%)	49 (73.13%)	0.66	1.00 (ref)
	Y	53 (28.80%)	35 (29.91%)	18 (26.87%)		0.95 (0.48, 1.88)
Any lab	N	6 (3.26%)	5 (4.27%)	1 (1.49%)	0.31	1.00 (ref)
	Y	178 (96.74%)	112 (95.73%)	66 (98.51%)		2.27 (0.25, 20.5)
Any imaging	N	46 (25.00%)	24 (20.51%)	22 (32.84%)	0.06	1.00 (ref)
	Y	138 (75.00%)	93 (79.49%)	45 (67.16%)		0.53 (0.26, 1.05)
Number of ED interventions		2 (1, 3)	2 (1, 3)	2 (1, 3)	0.20	0.00 (−0.54, 0.54)[2]
Number of ED tests		6 (4, 7)	6 (4, 7)	6 (5, 7)	0.62	0.00 (−0.45, 0.45)[2]

[1]Adjusted for age of patient as a continuous variable.
[2]The median difference for those with a BMI in the ≥85% percentile vs the <85% percentile.
BMI, body mass index; *aOR*, adjusted odds ratio; *DC,* discharge; *ED*, emergency department; *LOS*, length of stay; *Inpt*, inpatient; *hrs*, hours; *Ped*, pediatric; *GI*, gastroenterology; *IV*, intravenous.

4.42 vs 3.95 hrs, $P = 0.20$), or inpatient LOS (median 42.0 vs 34.2 hrs, $P = 0.06$). There was no statistically significant difference in total number of ED tests or interventions received by overweight/obese patients compared to normal/underweight patients.

The lack of statistical differences in ED resource use and LOS across BMI groups in our population was surprising, as our hypothesis—pediatric patients with elevated BMI who present to the ED with abdominal pain would have higher resource utilization—was based on prior studies

demonstrating higher ED utilization and higher rates of functional abdominal pain in overweight and obese pediatric patients.[3–5,7–9] This lack of statistical difference between BMI groups in regard to ED resource use for abdominal pain could potentially be explained by the general tendency to very closely evaluate and observe all pediatric abdominal pain in the ED, particularly when considering the higher rates of atypical presentations of acute appendicitis or missed diagnoses in the younger population.[16] Interestingly, our findings demonstrating lack of difference in ED resource utilization across BMI groups in the pediatric abdominal pain population parallel the findings of similar adult studies.[11,17]

LIMITATIONS

We were able to analyze only subjects whose BMI could be calculated (both height and weight recorded in the EHR). Unfortunately, height is not routinely obtained in the ED, and in this retrospective review we likely missed a large number of patients due to no height being recorded, resulting in a limited sample size. Notably, we did find that the majority of patients with height and weight recorded also had a primary care physician (PCP) at the same tertiary care institution where the study took place. It could be hypothesized that the "missed population" (patients who did not have a height recorded in the EHR) may have represented a larger proportion of patients who either resided in a more rural area with a PCP outside the tertiary system's EHR, or who did not have a PCP at all. In a sub-sample of pediatric patients with abdominal pain identified during the study time, those with height and weight recorded in the EHR were older than those who did not have height and weight recorded in the EHR, suggesting that the "missed population" may have had additional characteristics that differed from the study population. Future prospective studies could be aimed at obtaining a height and weight on all patients to eliminate this selection bias.

CONCLUSION

We found that the ED evaluation of pediatric patients with a chief complaint of abdominal pain did not differ significantly based on body mass index in regard to resource utilization, including testing, intervention, and length of stay. Further research is warranted to assess whether this finding is replicated outside a pediatric tertiary care center, in the general pediatric population.

Address for Correspondence: Carly Theiler, MD, FAAP, University of Iowa Department of Emergency Medicine 200 Hawkins Drive, 1008-RCP, Iowa City, Iowa, 52242. Email: carly-theiler@uiowa.edu

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.

REFERENCES

1. Fryar CD, Carroll MD, Afful MS. Prevalence of overweight, obesity, and severe obesity among children and adolescents aged 2–19 years: United States, 1963–1965 through 2017–2018. *NCHS Reports*. December 2020.
2. Hales CM, Carroll MD, Fryar CD, et al. Prevalence of obesity among adults and youth: United States, 2015-2016. *NCHS Data Brief*. 2017;(288):1–8.
3. Trasande L, Chatterjee S. The impact of obesity on health service utilization and costs in childhood. *Obesity (Silver Spring)*. 2009;17(9):1749–54.
4. Kovalerchik O, Powers E, Holland ML, et al. Differences in frequency of visits to pediatric primary care practices and emergency departments by body mass index. *Acad Pediatr*. 2020;20(4):532–9.
5. Bianchi-Hayes J, Calixte R, Huang J, et al. Healthcare utilization by obese and overweight children. *J Pediatr*. 2015;166(3):626–31 e2.
6. McDermott KW, Stocks C, Freeman WJ.Overview of Pediatric Emergency Department Visits, 2015: *Statistical Brief #242. Healthcare Cost and Utilization Project (HCUP) Statistical Briefs. Agency for Healthcare Research and Quality* (US); 2006.
7. Teitelbaum JE, Sinha P, Micale M, et al. Obesity is related to multiple functional abdominal diseases. *J Pediatr*. 2009;154(3):444–6.
8. Phatak UP, Pashankar DS. Prevalence of functional gastrointestinal disorders in obese and overweight children. *Int J Obes (Lond)*. 2014;38(10):1324–7.
9. Bonilla S, Wang D, Saps M. Obesity predicts persistence of pain in children with functional gastrointestinal disorders. *Int J Obes (Lond)*. 2011;35(4):517–21.
10. Grout RW, Thompson-Fleming R, Carroll AE, et al. Prevalence of pain reports in pediatric primary care and association with demographics, body mass index, and exam findings: a cross-sectional study. *BMC Pediatr*. 2018;18(1):363.
11. Chen EH, Shofer FS, Hollander JE, et al. Emergency physicians do not use more resources to evaluate obese patients with acute abdominal pain. *Am J Emerg Med*. 2007;25(8):925–30.
12. Mahajan P, Basu T, Pai CW, et al. Factors associated with potentially missed diagnosis of appendicitis in the emergency department. *JAMA Netw Open*. 2020;3(3):e200612.
13. Tantisook T, Aravapalli S, Chotai PN, et al. Determining the impact of body mass index on ultrasound accuracy for diagnosing appendicitis: Is it less useful in obese children? *J Pediatr Surg*. 2021;56(11):2010–15.

14. Schuh S, Man C, Cheng A, et al. Predictors of non-diagnostic ultrasound scanning in children with suspected appendicitis. *J Pediatr*. 2011;158(1):112–8.
15. BMI Percentile Calculator for Child and Teen. Centers for Disease Control and Prevention. Available at: https://www.cdc.gov/healthyweight/bmi/calculator.html. Accessed February 22, 2020.
16. Becker T, Kharbanda A, Bachur R. Atypical clinical features of pediatric appendicitis. *Acad Emerg Med*. 2007;14(2):124–9.
17. Platts-Mills TF, Burg MD, Snowden B. Obese patients with abdominal pain presenting to the emergency department do not require more time or resources for evaluation than nonobese patients. *Acad Emerg Med*. 2005;12(8):778–81.

Comparison of Pediatric Acute Appendicitis Before and During the COVID-19 Pandemic in New York City

Priya Mallikarjuna, MD*
Saikat Goswami, MBBS*
Sandy Ma, MD*
Won Baik-Han, MD*
Kelly L. Cervellione, MPhil†
Gagan Gulati, MD*
Lily Q. Lew, MD*

*Flushing Hospital Medical Center, Department of Pediatrics, Flushing, New York
†Medisys Health Network, Department of Clinical Research, Jamaica, New York

Section Editors: Cristina Zeretzke, MD, and Mark Langdorf, MD, MHPE
Submission history: Submitted November 10, 2022; Revision received March 27, 2023; Accepted May 25, 2023
Electronically published August 22, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59393

Background: Acute appendicitis (AA) is the most common abdominal surgical emergency in children and adolescents. In the year immediately following the declaration of the coronavirus disease 2019 (COVID-19) pandemic by the World Health Organization (WHO), there was a precipitous decline in emergency department (ED) visits especially for surgical conditions and infectious diseases. Fear of exposure to severe acute respiratory coronavirus 2 infection resulted in delay in presentation and time to surgery, and a shift toward more conservative management.

Objective: Our goal was to compare the incidence and severity of AA before and during the COVID-19 pandemic.

Methods: Patients aged 2–18 years admitted with the diagnosis of AA to Flushing Hospital Medical Center or Jamaica Hospital Medical Center in Queens, New York, were selected for chart review. Data extracted from electronic health records included demographics, clinical findings, imaging studies, and operative and pathological findings. We calculated the Alvarado score (AS) for incidence and the American Association for the Surgery of Trauma (AAST) grade for severity. We compared patients admitted between March 1, 2018–February 29, 2020 (pre-pandemic) to patients admitted between March 1, 2020–February 28, 2021 (pandemic). We then compared pre-pandemic and pandemic groups to determine differences in pediatric AA incidence and severity.

Results: Of 239 patients diagnosed with AA, 184 (77%) were in the pre-pandemic group and 55 (23%) in the pandemic group. Incidence (number per year) of AA declined by 40%. The pandemic group had significantly greater overall AS of $\geq$7, indicating increased likelihood to require surgery, ($P = 0.04$) and higher AAST grade demonstrating increased severity ($\boldsymbol{P = 0.02}$).

Conclusion: There was a decline in the number of AA cases seen in our pediatric EDs and admitted during the first year of the pandemic. Clinicians need to be aware of increased severity of AA at time of presentation during public health emergencies such as a pandemic, possibly due to modified patient behavior. [West J Emerg Med. 2023;24(5)956–961.]

INTRODUCTION

In March 2020 the first case of coronavirus disease 2019 (COVID-19) was identified in New York City (NYC), and the borough of Queens became the epicenter within days. Following the World Health Organization (WHO) declaration of a global pandemic, practices to reduce the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) included closing all nonessential businesses and schools, use of personal protective equipment, social distancing, and density reduction.[1] Routine pediatric and emergency department (ED) visits during the pandemic declined precipitously.[2] Acute appendicitis (AA), the most common abdominal surgical emergency in pediatrics, was impacted. There is a paucity of data on pediatric ED visits in urban teaching community hospitals and on whether the trends affected presentation or progression of AA in this type of setting. We compared the Alvarado score (AS) for incidence and the American Association for the Surgery of Trauma (AAST) grade for severity in patients with AA before and during the first year of the COVID-19 pandemic.

METHODS

The institutional review boards of Flushing Hospital Medical Center (FHMC) and Jamaica Hospital Medical Center (JHMC) approved the study. We analyzed charts of patients meeting inclusion criteria who were seen and admitted with AA to either FHMC or JHMC. Data extracted from electronic health records included demographics, clinical presentation, imaging studies, and operative and pathological criteria to determine the AS and AAST grade. Demographics included age, gender, and ethnicity. The AS uses a 10-point clinical scoring system to identify AA based on criteria such as migration of pain, anorexia, nausea, tenderness in right lower quadrant, rebound, fever, leukocytosis and left shift of leukocytosis. Right lower quadrant pain and leukocytosis are assigned two points and the remaining six criteria assigned one point each. A patient with a score of 1–6 is least likely to require surgery while a patient with a score of 7–10 is more likely to require surgery.[3] The AAST grade includes whether the appendix is inflamed, gangrenous, or perforated. The grade ranges from I to V, with grade I the least severe and grade V the most severe.[4] Patients diagnosed with AA were grouped according to time period, between March 1, 2018–February 29, 2020 as the pre-pandemic group and between March 1, 2020–February 28, 2021 as the pandemic group.

We included patients aged 2–18 years who were diagnosed with AA between March 1, 2018–February 28, 2021 (Figure 1). Data were collected in adherence to the methodological standards proposed for medical record review studies by Worster et al.[5] We used AS to determine incidence[3] and AAST to determine severity.[4] We analyzed the data using SPSS version 22 software (SPSS Inc, Chicago, IL). Independent sample *t*-tests, chi-square tests and Fisher exact tests were used for between-group analyses; $P < 0.05$ was considered significant.

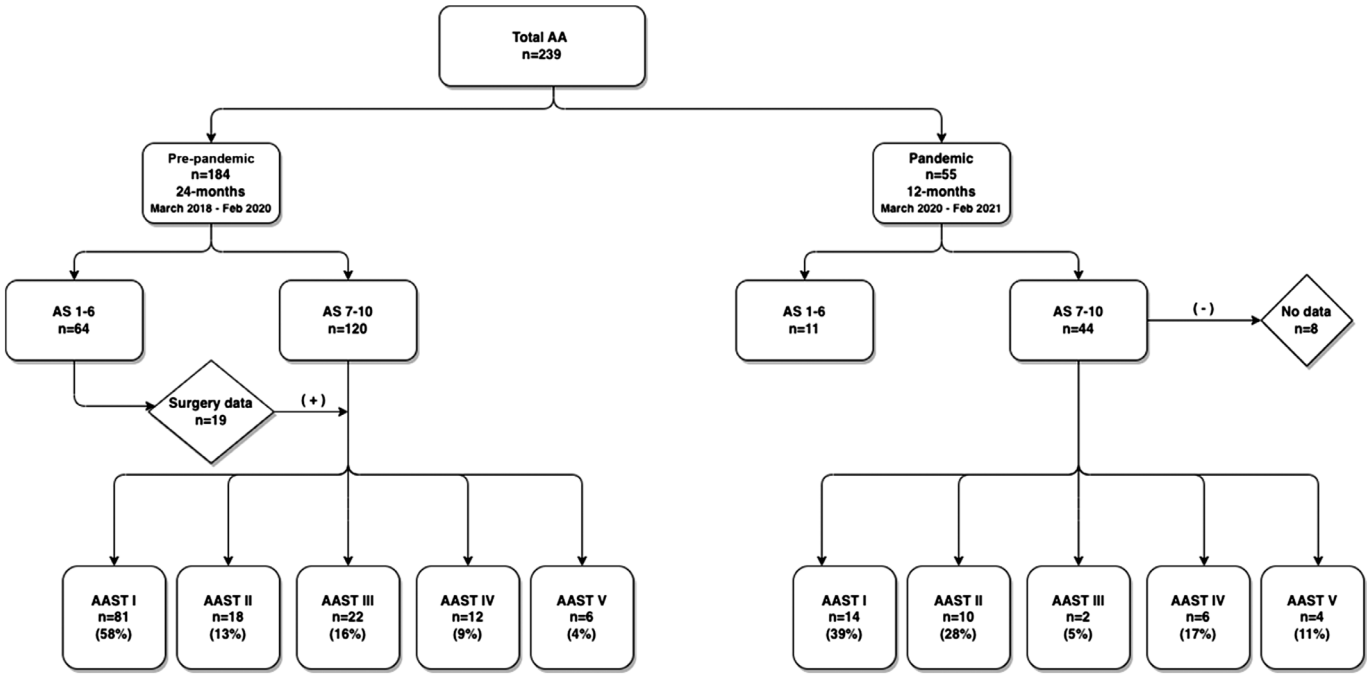


Figure 1. Flowchart of patients reviewed before and during COVID-19 pandemic.
AA, acute appendicitis; *AS*, Alvarado score; *AAST*, American Association for the Surgery of Trauma grade.

RESULTS

Demographics

We reviewed 239 patient charts. There were 184 (77%) patients in the pre-pandemic group and 55 (23%) in the pandemic group. The average number of patients per year in the two years preceding the pandemic was 92 (38% per year) compared to 55 (23%) in the first pandemic year, a decline of 40%. The mean age of patients in our study group was 10.2 ± 3.9 years. Male gender was predominant (60%). The majority of our patients were of Hispanic or Asian ethnicity, reflective of our Queens community. Mean age, gender, and ethnicity were similar for pre-pandemic and pandemic groups.

Alvarado Score

In both the pre-pandemic and pandemic groups, tenderness in the right lower quadrant was the primary clinical finding, and leukocytosis with left shift was the most frequent laboratory finding. An AS of 7–10 was more likely in patients in the pandemic group. Pre-pandemic AS compared to pandemic AS was significant (OR 2.13, 95% CI 1.03–4.41; $P = 0.04$).

Table 1. Alvarado score and American Association for the Surgery of Trauma grade before and during the COVID-19 pandemic.

Variables	Pre-pandemic n = 184 (24-months) n (%)	Pandemic n = 55 (12-months) n (%)	*P*-value
Demographics			
Age (years) mean (SD)	10.21 (3.9)	10.2 (3.9)	0.85
Gender			0.84
Male	111 (60.3)	34 (61.8)	
Female	73 (39.7)	21 (38.2)	
Ethnicity			
Caucasian	6 (3.3)	1 (1.8)	0.58
Hispanic	134 (72.8)	45 (81.8)	0.18
African American	6 (3.3)	3 (5.5)	0.45
Asian	36 (19.6)	6 (10.9)	0.14
Other	2 (1.1)	0 (0)	0.67
Alvarado score			
Migration of pain	84 (48.3)	34 (64.2)	0.04*
Anorexia	72 (52.9)	32 (69.6)	0.05*
Nausea	142 (78.9)	42 (80.8)	0.77
Tenderness in right lower quadrant	179 (97.8)	55 (100)	0.27
Rebound pain	44 (27.7)	17 (38.6)	0.16
Left shift	178 (96.7)	54 (98.2)	0.58
Fever	77 (41.8)	29 (52.7)	0.15
Leukocytosis	159 (86.4)	51 (92.7)	0.41
Total Alvarado score			0.04*
1–6	64 (34.8)	11 (20.0)	
7–10	120 (65.2)	44 (80.0)	
American Association for the Surgery of Trauma (AAST) grade			
I: Acute inflamed appendix intact	81 (58.3)	14 (38.9)	0.37
II: Gangrenous appendicitis intact	18 (12.9)	10 (27.8)	0.31
III: Perforated appendix with local contamination	22 (15.8)	2 (5.6)	1.00
IV: Perforated appendix with phlegmon or abscess	12 (8.6)	6 (16.7)	1.00
V: Perforated appendix with generalized peritonitis	6 (4.3)	4 (11.1)	1.00
Total AAST grade			0.02*

*P < 0.05 was significant.

Ultrasound of the Appendix

We obtained an imaging study in 53% of patients in the pre-pandemic group and in 47% of patients in the pandemic group, $P = 0.39$.

American Association for the Surgery of Trauma Grade

The AAST was applied to those with AS 7–10 and to an additional 19 patients with AS <7 and surgical data (total of 139 in the pre-pandemic group, 36 in the pandemic group). In the pandemic group, eight patients (15%) were transferred to a tertiary care center. The majority of patients in the pre-pandemic group had grade I, and the least number of patients were categorized with grade V. Most of the patients in the pandemic group had grade I and grade II severity and the least had grade III and grade IV severity. Chi-square analysis revealed a significant difference in the AAST severity grade distributions between pre-pandemic and pandemic groups (OR 0.36, 95% CI 0.1–1.35, $P = 0.02$) (Table 1). Only three patients tested positive for SARS-CoV-2.

DISCUSSION

Acute appendicitis is the most common abdominal surgical emergency in pediatrics and generally occurs frequently in males 10–19 years in age.[6,7] The typical presentation includes periumbilical pain that migrates to the right lower quadrant of the abdomen associated with fever between 37.2–38.0° Celsius, nausea, loss of appetite, and diarrhea. Since these symptoms mimic other conditions, diagnosis of AA can be challenging. The AS assists in the diagnosis of AA, and visualization of the appendix on ultrasound is confirmatory. Delay in diagnosis can result in rupture of the appendix.[6] Early surgical intervention is associated with lower risk of perforation. However, there are ongoing studies investigating whether appendectomy can be delayed by 12-24 hours and the role of non-operative management with the use of antibiotics as an effective treatment alternative.[7] An AS of ≥7 is more likely to require surgery.[3] The AAST anatomic grading system for appendicitis is a validated tool to assess severity. A higher AAST grade is associated with most severe cases and higher complication rates.[4] We used the AS to determine incidence and the AAST grade to determine severity. Each patient was assigned to the highest group for analysis.

The WHO declared the COVID-19 pandemic in March 2020 as the virus spread worldwide.[8] Measures to mitigate the spread of the virus modified the behavior of patients and the delivery of healthcare.[9] The fear of exposure resulted in decline in pediatric routine and ED visits.[1,2,10] Emergency departments were overwhelmed with COVID-19 cases, while the remainder of the hospital and medical staff was reorganized to care for those who were admitted. Elective surgeries were canceled, and non-urgent surgeries were delayed.[11] Studies have reported the possible effect of the COVID-19 pandemic on presentation, management, and outcomes on appendicitis.[12–16] A small percentage (5%) of our patients with AA tested positive for SARS-CoV-2, despite a reported possibility of AA as a post-inflammatory complication of SARS-CoV-2 infection.[17,18]

In our study, the median age and gender of our patients were concordant with known epidemiology of AA. The number of patients in each ethnic group is reflective of our community. The mean number of patients with AA per year pre-pandemic compared to pandemic declined by 40%, similar to findings by the US Centers for Diseases Control and Prevention.[19] For each clinical criterion on the AS, pre-pandemic and pandemic groups were not significantly different. The percentage of ultrasound of the appendix performed was lower in the pandemic group and was also not significantly different. However, the higher number of patients with AS ≥7 in the pandemic group was significant. All our patients with AS 1–6 were managed with antibiotics. In both groups, only 66% of patients had complete surgical and pathological data. The percentage of grades I and II was higher in the pre-pandemic group, and the percentage of grades IV and V was higher in the pandemic group. The higher AAST grade was significant in the pandemic group.

Other studies regarding incidence and severity of AA during the COVID-19 pandemic were variable. In one study, a lower incidence and a higher complication rate in adults with AA were observed in a multicenter study in the Netherlands during the same period studied by us.[20] Lucero et al reported a reduction in ED visits in both children and adults across our country.[2] We concur with a decline in ED visits for AA. Studies related to severity of AA in children were all retrospective and based on patients with delayed presentation and increased incidence of complications.[13,15,21,22] We did not correlate delayed presentation with severity. Incidence of complications was assessed using ASST grade. Gerall et al reported in a small sample of 48 patients in the pandemic group with delayed presentation and increased severity based on clinical presentation and radiological imaging of perforation and intra-abdominal abscess.[23] We did see an increase in perforation with abscess (grade IV) in our pandemic group compared to the study from Italy by La Pergola et al in which the pandemic group had overall decreased hospital admission and unchanged number of complicated appendectomies as an indication of severity,[24] and to the study from Lithuania by Vansevičienė et al when a surgical delay of four hours was not associated with increased complications.[25] Not all studies confirmed delay in presentation or demonstrated increased severity of AA during the pandemic.[13,26] There may be unmeasurable factors contributing to the changes seen during the peak of the pandemic affecting the behavior and relationship of our patients and healthcare systems.

LIMITATIONS

This was a retrospective study conducted in two community, non-profit, teaching hospitals. We focused on the first year of the pandemic in NYC when the COVID-19 vaccine was limited for the age group studied and after worldwide spread. Change in medical coverage and parental health literacy were not taken into consideration when evaluating patient behavior. We did not include data on time from ED to operating room, outcomes, or follow-up after hospital discharge.

CONCLUSION

In our sample from two urban community hospitals, there was a decline in the number of AA visits in our pediatric EDs. The severity of acute appendicitis in children and adolescents who presented to the ED was heightened during the COVID-19 pandemic. Clinicians need to be aware of increased severity when evaluating AA and possible increased risk of complications during a public health emergency. The increasing use of telemedicine to screen patients and of social media to obtain health information by patients fueled by the COVID-19 pandemic may contribute to the changing presentation of many conditions, including AA.

Address for Correspondence: Lily Q. Lew, MD, Flushing Hospital Medical Center, Department of Pediatrics, 4500 Parsons Blvd, Flushing, New York 11355. Email: llew2.flushing@jhmc.org

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.

REFERENCES

1. Pines JM, Zocchi MS, Black BS, et al. Characterizing pediatric emergency department visits during the COVID-19 pandemic. *Am J Emerg Med.* 2021;41:201–4.
2. Lucero AD, Lee A, Hyun J, et al. Underutilization of the emergency department during the COVID-19 pandemic. *West J Emerg Med.* 2020;21(6):15–23.
3. Ohle R, O'Reilly F, O'Brien KK, et al. The Alvarado score for predicting acute appendicitis: a systematic review. *BMC Med.* 2011;9:139.
4. Finnesgard EJ, Hernandez MC, Aho JM, et al. The American Association for the Surgery of Trauma emergency general surgery anatomic severity scoring system as a predictor of cost in appendicitis. *Surg Endosc.* 2018;32(12):4798–804.
5. Worster A, Bledsoe RD, Cleve P, et al. Reassessing the methods of medical record review studies in emergency medicine research. *Ann Emerg Med.* 2005;45(4):448–51.
6. Addis DG, Shaffer N, Fowler BS, et al. The epidemiology of appendicitis and appendectomy in the Unites States. *Am J Epidemiol.* 1990;132(5):910–25.
7. Krzyzak M, Mulrooney SM. Acute appendicitis review: background, epidemiology, diagnosis, and treatment. *Cureus.* 2020;12(6):e8562.
8. Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Biomed.* 2020;91(1):157–60.
9. New York State COVID-19 data. Available at: https://coronavirus.health.ny.gov/home. Accessed March 17, 2021.
10. Delgado-Miguel C, Garcia Urbán J, Del Monte Ferrer C, et al. Impact of the COVID-19 pandemic on acute appendicitis in children. *J Healthc Qual Res.* 2022;37(4):225–30.
11. Kvasnovsky CL, Shi Y, Rich BS, et al. Limiting hospital resources for acute appendicitis in children: lessons learned from the U.S. epicenter of the COVID-19 pandemic. *J Pediatr Surg.* 2021;56(5):900–4.
12. Li C, Saleh A. Effect of COVID-19 on pediatric appendicitis presentations and complications. *J Pediatr Surg.* 2022;57(5):861–5.
13. Tristán JG, Romero HS, Pellitero SE, et al. Acute appendicitis in children during the COVID-19 pandemic: neither delayed diagnosis nor worse outcomes. *Pediatr Emerg Care.* 2021;37(3):185–90.
14. Lotfallah A, Aamery A, Moussa G, et al. Surgical versus conservative management of acute appendicitis during the COVID-19 pandemic: a single-centre retrospective study. *Cureus.* 2021;13(3):e14095.
15. Pawelczyk A, Kowalska M, Tylicka M, et al. Impact of the SARS-CoV-2 pandemic on the course and treatment of appendicitis in the pediatric population. *Sci Rep.* 2021;11(1):23999.
16. Place R, Lee J, Howell J. Rate of pediatric appendiceal perforation at a children's hospital during the COVID-19 pandemic compared with the previous year. *JAMA Netw Open.* 2020;3(12):e2027948.
17. Malhotra A, Sturgill M, Whitley-Williams P, et al. Pediatric COVID-19 and appendicitis: a gut reaction to SARS-CoV-2? *Pediatr Infect Dis J.* 2021;40(2):e49–55.
18. Malbul K, Katwal S, Maharjan S, et al. Appendicitis as a presentation of COVID-19: a case report. *Ann Med Surg.* 2021;69:102719.
19. Hartnett KP, Kite-Powell A, DeVies J, et al. Impact of the COVID 19 pandemic on emergency department visits – United States January 1, 2019–May 30, 2020. *Morb Mortal Wkly Rep.* 2020;69(23):699–704.
20. Scheijman JGC, Burstein ABJ, Puylaert CAJ, et al. Impact of the COVID-19 pandemic on incidence and severity of acute appendicitis: a comparison between 2019 and 2020. *BMC Emerg Med.* 2021;21(1):61.
21. Raffaele A, Cervone A, Ruffoli M, et al. Critical factors conditioning the management of appendicitis in children during COVID-19 pandemic: experience from the outbreak area of Lombardy, Italy. *Br J Surg.* 2020;107(11):e529–30.
22. Snapiri O, Rosenberg Danziger C, Krause I, et al. Delayed diagnosis of paediatric appendicitis during the COVID-19 pandemic. *Acta Paediatr.* 2020;109(8):1672–6.

23. Gerall CD, DeFazio JR, Kahan AM, et al. Delayed presentation and sub-optimal outcomes of pediatric patients with acute appendicitis during the COVID-19 pandemic. *J Pediatr Surg.* 2021;56(5):905–10.
24. LaPergola E, Sgro A, Rebosio F, et al. Appendicitis in children in a large Italian COVID-19 pandemic area. *Front Pediatr.* 2020;8:600320.
25. Vansevičienė I, Bučinskaitė D, Malcius D, et al. Did the COVID-19 pandemic prolong the time till diagnosis and worsen outcomes for children with acute appendicitis? *Medicina.* 2021;57(11):1234.
26. Nassiri AM, Pruden RD, Holan CA, et al. Pediatric appendicitis in the time of the COVID-19 pandemic: a retrospective chart review. *J Amer Coll Emerg Physicians Open.* 2022;3(2):e12722.

Expanding Diabetes Screening to Identify Undiagnosed Cases Among Emergency Department Patients

David C. Lee, MD, MS[*†‡]
Harita Reddy, MPH[*]
Christian A. Koziatek, MD[*‡]
Noah Klein[*]
Anup Chitnis, MD[*]
Kashif Creary[*]
Gerard Francois[*]
Olumide Akindutire, MD[*]
Robert Femia, MD, MBA[*‡]
Reed Caldwell, MD[*]

[*]New York University, NYU Grossman School of Medicine, Ronald O. Perelman Department of Emergency Medicine, New York, New York
[†]New York University, NYU Grossman School of Medicine, Department of Population Health, New York, New York
[‡]Bellevue Hospital Center, Department of Emergency Medicine, New York, New York

Section Editors: Erik Anderson, MD, and Gayle Galletta, MD
Submission history: Submitted January 21, 2023; Revision received May 30, 2023; Accepted July 8, 2023
Electronically published August 8, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59957

Introduction: Diabetes screening traditionally occurs in primary care settings, but many who are at high risk face barriers to accessing care and therefore delays in diagnosis and treatment. These same high-risk patients do frequently visit emergency departments (ED) and, therefore, might benefit from screening at that time. Our objective in this study was to analyze one year of results from a multisite, ED-based diabetes screening program.

Methods: We assessed the demographics of patients screened, identified differences in rates of newly diagnosed diabetes by clinical site, and the geographic distribution of high and low hemoglobin A1c (HbA1c) results.

Results: We performed diabetes screening (HbA1c) among 4,211 ED patients 40–70 years old, with a body mass index ≥25, and no prior history of diabetes. Of these patients screened for diabetes, 9% had a HbA1c result consistent with undiagnosed diabetes, and nearly half of these patients had a HbA1c ≥9.0%. Rates of newly diagnosed diabetes were notably higher at EDs located in neighborhoods of lower socioeconomic status.

Conclusion: Emergency department-based diabetes screening may be a practical and scalable solution to screen high-risk patients and reduce health disparities experienced in specific neighborhoods and demographic groups. [West J Emerg Med. 2023;24(5)962–966.]

INTRODUCTION

Among the 35 million Americans with diabetes, nearly one in four are unaware of their condition.[1] Diabetes screening traditionally occurs in primary care settings, but many people at high risk of diabetes face substantial barriers when accessing healthcare.[2,3] Therefore, diagnosis is delayed among those most likely to develop diabetes at an early age, and there is greater risk of diabetes-related morbidity and mortality that would otherwise have been preventable.[4,5] Many high-risk patients, however, do have frequent interactions with the healthcare system. Patients with socioeconomic burdens and time constraints are more likely to visit emergency departments (ED) for care.[6–8]

In June 2019, we began an ED initiative to test hemoglobin A1c (HbA1c) for patients without a history of diabetes who met US Preventive Services Task Force

(USPSTF) guidelines for screening. Our goal in this study was to evaluate one year of results from this screening program to assess program efficacy and the demographics of ED patients with newly diagnosed diabetes. We aimed to examine whether ED-based diabetes screening can be scalable and effective in helping address disparities in the diagnosis of new diabetes and identifying patients who need linkage to outpatient care for management.

METHODS

Study Design

We performed a retrospective chart review of patients screened for diabetes from February 2021–January 2022 with a HbA1c test at four EDs in New York City. The primary outcome of interest was the percentage of patients with an elevated HbA1c. We analyzed the demographic characteristics of screened patients, differences by clinical site, and the geographic distribution of results among patients screened.

Study Population

Patients screened included anyone already receiving blood work for their clinical care who met USPSTF guidelines for diabetes screening. At the time of the study, those guidelines recommended screening for adults 40–70 years old with a body mass index (BMI) ≥25. Eligible patients were automatically identified through the electronic health record (EHR) as not having a history of diabetes (based on problem list, auto-populated via the shared health record system Care Everywhere [Care Everywhere LLC, Natick, MA] or by patient-provided past medical history at ED triage), and as not having a HbA1c test in the previous six months. The HbA1c tests were offered at no charge, and patients were given the opportunity to decline the test, although data on those declined was not tracked.

Statistical Analysis

We performed a descriptive analysis of screened patients during the study period, for both the overall study population and by clinical site. We analyzed BMI categorically: overweight (BMI 25.0–29.9); obese (30.0–39.9); and morbidly obese (≥ 40). The HbA1c result was categorized as normal (<5.7%), prediabetes (5.7%–6.4%), diabetes (6.5%–8.9%), and poorly controlled diabetes (≥9.0%). To identify statistically significant differences in patient characteristics among hospitals, we used ANOVA for continuous variables and chi-squared tests for categorical variables.

We conducted a geospatial analysis to determine whether high and low HbA1c values were concentrated in specific geographic areas. To do this, we performed a Getis-Ord Gi* hotspot analysis on HbA1c values, a commonly used approach to identify significant spatial clustering of high and low values for a given variable.[9,10] We used the K-nearest neighbors to model spatial proximity.

Statistical analyses were performed using Stata 16.1 (Stata Corp, College Station, TX). Geographic analysis was performed using ArcGIS Pro 2.8.3 (ESRI; Redlands, CA). This study was approved by the institutional review board at New York University School of Medicine.

RESULTS

Study Population

We screened 4,211 ED patients 40–70 years old, with BMI ≥25 and no prior history of diabetes (Table 1). Of the patients screened, 58% were minorities; the proportion of each race/ethnicity differed among the four sites. Demographic differences at each site generally reflected the local populations living near those EDs. Of the patients screened, 16% reported that English was not their primary language. By insurance type, 55% of patients screened had private/commercial insurance, 15% were insured by Medicare, 25% by Medicaid, and 5% were self-pay or uninsured. Thirty-four percent of patients screened at NYU Brooklyn were insured by Medicaid, much higher than the proportion at the other EDs. In terms of BMI, 43% were obese, 10% were morbidly obese, and the remainder were overweight, given the BMI screening cutoff of 25.

Primary Outcome

Eighteen percent of screened ED patients had a HbA1c result consistent with prediabetes, and 9% had HbA1c results consistent with undiagnosed diabetes. Notably, almost half of ED patients with a new diagnosis of diabetes had a HbA1c ≥9.0%, consistent with poorly controlled diabetes. Comparing the proportion of patients newly diagnosed with diabetes at each of the four EDs, rates were notably higher at NYU Brooklyn (16%) and NYU Cobble Hill (9%) compared to NYU-Tisch Hospital in Manhattan (6%) and NYU Long Island (6%) (P-value < 0.01).

Geospatial Analysis of HbA1c Results

In a geospatial analysis, we identified statistically significant clustering of high and low HbA1c values in the New York City area (Figure 1). Sensitivity analyses for the number of nearest neighbors demonstrated a generally similar geographic location of these hot and cold spots, which suggests that these findings were robust (not affected by changing the number of nearest neighbors specified).[11]

DISCUSSION

Our study reviewed one year of data from an ED-based diabetes screening program and found a high rate of previously undiagnosed diabetes among ED patients meeting USPSTF criteria to be screened. Many of these patients had poorly controlled diabetes (HbA1c of >9.0%). While EDs are not designed to provide long-term

Table 1. Characteristics of emergency department patients screened for diabetes and hemoglobin A1c results.

Population characteristics	All hospitals	NYU-Tisch Hospital Manhattan	NYU Brooklyn	NYU Cobble Hill	NYU Long Island	*P*-value for differences
Patients	4,311	1,092	1,079	589	1,551	
Age (median)	54	55	53	51	55	< 0.01
Gender						
Female	2,155 (50%)	513 (47%)	496 (46%)	330 (56%)	807 (52%)	< 0.01
Male	2,156 (50%)	579 (53%)	583 (54%)	259 (44%)	744 (48%)	
Race/ethnicity						
White	1,811 (42%)	491 (45%)	345 (32%)	194 (33%)	776 (50%)	< 0.01
Black	905 (21%)	229 (21%)	129 (12%)	224 (38%)	310 (20%)	
Hispanic	1,121 (26%)	218 (20%)	464 (43%)	112 (19%)	357 (23%)	
Asian	129 (3%)	33 (3%)	32 (3%)	12 (2%)	47 (3%)	
Other	345 (8%)	120 (11%)	108 (10%)	47 (8%)	62 (4%)	
Language						
English	3,621 (84%)	1,005 (92%)	712 (66%)	565 (96%)	1,334 (86%)	< 0.01
Spanish	517 (12%)	44 (4%)	281 (26%)	18 (3%)	186 (12%)	
Other	172 (4%)	44 (4%)	86 (8%)	6 (1%)	62 (2%)	
Insurance						
Private	2,371 (55%)	612 (56%)	432 (40%)	342 (58%)	977 (63%)	< 0.01
Medicare	733 (17%)	229 (21%)	183 (17%)	88 (15%)	248 (16%)	
Medicaid	1,035 (24%)	240 (22%)	367 (34%)	141 (24%)	295 (19%)	
Self-pay	172 (4%)	22 (2%)	97 (9%)	18 (3%)	31 (2%)	
BMI						
Overweight	2,026 (47%)	557 (51%)	529 (49%)	253 (43%)	698 (45%)	< 0.01
Obese	1,854 (43%)	437 (40%)	453 (42%)	253 (43%	713 (46%)	
Morbidly obese	431 (10%)	98 (9%)	97 (9%)	82 (14%)	140 (9%)	
HbA1c result						
≥ 9.0%	172 (4%)	22 (2%)	97 (9%)	24 (4%)	31 (2%)	< 0.01
6.5% to 8.9%	216 (5%)	44 (4%)	76 (7%)	29 (5%)	62 (4%)	
5.7% to 6.4%	776 (18%)	164 (15%)	183 (17%)	88 (15%)	326 (21%)	
< 5.7%	3,147 (73%)	863 (79%)	723 (67%)	448 (76%)	1,132 (73%)	

BMI, body mass index; *HbA1c*, hemoglobin A1c.

management of chronic diseases, rates of undiagnosed diabetes are known to be two times higher among patients with poor access to primary care.[12] Patients diagnosed with diabetes through preventive screening are diagnosed much earlier, and have lower mortality, when compared to patients diagnosed with diabetes due to clinical symptoms.[13,14] The ED provides a setting for diabetes screening where new cases could be diagnosed that might otherwise go undetected, especially among high-risk patients with poor access to primary care. Previously published efforts to screen ED patients for diabetes have demonstrated even higher rates of undiagnosed diabetes, which may be due to the screening criteria used or the patient populations in those health systems.[15–19]

Our study also found higher rates of undiagnosed diabetes in our EDs that are located primarily in neighborhoods of lower socioeconomic status, including those with a high proportion of patients for whom English is not the primary language. Leveraging the ED to promote diabetes screening has the potential to reduce racial and ethnic disparities in diabetes burden, especially among patients who may face language barriers. Limiting preventive screening to the primary care setting risks the perpetuation of poor health outcomes for those patients who face barriers to healthcare access. If the primary concern is that these newly diagnosed ED patients may not follow up for appropriate outpatient care, then efforts should focus on how to improve care coordination from the ED to the primary care setting.

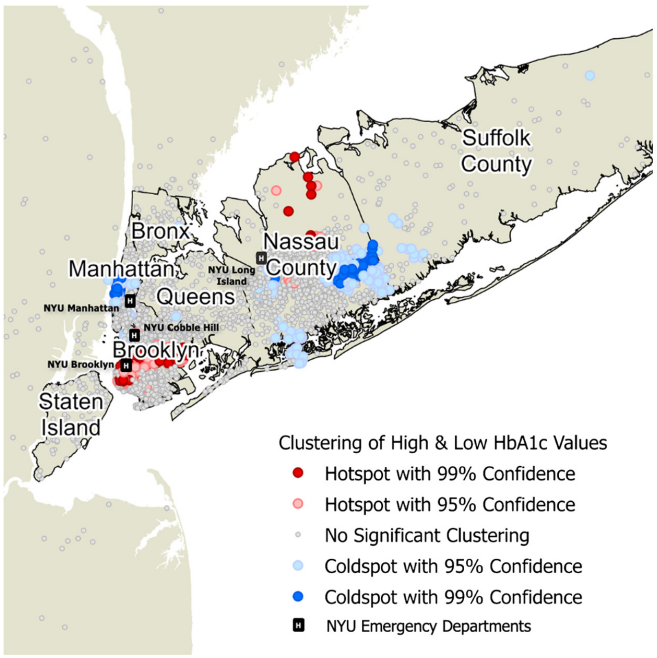


Figure 1. Geographic distribution of emergency department patients screened for diabetes in the New York City area and marked locations of the emergency departments.

Our study demonstrates that the highest yield of this diabetes screening was in EDs seeing a high proportion of patients of lower socioeconomic status. In a multivariable analysis controlling for age, gender, race/ethnicity, language, and insurance type, we found male gender, all non-White race/ethnicities, other language, and self-pay insurance status were statistically significant predictors of previously undiagnosed diabetes. In addition, the location of hot and cold spots of HbA1c values correlated well with prior studies of the geographic distribution of poor glycemic control among diabetes patients in New York City.[20] Promoting diabetes screening in EDs that serve high-risk patient populations can help identify undiagnosed cases of diabetes in these neighborhoods, which may be a critical step in addressing poor health outcomes experienced in these geographic areas.

LIMITATIONS

Our study has several limitations. First, ED patients receiving bloodwork are likely to have some differences from patients not receiving bloodwork; these findings may not be generalizable to every ED patient. Additionally, our study was in one metro area, and while our findings do fit well with existing diabetes literature for the New York City area, it is possible that other geographic areas will have different patient types visiting the ED and, therefore, may have different amounts of undiagnosed diabetes than found in our study. It is also possible that patients identified as newly diagnosed in our study did have a previous diagnosis elsewhere, which they did not disclose during their ED visit and was not available in our EHR data. Finally, there may have been other confounders (eg, dietary behaviors) that are highly correlated with the factors analyzed in our study, which may be an unmeasured predictor of undiagnosed diabetes and may be a limitation of relying only on EHR data.

CONCLUSION

We found a high percentage of screened patients in the ED with undiagnosed diabetes. We further found that the burden of undiagnosed diabetes in the ED is concentrated in certain geographic areas, corroborating known socioeconomic elements to undiagnosed diabetes. This suggests that ED-based diabetes screening can be a scalable solution for addressing disparities in the burden of diabetes and identifying patients who need linkage to outpatient care. Further work can focus on improved screening criteria specific to the ED population to improve yield and follow-on systems development for further care of newly diagnosed patients.

Address for Correspondence: Reed Caldwell, MD, New York University, NYU Grossman School of Medicine, Ronald O. Perelman Department of Emergency Medicine, 550 1st Avenue, New York, New York 10016. Email: reed.caldwell@nyulangone.org

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.

REFERENCES

1. Menke A, Casagrande S, Geiss L, et al. Prevalence of and trends in diabetes among adults in the United States, 1988–2012. *JAMA*. 2015;314(10):1021–9.
2. Liao Y, Bang D, Cosgrove S. Surveillance of health status in minority communities - Racial and Ethnic Approaches to Community Health Across the U.S. (REACH U.S.) Risk Factor Survey, United States, 2009 - PubMed. *Morb Mortal Wkly Rep*. 2011;60(6):1–44.
3. Gary TL, Venkat Narayan KM, Gregg EW, et al. Racial/ethnic differences in the healthcare experience (coverage, utilization, and satisfaction) of US adults with diabetes. *Ethn Dis*. 2003;13(1):47–54.
4. Lee DC, Young T, Koziatek CA, et al. Age disparities among patients with type 2 diabetes and associated rates of hospital use and diabetic complications. *Prev Chronic Dis*. 2019;16:E101.

5. Gopalan A, Mishra P, Alexeeff SE, et al. Prevalence and predictors of delayed clinical diagnosis of type 2 diabetes: a longitudinal cohort study. *Diabet Med*. 2018;35(12):1655–62.
6. Capp R, Kelley L, Ellis P, et al. Reasons for frequent emergency department use by Medicaid enrollees: a qualitative study. *Acad Emerg Med*. 2016;23(4):476–81.
7. Malecha PW, Williams JH, Kunzler NM, et al. Material needs of emergency department patients: a systematic review. *Acad Emerg Med*. 2018;25(3):330–59.
8. Kangovi S, Barg FK, Carter T, et al. Understanding why patients of low socioeconomic status prefer hospitals over ambulatory care. *Health Aff (Millwood)*. 2013;32(7):1196–203.
9. Soltani A, Askari S. Exploring spatial autocorrelation of traffic crashes based on severity. *Injury*. 2017;48(3):637–47.
10. Besser LM, Meyer OL, Jones MR, et al. Neighborhood segregation and cognitive change: multi-ethnic study of atherosclerosis. *Alzheimers Dement*. 2023;19(4):1143–51.
11. Vizuete-Jaramillo E, Meza-Figueroa D, Reyes-Castro PA, et al. Using a sensitivity analysis and spatial clustering to determine vulnerability to potentially toxic elements in a semiarid city in Northwest Mexico. *Sustain*. 2022;14(17):10461.
12. Zhang X, Geiss LS, Cheng YJ, et al. The missed patient with diabetes: how access to health care affects the detection of diabetes. *Diabetes Care*. 2008;31(9):1748–53.
13. Feldman AL, Griffin SJ, Fhärm E, et al. Screening for type 2 diabetes: do screen-detected cases fare better? *Diabetologia*. 2017;60(11):2200–9.
14. Umpierrez GE, Isaacs SD, Bazargan N, et al. Hyperglycemia: an independent marker of in-hospital mortality in patients with undiagnosed diabetes. *J Clin Endocrinol Metab*. 2002;87(3):978–82.
15. Danielson KK, Rydzon B, Nicosia M, et al. Prevalence of undiagnosed diabetes identified by a novel electronic medical record diabetes screening program in an urban emergency department in the US. *JAMA Netw Open*. 2023;6(1):e2253275.
16. Menchine MD, Arora S, Camargo CA, et al. Prevalence of undiagnosed and suboptimally controlled diabetes by point-of-care HbA1C in unselected emergency department patients. *Acad Emerg Med*. 2011;18(3):326–9.
17. Charfen MA, Ipp E, Kaji AH, et al. Detection of undiagnosed diabetes and prediabetic states in high-risk emergency department patients. *Acad Emerg Med*. 2009;16(5):394–402.
18. George PM, Valabhji J, Dawood M, et al. Screening for type 2 diabetes in the accident and emergency department. *Diabet Med*. 2005;22(12):1766–9.
19. Anderson ES, Dworkis DA, DeFries T, et al. Nontargeted diabetes screening in a Navajo Nation emergency department. *Am J Public Health*. 2019;109(2):270–2.
20. Lee DC, Jiang Q, Tabaei BP, et al. Using indirect measures to identify geographic hot spots of poor glycemic control: cross-sectional comparisons with an A1C registry. *Diabetes Care*. 2018;41(7):1438–47.

Factors Associated with Overutilization of Computed Tomography of the Cervical Spine

Karl T. Chamberlin, MD
Maureen M. Canellas, MD, MBA
Martin A. Reznek, MD, MBA
Kevin A. Kotkowski, MD, MBA

University of Massachusetts Chan Medical School, Department of Emergency Medicine, Worcester, Massachusetts

Section Editors: David Thompson, MD, and Patrick Maher, MD, MS
Submission history: Submitted September 19, 2022; Revision received June 23, 2023; Accepted July 3, 2023
Electronically published August 28, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.58948

Introduction: Despite the wide availability of clinical decision rules for imaging of the cervical spine after a traumatic injury (eg, NEXUS C-spine rule and Canadian C-spine rule), there is significant overutilization of computed tomography (CT) imaging in patients who are deemed to be at low risk for a clinically significant cervical spine injury by these clinical decision rules. The purpose of this study was to identify the major factors associated with the overuse of CT cervical spine imaging using a logistic regression model.

Methods: This was a retrospective review of all adult patients who underwent CT cervical spine imaging for evaluation of a traumatic injury at a tertiary academic emergency department (ED) and three affiliate community EDs in January and February 2019. We performed multivariable logistic regression to identify factors associated with obtaining CT cervical spine imaging despite low-risk classification by the NEXUS C-spine Rule.

Results: A total of 1,051 patients underwent CT cervical spine imaging for traumatic indications during the study period, and 889 patients were included in the analysis. Of these patients, 376 (42.3%) were negative by the NEXUS C-spine rule. Variables that were associated with increased likelihood of unnecessary imaging included age over 65, Emergency Severity Index (ESI) score 2 and 3, arrival as a walk-in, and anticoagulation status. Patients who presented to the tertiary academic ED had a significantly lower likelihood of unnecessary imaging. Twenty-one patients (2.4%) were found to have cervical spine fractures on imaging, two of whom were negative by the NEXUS C-spine rule, but neither had a clinically significant fracture.

Conclusion: Cervical spine imaging is vastly overused in patients presenting to the ED with traumatic injuries, as adjudicated using the NEXUS C-spine rule as a reference standard. Older age, ESI level, arrival as a walk-in, and taking anticoagulation drugs were associated with overutilization of CT imaging. Conversely, presenting to the tertiary academic ED was associated with a lower likelihood of undergoing unnecessary imaging. This model can guide future interventions to optimize ED CT utilization and minimize unnecessary testing. [West J Emerg Med. 2023;24(5)967–973.]

INTRODUCTION

Evaluation of potential cervical spine injury is a common reason for presentation to the emergency department (ED). Annually, more than 2.5 million patients in the United States seek care at an ED for evaluation of a potential injury to the cervical spine.[1] It has been previously estimated that 3–10% of these patients may have clinically significant cervical spine injuries.[2–5] In recent decades, the volume of radiographic imaging performed in EDs has increased exponentially, particularly computed tomography (CT).[6,7] This dramatic

increase in imaging studies presents numerous potential negative implications, including increased healthcare costs, risks of radiation, longer lengths of stay, more incidental findings, and inefficiencies in ED throughput.[8–10] Therefore, it is a valuable objective to moderate the use of imaging in the ED to avoid unnecessary imaging.

Clinical decision rules have gained traction in emergency medicine to assist with decision-making, and several clinical decision rules have been well-studied and validated to determine the need for imaging of the cervical spine after a traumatic injury. The most used decision rules are the NEXUS C-spine rule and the Canadian C-spine rule.[11,12] The NEXUS C-spine rule establishes criteria that can be used to risk-stratify patients and thereby identify patients who are at low risk for a clinically significant cervical spine injury and for whom cervical spine imaging is thus unnecessary.

Although these clinical decision rules are widely available, utilization of these rules is variable. Prior literature has demonstrated that approximately 25% of CT C-spine studies were performed on patients who did not meet NEXUS criteria for imaging.[13–16] To date it is not well understood why the high rate of CT C-spine overutilization persists despite validated decision rules having been in place and broadly communicated for the last two decades. Understanding factors contributing to the overuse of CT C-spine may inform targeted strategies to increase decision-rule adherence and thereby reduce unnecessary imaging studies. Our objective in this study was to identify the major factors associated with the overutilization of CT cervical spine imaging, as adjudicated by the NEXUS C-spine rule as a reference standard, using a logistic regression model.

Population Health Research Capsule

What do we already know about this issue?
CT of the cervical spine is frequently performed on patients who are low risk for a clinically significant injury by well-validated criteria like the NEXUS C-spine rule.

What was the research question?
We sought to identify factors that are associated with overutilization of CT cervical spine.

What was the major finding of the study?
Variables associated with overuse include age > 65, lower Emergency Severity Index score, arrival not by EMS, anticoagulation, and non-university academic site.

How does this improve population health?
These variables may guide future interventions to reduce overuse of CT cervical spine, resulting in improved ED efficiency, reduction in radiation exposure, and lower healthcare costs.

METHODS

This was a multicenter, retrospective review of all adult patients who underwent CT cervical spine imaging for evaluation of blunt traumatic spinal injury. We obtained data on patients who presented to an urban, tertiary academic ED (approximately 77,000 annual patient encounters) and three affiliate community EDs (ranging from approximately 13,000–43,000 annual patient encounters) in January and February 2019. Exclusion criteria included patients <18 years of age, and CT indications that were nontraumatic, penetrating trauma, or unspecified. This study was granted an institutional review board exemption.

We extracted data from the electronic health record on all patients who underwent CT of the cervical spine in the ED during the pre-specified period. In addition to the demographic data obtained, each chart was manually reviewed by a single reviewer for the presence of each of the five NEXUS criteria: focal neurological deficit; midline cervical spine tenderness; distracting injury; intoxication; or altered mental status. During initial chart review, we also collected data on the Canadian criteria. However, there was inadequate data to proceed with analysis of the Canadian C-spine rule because of insufficient clinical documentation of low-risk factors and range of motion of the neck. Due to the demands of chart review and the number of cases, we selected a two-month study period for feasibility.

We defined the NEXUS criteria as follows: 1) focal neurological deficit—any acute abnormality of the motor or sensory exam that was not attributed to pain; 2) midline tenderness—bony or midline tenderness of the neck or cervical spine; 3) distracting injuries—fractures of the humerus, radius, ulna, femur, tibia, fibula, or sternum, multiple rib fractures, or any other injury that was documented as "distracting"; 4) intoxication—clinical signs of intoxication on exam, history of recent alcohol intake, or a detectable serum ethanol level; and 5) altered mental status—Glasgow Coma Score between 3–14 as documented by the physician or nurse, or documentation that the patient was disoriented, confused, nonverbal, or unresponsive. Each of these criteria has high clinical relevance that warrants documentation in the health record; therefore, NEXUS criteria that were not documented were presumed to be absent. Patients who were negative for all five criteria were deemed at low risk for a clinically significant cervical spine injury by NEXUS criteria. We classified the CT cervical spine studies as "overutilization" if

they were ordered on patients who were at low risk by NEXUS criteria.

We performed multivariable logistic regression to identify factors associated with obtaining CT cervical spine imaging despite low-risk classification by the NEXUS C-spine rule. The following variables were included in the regression analysis: age; gender, mechanism of injury; ED site; Emergency Severity Index (ESI) score; arrival time of day; arrival day of week; means of arrival; anticoagulation status; concurrent head CT; trauma activation level (ie, 1, 2, 3, or none); physician level of training (ie, resident or attending); and ordering attending. There were no missing or imputed values. Trauma activation level, ESI 1, physician level of training, and ordering attending were removed due to significant multicollinearity (over 70%) with ED site. Variable statistical significance was denoted by a *P*-value of less than 0.05. We performed all analyses using R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

During the two-month study period, 1,051 CTs of the cervical spine were performed across all sites, and 889 met the inclusion criteria. Baseline characteristics of the study population are shown in Table 1. Of the scans that met inclusion criteria, 376 (42.3%) did not meet any of the NEXUS criteria. Notably, of the 376 CTs that were performed on NEXUS-negative patients, 373 (99.2%) were negative for any acute fracture. Two images were positive for clinically insignificant transverse process fractures that did not require intervention. One was nondiagnostic due to motion artifact, and this patient did not subsequently require further imaging, intervention, or management. None of the patients in the NEXUS-negative group were identified to have a clinically significant cervical spine fracture. In the NEXUS-positive group, 19/513 CTs (3.7%) were positive for fracture, and five were indeterminate for fracture. All five patients with indeterminate initial imaging underwent follow-up imaging with MRI or repeat CT. Four had no injury on follow-up imaging, and one was found to have a clinically significant fracture. These results are shown in Figure 1.

Table 1. Population baseline characteristics for adult patients who presented to four emergency departments for evaluation of potential cervical spine traumatic injury.

Variable	n	%
Age		
18–44	175	19.7
45–64	207	23.3
65–84	300	33.7
≥85	207	23.3
Gender		
Male	438	49.3
Female	451	50.7
Mechanism of injury		
Fall	660	74.2
MVC	154	17.3
Assault	20	2.2
Seizure	17	1.9
Pedestrian struck	10	1.1
Other	28	3.1
Site of arrival		
Academic ED	585	65.8
Community ED #1	95	10.7
Community ED #2	172	19.3
Community ED #3	36	4.0
Emergency Severity Index score		
1	52	5.8
2	294	22.1
3	431	48.5
4	105	11.8
5	1	0.1
Trauma activation level		
1	24	2.7
2	169	19.0
3	17	1.9
None	679	76.4
Means of arrival		
Emergency medical services	728	81.9
Walk-in	161	18.1
Anticoagulation		
Yes	135	15.2
No	748	84.1
Concurrent CT head		
Yes	775	87.2
No	114	12.8
Role of ordering clinician		
Resident	480	54.0
Attending	404	45.4
Advanced practice practitioner	4	0.4

MVC, motor vehicle collision; *ED,* emergency department; *CT*, computed tomography.

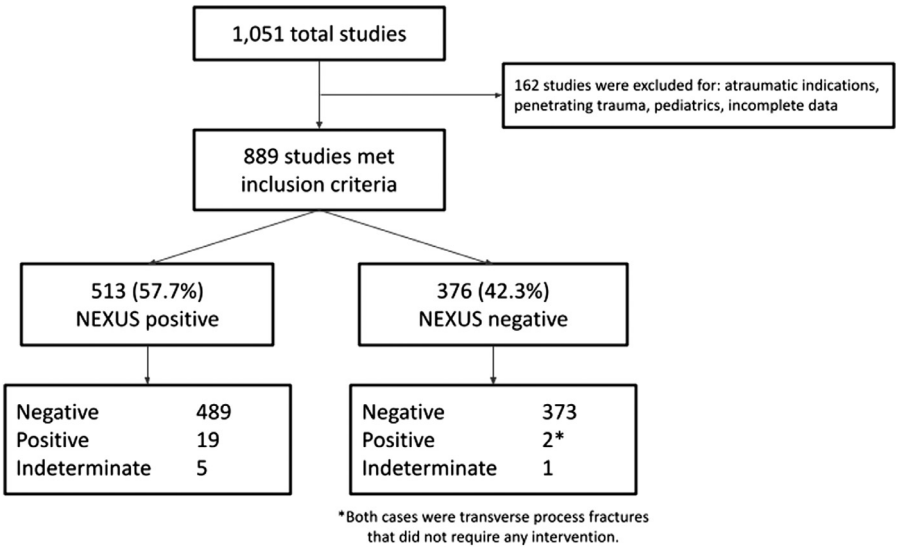


Figure 1. Of the 1,051 computed tomography C-spine studies performed in the study period, 889 met inclusion criteria. Forty-two percent of the studies were performed on NEXUS-negative patients, and none of the NEXUS-negative patients were found to have a clinically significant cervical spine injury.

The regression analysis output is shown in Table 2. Variables associated with increased likelihood of unnecessary imaging include age 65–84 ($P < 0.001$); age ≥85 years ($P < 0.001$); arrival by walk-in ($P < 0.001$); ESI 2 ($P < 0.01$); ESI 3 ($P < 0.001$); and anticoagulation use ($P < 0.05$). Patients who presented to the tertiary academic ED had a significantly lower likelihood of unnecessary imaging ($P < 0.01$).

DISCUSSION

Our investigation identified multiple factors associated with overutilization of CT C-spine imaging. In addition, our study confirmed prior reports related to C-spine evaluation, redemonstrating the sensitivity of the NEXUS C-spine rule and the significant overutilization of cervical spine imaging. This study expands the very limited published literature on CT overutilization in the ED setting. It is the first multicenter investigation to evaluate CT C-spine overutilization and the first to study the topic in community EDs. These novel findings have potential implications for future efforts to reduce unnecessary CT imaging of the cervical spine.

The outcomes for NEXUS-negative patients in this study align with prior data validating the sensitivity of the NEXUS C-spine rule for identifying cervical spine fractures. None of the patients in the NEXUS-negative cohort were found to have a clinically significant cervical spine injury. Despite this sensitivity within our own patient population, nearly half of all cervical spine CTs were ordered despite the patient's status as NEXUS negative.

Our regression analysis demonstrated that patient age was strongly associated with overutilization, with geriatric patients more likely to undergo CT imaging despite being NEXUS-negative. There are several factors that may be driving this association. Some physicians may be influenced in their practice by the Canadian C-spine rule, which recommends imaging for patients >65 years in age. Some

Table 2. The output of the logistic regression analysis shows that the variables significantly associated with overutilization of computed tomography C-spine include ED site, age, means of arrival, ESI score, and anticoagulation status.

Variable	Odds ratio	*P*-value	CI 2.5%	CI 97.5%
Academic ED	0.56	<0.05	0.39	0.79
Age 65–84	3.40	<0.001	1.93	6.09
Age 85+	3.63	<0.001	1.98	6.78
Walk-in arrival	2.61	<0.001	1.69	4.06
ESI 2	4.08	<0.01	1.70	11.46
ESI 3	5.35	<0.001	2.23	15.09
On anticoagulation	1.55	<0.05	1.01	2.40

ED, emergency department; *ESI*, Emergency Severity Index; *CI*, confidence interval.

clinicians may also be less judicious with imaging in geriatric patients, particularly because of a perceived higher likelihood of injury and lower long-term risk of radiation among older adults. Nonetheless, our results reinforce that age should not influence CT decision-making; none of the NEXUS-negative patients in our study population, including the patients who were over 65, were found to have a clinically significant fracture. Future efforts to reduce CT overutilization should emphasize that although radiation may be less of a concern in the elderly population, we did not find any additional risk based on age alone, and there are other significant negative ramifications of overutilization including cost, ED throughput, and incidental findings.

In contrast to age, concurrent CT head was surprisingly not associated with overutilization of CT C-spine. We hypothesize that some physicians may order a CT of the cervical spine on a NEXUS-negative patient if the patient is already going to be undergoing a CT head, and the clinician may not perceive much additional risk to ordering a concurrent CT C-spine. However, in this population, this variable was not significant, likely due to collinearity (though under the 70% threshold) between ordering of CT head and CT C-spine. The vast majority of the patients in this study underwent a concurrent CT head, and there was not a statistically significant difference between the NEXUS-positive and NEXUS-negative cohorts.

Means of arrival was also noted to be a significant variable in this model, with an increased likelihood of overutilization in patients who arrived as walk-ins. This is likely related to patient self-sorting of arrival modality. We hypothesized that patients who walk into the ED are categorically less likely to have a significant injury. Furthermore, walk-in patients are less likely to meet certain NEXUS criteria, such as having a distracting injury or a neurological deficit, which typically warrant EMS transport. Thus, it is likely that fewer CTs are ordered on walk-in patients, which may be driving this phenomenon, although a definitive explanation remains unclear.

Patients who were on anticoagulants were more likely to receive unnecessary CT imaging of the cervical spine. Our study was not designed to explore the underlying drivers of this behavior or to infer causality. It is possible that patients on anticoagulation were more likely to undergo CT head, even with relatively minor mechanisms of injury, and clinicians reflexively ordered a concurrent CT C-spine, as it has been established that a common practice pattern in our study population involves concurrent ordering of CT head and CT C-spine. However, further research would be needed to explore this hypothesis.

Additionally, ESI scores of 2 and 3 were also associated with overutilization. This finding was of unclear significance, but it may offer potential targets for future interventions to reduce CT overutilization. The ED site of presentation was significantly associated with overutilization in this study. At the academic tertiary care ED, there was significantly less overutilization compared to the community EDs. It is hypothesized that academic faculty and residents may be more likely to follow evidence-based guidelines than physicians practicing at community sites; however, there is notably significant overlap in the clinicians who practice at each of the sites in this study. This could also be a result of patient self-selection similar to mode of arrival discussed above. Further investigation is warranted with regard to our observations of overutilization in the academic center vs community sites because if this is a generalized phenomenon, it may better inform strategies to reduce CT overutilization on a national level. Furthermore, to date, findings related to resource utilization on teaching vs non-teaching settings have shown either equivalence or overuse in the academic setting.[17–20] Our results appear to refute this trend, at least for CT C-spine utilization, for reasons that remain unclear.

The associations identified in this study can be used to inform strategies to improve dissemination and adoption of the NEXUS C-spine rule and, thus, reduce unnecessary CT imaging. A reduction in overutilization of CT imaging may reduce healthcare costs, minimize unnecessary radiation to patients, and improve ED throughput. At a minimum, emphasis on clinician education regarding sensitivity of NEXUS in elderly patients may be needed. It may also be prudent to focus educational strategies at community practice sites, which demonstrated higher rates of overutilization in our study. Additionally, this information could be used in audit and feedback strategies to include not just utilization rates but age ranges and rates of identifying significant injuries.

LIMITATIONS

Foremost, our investigation was not designed to determine causality but rather only association. Therefore, while many of the variables used in this regression were correlated with overutilization of CT imaging, we were unable to prove a causative relationship for these factors. Furthermore, while our investigation did include four EDs that differed in size and patient populations, they were staffed by members of a single academic department of emergency medicine, limiting generalizability.

This study was also limited by the documentation that was available upon chart review. It is possible that NEXUS criteria could have been present but were not documented by the clinician, causing the rate of overutilization to be overestimated. However, given the clinical importance of each of the NEXUS criteria in the evaluation of patients with potential cervical spine injury, it is likely that positive criteria would have been included in the clinician's documentation. In addition to reviewing clinician documentation, chart reviewers also reviewed lab studies, imaging, and nursing notes to identify any information regarding the NEXUS criteria.

To support feasibility, our study was limited to a two-month period. These occurred during winter months, and some of the patients had season-specific mechanisms of injury. For example, mechanisms of injury included skiing/snowboarding accidents and snowmobile collisions. Although none of the mechanisms of injury in this study were significantly associated with overutilization of CT imaging, there may be significant mechanisms of injury with seasonal variation that were not identified in this population due to the timing of the study.

Overall, the rate of overutilization at the sites in this study was higher than the rates identified previously in the literature. In this cohort, nearly one-half of the patients who underwent CT of the cervical spine were negative by NEXUS criteria. Although this is higher than previously reported rates, it should be noted that there is very limited published data on this topic, and prior research has been limited to academic medical centers.[12–14] It is unclear whether or how this may have affected our observed results.

Lastly, there may be significant variability in individual physician practice patterns, which may be a factor associated with overutilization of CT imaging. However, due to the limited number of studies that were ordered by each physician during the study period, we were unable to assess the association between individual physician practice patterns and overutilization. Future investigation with a larger study population would be needed to answer this question.

CONCLUSION

Computed tomography C-spine imaging continues to be overutilized in the ED setting. Factors that were associated with overuse of CT imaging include >65 years old, ESI scores 2 and 3, arrival by walk-in, anticoagulation, and presenting to a community ED. These findings may assist in guiding future interventions to optimize resource utilization and promote safer and more efficient emergency care.

Address for Correspondence: Karl T. Chamberlin, MD, University of Massachusetts Chan Medical School, Department of Emergency Medicine, 55 Lake Avenue North, Worcester, Massachusetts 01615. Email: karl.chamberlin@umassmemorial.org

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.

REFERENCES

1. Cairns C, Kang K. *National Hospital Ambulatory Medical Care Survey: 2019 Emergency Department Summary Tables*. Hyattsville, Maryland: National Center for Health Statistics; 2022.
2. Inaba K, Byerly S, Bush LD, et al. Cervical spinal clearance: a prospective Western Trauma Association multi-institutional trial. *J Trauma Acute Care Surg*. 2016;81(6):1122–30.
3. Hasler RM, Exadaktylos AK, Bouamra O, et al. Epidemiology and predictors of cervical spine injury in adult major trauma patients: a multicenter cohort study. *J Trauma Acute Care Surg*. 2012;72(4):975–81.
4. Milby AH, Halpern CH, Guo W, et al. Prevalence of cervical spinal injury in trauma. *Neurosurg Focus*. 2008;25(5):E10.
5. Young AJ, Wolfe L, Tinkoff G, et al. Assessing incidence and risk factors of cervical spine injury in blunt trauma patients using the National Trauma Data Bank. *Am Surg*. 2015;81(9):879–83.
6. Larson DB, Johnson LW, Schnell BM, et al. National trends in CT use in the emergency department: 1995–2007. *Radiology*. 2011;258(1):164–73.
7. Berdahl CT, Vermeulen MJ, Larson DB, et al. Emergency department computed tomography utilization in the United States and Canada. *Ann Emerg Med*. 2013;62(5):486–94.e3.
8. Mills AM, Raja AS, Marin JR. Optimizing diagnostic imaging in the emergency department. *Acad Emerg Med*. 2015;22(5):625–31.
9. Bellolio MF, Heien HC, Sangaralingham LR, et al. Increased computed tomography utilization in the emergency department and its association with hospital admission. *West J Emerg Med*. 2017;18(5):835–45.
10. Evans CS, Arthur R, Kane M, et al. Incidental radiology findings on computed tomography studies in emergency department patients: a systematic review and meta-analysis. *Ann Emerg Med*. 2022;80(3):243–56.
11. Hoffman JR, Mower WR, Wolfson AB, et al. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. National Emergency X-Radiography Utilization Study Group. *N Engl J Med*. 2000;343(2):94–9.
12. Stiell IG, Clement CM, McKnight RD, et al. The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. *N Engl J Med*. 2003;349(26):2510–8.
13. Griffith B, Bolton C, Goyal N, et al. Screening cervical spine CT in a level I trauma center: overutilization?. *AJR Am J Roentgenol*. 2011;197(2):463–7.
14. Griffith B, Kelly M, Vallee P, et al. Screening cervical spine CT in the emergency department, phase 2: a prospective assessment of use. *AJNR Am J Neuroradiol*. 2013;34(4):899–903.
15. Griffith B, Vallee P, Krupp S, et al. Screening cervical spine CT in the emergency department, phase 3: increasing effectiveness of imaging. *J Am Coll Radiol*. 2014;11(2):139–44.
16. Uriell ML, Allen JW, Lovasik BP, et al. Yield of computed tomography of the cervical spine in cases of simple assault. *Injury*. 2017;48(1):133–6.

17. Reznek MA, Michael SS, Harbertson CA, et al. Clinical operations of academic versus non-academic emergency departments: a descriptive comparison of two large emergency department operations surveys. *BMC Emerg Med*. 2019;19(1):72.
18. Salazar A, Corbella X, Onaga H, et al. Impact of a resident strike on emergency department quality indicators at an urban teaching hospital. *Acad Emerg Med*. 2001;8(8):804–8.
19. French D, Zwemer FL Jr, Schneider S. The effects of the absence of emergency medicine residents in an academic emergency department. *Acad Emerg Med*. 2002;9(11):1205–10.
20. Khaliq AA, Huang CY, Ganti AK, et al. Comparison of resource utilization and clinical outcomes between teaching and nonteaching medical services. *J Hosp Med*. 2007;2(3):150–7.

Sexual Assault Nurse Examiners Lead to Improved Uptake of Services: A Cross-Sectional Study

Meredith Hollender, MPP*
Ellen Almirol, MPH, MAMS†
Makenna Meyer, BS†
Heather Bearden, RN, SANE-A‡
Kimberly A. Stanford, MD, MPH†‡

*University of Chicago, Pritzker School of Medicine, Chicago, Illinois
†Chicago Center for HIV Elimination, Chicago, Illinois
‡University of Chicago, Section of Emergency Medicine, Chicago, Illinois

Section Editor: Tehreem Rehman, MD, MPH
Submission history: Submitted November 29, 2022; Revision received April 13, 2023; Accepted May 24, 2023
Electronically published August 11, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59514

Introduction: Sexual Assault Nurse Examiners (SANE), who are trained to provide comprehensive and compassionate specialty care to sexual assault survivors, are increasingly used in the emergency department (ED), but there is little published literature to support their benefit. In this study we aimed to compare services offered and received by sexual assault survivors in the ED when care was provided by a SANE vs those with traditional care teams, hypothesizing that SANE utilization will be associated with improved uptake of recommended services.

Methods: This was a retrospective review examining all patient encounters in which a sexual assault was disclosed in a large, urban, adult ED between June 1, 2019–June 30, 2022. We extracted timeline information from the ED encounter, demographic information, resources offered to and accepted by the patient, clinical care data, and continuity of care data from the medical record. We used unadjusted and adjusted analyses to compare patient demographics and services offered and accepted between SANE and non-SANE encounters.

Results: We included a total of 182 encounters in the analysis, of which 130 (71.4%) involved SANEs. Demographics were similar between groups, except there was a larger proportion of cisgender men in the non-SANE group (14.0% vs 5.5%), and the timing of visits differed, with non-SANE visits more common during the overnight shift. All recommended testing, prophylaxis, and resources were offered more frequently during SANE visits, and all but one were more frequently accepted by patients during SANE visits, although not all comparisons reached statistical significance.

Conclusion: Patients who received care from a SANE were more often offered recommended services and resources and more frequently accepted them. Making SANE care available at all times to these vulnerable patients would both improve patient outcomes and allow hospitals to meet required quality metrics. States should consider expanding legislation to encourage and fund SANE coverage for all hospitals to support access to vital resources in the ED for survivors of sexual assault. [West J Emerg Med. 2023;24(5)974–982.]

INTRODUCTION

Sexual assault (SA) is a major public health issue that affects people of all socioeconomic and cultural backgrounds. Each year in the United States, more than 100,000 survivors of SA seek care in the emergency department (ED).[1] Understanding that survivors of SA are a vulnerable group with unique acute and chronic care needs, there have been recent moves toward implementing legislation that will help support comprehensive and compassionate hospital care for survivors, including the

federal Survivors' Bill of Rights Act of 2016, the Illinois Sexual Assault Survivors Emergency Treatment Act (SASETA) amended in 2019, and the No Surprises for Survivors Act, introduced in 2022.[2–4] These laws aim to protect SA survivors from financial ruin after their hospital visit, ensure medical forensic kits are processed in an efficient and timely manner, establish care guidelines and reporting systems for hospitals that treat SA survivors, and promote the provision of comprehensive, trauma-informed care.

The goal of these initiatives is to address inequities in access to care faced by survivors of SA, among whom the most vulnerable members of society—particularly young, socioeconomically disadvantaged women— are disproportionately represented.[5–7] Survivors face many barriers to receiving optimal care, with fewer than one in five US hospitals providing all 10 metrics of what is considered "comprehensive medical care management" for SA survivors in the ED.[6] One proposed mechanism to address this gap is to use specially trained Sexual Assault Nurse Examiners (SANE).

Sexual Assault Nurse Examiner programs were developed in 1976 to augment training, address concerns of physicians about caring for survivors of sexual assault, decrease long ED wait times, and support sensitive and socially competent care.[8] Many emergency physicians and nurses feel unprepared and uncomfortable providing some or all necessary patient care in cases of SA.[9] They may also face significant challenges due to the unique ED environment, including crowding, caring for multiple patients simultaneously, or needing to care for patients who require immediate attention. Earlier studies have shown that when SANEs provide care, they do so in a compassionate, respectful, and safe manner that is associated with feelings of confidence and relief in survivors.[10,11] The SANEs are able to build a unique, trusting relationship with their patients that is focused on providing SA survivors with control and choices surrounding their care decisions.[12]

Sexual Assault Nurse Examiner programs are increasingly common, and there is rising awareness of the importance of specialized SANE training; however, there is still a nationwide shortage of SANEs.[13] Rural areas have few SANEs and are less likely than urban areas to have 24-hour continuous SANE coverage.[14] Even in urban areas, 85.5% of nurses indicate that they are not SANE-trained, yet they have cared for SA survivors in their healthcare institution.[13] While some studies have examined the impact of SANEs on the patient experience, few have evaluated the effects of SANE care on quality metrics in terms of the actual delivery of recommended services and resources.

We conducted this study at a large, urban, tertiary care hospital with a Level I trauma center. Approximately 60–80 adult survivors of SA visit our ED annually. In this ED, a SANE is unavailable in the adult ED approximately 20-30% of the time, mostly overnight. Care for a SA survivor is always provided by a SANE, if available; if not, then care is provided by a physician or non-physician clinician and a registered nurse, which is the standard of care. During a visit for SA, patients are offered a medical forensic examination kit, if appropriate, which can be used as evidence should a case go to trial, testing and prophylaxis for HIV and other sexually transmitted infections (STI), a pregnancy test, and emergency contraception. They should also have the opportunity to speak with police, a SA advocate, and social services, and access other hospital resources as needed, such as behavioral health support or safe housing options, and they are given a packet of post-visit resources before discharge. Both SANEs and registered nurses have access to a checklist of these items that should be completed during the ED visit. This study compared the rate at which these services were offered or accepted between encounters in which care was provided by a SANE vs those with traditional care teams, hypothesizing that SANEs would be more likely to offer services, and that their patients would be more likely to accept them. Increased uptake of recommended services with SANE care would support the adoption and expansion of SANE programs, which would ultimately address disparities in care faced by SA survivors.

Population Health Research Capsule

What do we already know about this issue?
Few studies have examined the impact of Sexual Assault Nurse Examiners (SANE) on the patient experience, or evaluated their effects on delivery of recommended services.

What was the research question?
Were sexual assault survivors more likely to receive recommended healthcare services in the ED if they were cared for by a SANE?

What was the major finding of the study?
Patients cared for by a SANE were more likely to be offered advocate services ($P < 0.05$), medical forensic exam kits ($P < 0.05$), and resource packets ($P < 0.05$).

How does this improve population health?
Sexual assault survivors cared for by a SANE are more likely to receive recommended treatment in the ED, which may have major impacts on long-term outcomes for them.

METHODS

Study Design

This was a retrospective review of all adult patient encounters in which a SA was disclosed (defined as a triage chief complaint or ED diagnosis code for SA) in the ED between June 1, 2019–June 30, 2022. Encounters were included even if the patient left before the visit was considered complete, provided any services had been offered. For patients who were included more than once (i.e., had two instances of SA during the study period), each encounter was considered an independent event, as the details of the assault and the ED encounter were unique. This study was approved by our institutional review board.

Measures

Data extracted from the electronic health record (EHR) included the following: demographics (e.g., age, gender, race/ethnicity); the time the patient was admitted to the ED; days since incident reported; clinical care data (e.g., STI testing and prophylaxis, forensic kit collection, pregnancy testing and provision of emergency contraceptives); and continuity of care data (e.g., linkage to primary care or mental health resources). Encounter time was divided according to shift times in the ED, with 6:30 AM–2:30 PM considered the morning, 2:30 PM–10:30 PM considered the afternoon, and 10:30 PM–6:30 AM considered overnight.

The primary outcomes of this study were the proportions of patients offered and accepting services when cared for by a SANE or non-SANE team. In certain cases, for which a service was not applicable during the ED visit (e.g., already completed elsewhere, too much time passed since the incident, or pregnancy testing for individuals without a uterus), these were removed from the denominator of services offered. If an applicable service was not explicitly documented to have been offered or accepted in the EHR, it was considered not offered or not accepted for the purposes of the analysis. If a service was partially accepted (e.g., prophylaxis for gonorrhea and chlamydia but not hepatitis), the outcome (e.g., STI prophylaxis) was considered accepted in the analysis.

Statistical Analyses

We compared patient demographics and the proportion of patients offered and accepting services to identify differences between SANE and non-SANE evaluated patients, using a *t*-test for continuous variables and chi-square ($\chi 2$) test or the Fisher exact test for categorical variables. We used logistic regression to calculate odds ratios between groups, adjusting for patient arrival time as a potential confounder in the model. Offering the medical forensic kit, accepting the discharge resource packet, and accepting the social work consult were excluded from the logistic regression analysis due to the presence of zero responses. Differences were considered significant at $P \leq 0.05$. We performed all statistical analyses using R version 4.2.1. (R Core Team, R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Participant Characteristics

Over the three-year study period, we identified 182 adult ED encounters for SA, including 177 unique individuals, five of whom presented on two separate occasions for SA. Of all encounters, 130 (71.4%) received care from a SANE, while 52 (28.6%) received the standard of care with a physician/nurse team (Table 1). Cisgender women (90.4%) and non-Hispanic Black individuals (82.7%) represented the majority of encounters, with a mean age of 30 years (range 18–79). Demographics were similar between the two groups; however, the non-SANE group had more cisgender men than the SANE group (14.0% vs 5.5%) and no transgender individuals. The groups differed by time of patient arrival, with a larger proportion of SANE encounters (48.5%) in the afternoon, and the largest proportion of non-SANE encounters (50.0%) during the overnight shift ($P < 0.01$). Both SANE and non-SANE groups presented to the ED within similar time frames after the assault (mean 1.16 days, SD 1.44, non-SANE vs mean 1.28 days, SD 1.72, SANE; $P = 0.65$). Additionally, there was a significant difference in the number of patients who left before treatment was complete (15.4% non-SANE vs 2.3% SANE, $P < 0.01$).

Resources, Medical Care, and Services Offered and Accepted

While not all differences were statistically significant, every type of recommended resource or care studied was offered in a higher proportion of SANE encounters than non-SANE encounters (Table 2). Significant differences observed in services offered between SANE and non-SANE groups included SA advocate (97.7% SANE vs 89.4% non-SANE; odds ratio [OR] 5.04, 95% confidence interval [CI] 1.16-21.99, $P = 0.03$), medical forensic kit (100% vs 93.6%, $P = 0.02$); pregnancy testing (96.2% vs 86.1%; OR 4.11, 95% CI 1.09-15.54, $P = 0.05$); and discharge resource packet (69.0% vs 48.9%; OR 2.33, 95% CI 1.16-4.65, $P = 0.03$). A higher percentage of the SANE group was offered emergency contraception (94.3% vs 82.4%, $P = 0.07$), although not significant. The proportion of encounters offered safe disposition planning (28.7% vs 21.7%) or a social work consult (33.3% vs 27.7%) was markedly low in both groups, although it is unknown whether this was related simply to lack of documentation around these services.

For those services documented to have been applicable and offered, the proportion of recommended resources and care accepted in SANE encounters was also higher for every service category except the discharge resource packet, which was comparable between groups (98.9% SANE vs

Table 1. Demographics of emergency department patient encounters for sexual assault from June 1, 2019–June 30, 2022, by type of care team.

	All encounters (n = 182)		SANE (n = 130)		Non-SANE (n = 52)		*P*-value
	n	(%)	n	(%)	n	(%)	
Age (mean, SD)	30.2	(13.1)	30.1	(13.5)	30.6	(12.3)	0.81
Gender[+]							0.11
Female	160	(90.4%)	117	(92.1%)	43	(86.0%)	
Male	14	(7.9%)	7	(5.5%)	7	(14.0%)	
Transgender/Non-binary	3	(1.7%)	3	(2.4%)	0	(0.0%)	
Race/Ethnicity[+]							0.83
Non-Hispanic White	14	(8.4%)	10	(8.1%)	4	(9.3%)	
Non-Hispanic Black	138	(82.7%)	101	(81.5%)	37	(86.0%)	
Hispanic	9	(5.4%)	8	(6.5%)	1	(2.3%)	
Other	6	(3.6%)	5	(4.0%)	1	(2.3%)	
Patient arrival time[^]							<0.01*
Morning	48	(26.4%)	32	(24.6%)	16	(32.0%)	
Afternoon	73	(40.1%)	63	(48.5%)	10	(18.0%)	
Overnight	61	(33.5%)	35	(26.9%)	26	(50.0%)	
Days since incident (mean, SD)	1.19	1.51	1.16	1.44	1.28	1.72	0.65

SANE, Sexual Assault Nurse Examiner.
*Indicates a *P*-value ≤ 0.05; Fisher tests were conducted due to the small cell counts.
[+]Gender (n = 177) and race/ethnicity (n = 177), given that five individuals had two encounters.
[^]Patient arrival times were categorized into the following: morning 6:30 AM–2:30 PM; afternoon 2:30 PM–10:30 PM; and overnight 10:30 PM–6:30 AM.
Missing values for race/ethnicity (n = 15, 8%) and days since incident (n = 7, 4%).

100.0% non-SANE, $P = 1.00$). A much larger proportion of encounters in the SANE group accepted SA advocate services (78.7% vs 61.9%; OR 2.28, 95% CI 1.07-4.84, $P = 0.05$) and a medical forensic kit (88.4% vs 68.2%; OR 3.55, 95% CI 1.54-8.15, $P < 0.01$). Large differences that did not reach statistical significance were found for several service types, including making a police report (82.4% vs 67.5%), HIV prophylaxis (76.3% vs 64.1%), HIV testing (93.4% vs 85.7%) and STI testing (93.5% vs 86.0%), emergency contraception (66.3% vs 57.1%), and social worker consultation (100% vs 84.6%).

Because SANE encounters occurred more often during the afternoon and non-SANE encounters more often overnight, additional models were created to adjust for the effects of patient arrival time on services offered and accepted (Tables 3 and 4). In the adjusted analysis, SANE encounters were still more likely to offer recommended services such as SA advocates (adjusted [aOR] 5.51, 95% CI 1.26-24.05, $P = 0.03$) and to accept both the advocate services (aOR 2.60, 95% CI 1.22-5.52, $P = 0.02$) and the medical forensic kit (aOR 2.90, 95% CI 1.26-6.66, $P = 0.02$). Of note, after adjusting for arrival time, the higher proportion of SANE encounters completing a police report was significant (aOR 2.63, 95% CI 1.17-5.93, $P = 0.03$). While the non-SANE group had a higher proportion of cisgender men than the SANE group (Table 1), the model was not adjusted for patient gender, as this observed difference did not reach statistical significance.

DISCUSSION

We found that survivors cared for by a SANE were more often offered the recommended care and resources in every category examined, and they accepted this offer more often for all but one category. The SANEs were significantly more likely to offer a pregnancy test and emergency contraception, and survivors cared for by a SANE were significantly more likely both to be offered and to accept SA advocate services and a medical forensic examination kit. While only a few categories reached statistical significance, this is likely due to the small sample size inherent in studying a relatively uncommon event, and the results of this study suggest major potential benefits from SANE care.

Recent data shows a concerning trend in US ED visits for SA, which have increased more than 1,533.0% from 2006 to 2019.[5] Young, low-income women are disproportionately represented among survivors of SA.[5] Survivors may have increased risk for a variety of mental health complications, substance use, and chronic health conditions.[15–17] Providing

Table 2. Bivariate analysis of services offered and accepted by emergency department patients evaluated after sexual assault from June 1, 2019–June 30, 2022, by type of care team.

	SANE (n = 130)		Non-SANE (n = 52)		*P*-value
	n/N	(%)	n/N	(%)	
Testing and prophylaxis					
HIV testing					
Offered[+]	122/128	(95.3%)	42/46	(91.3%)	0.46
Accepted[+]	113/121	(93.4%)	36/42	(85.7%)	0.20
STI testing					
Offered[+]	124/129	(96.1%)	43/47	(91.5%)	0.25
Accepted[+]	115/123	(93.5%)	37/43	(86.0%)	0.20
Pregnancy testing					
Offered[+]	102/106	(96.2%)	31/36	(86.1%)	0.05*
Accepted[+]	94/101	(93.1%)	28/31	(90.3%)	0.70
HIV prophylaxis					
Offered[+]	115/126	(91.3%)	39/44	(88.6%)	0.56
Accepted	87/114	(76.3%)	25/39	(64.1%)	0.20
STI prophylaxis					
Offered[+]	122/129	(94.6%)	41/46	(89.1%)	0.31
Accepted	103/121	(85.1%)	33/41	(80.5%)	0.65
Emergency contraception					
Offered[+]	99/105	(94.3%)	28/34	(82.4%)	0.07
Accepted	65/98	(66.3%)	16/28	(57.1%)	0.50
Services and resources					
Medical forensic kit					
Offered[+]	129/129	(100.0%)	44/47	(93.6%)	0.02*
Accepted	114/129	(88.4%)	30/44	(68.2%)	<0.01*
Sexual assault advocate					
Offered[+]	127/130	(97.7%)	42/47	(89.4%)	0.03*
Accepted	100/127	(78.7%)	26/42	(61.9%)	<0.05*
Police report					
Offered to call[+]	119/125	(95.2%)	40/44	(90.9%)	0.29
Report complete	98/119	(82.4%)	27/40	(67.5%)	0.08
Resource packet					
Offered	89/129	(69.0%)	22/45	(48.9%)	0.03*
Accepted[+]	88/89	(98.9%)	22/22	(100.0%)	1.00
Social worker consult					
Offered	43/129	(33.3%)	13/47	(27.7%)	0.60
Accepted[+]	43/43	(100.0%)	11/13	(84.6%)	0.05
Safe discharge planning					
Offered	37/129	(28.7%)	10/46	(21.7%)	0.47
Accepted[+]	36/37	(97.3%)	9/10	(90.0%)	0.38
Left before treatment complete	3/130	(2.3%)	8/52	(15.4%)	<0.01

SANE, Sexual Assault Nurse Examiner; *STI*, sexually transmitted infections.
*Indicates a *P*-value ≤ 0.05; [+]Fisher tests were performed due to small cell counts.

Table 3. Odds ratios of services offered to emergency department patients evaluated after sexual assault from June 1, 2019–June 30, 2022, by type of care team.

	Unadjusted odds ratio	95% Confidence interval	*P*-value	Adjusted odds ratio	95% Confidence interval	*P*-value
Testing and prophylaxis						
HIV testing	2.35	(0.77, 7.24)	0.13	1.93	(0.63, 5.95)	0.27
STI testing	2.33	(0.76, 7.16)	0.14	2.40	(0.78, 7.36)	0.15
Pregnancy testing	1.44	(1.00, 16.96)	0.62	1.41	(0.87, 14.79)	0.64
HIV prophylaxis	1.80	(0.82, 3.95)	0.14	1.87	(0.86, 4.10)	0.14
STI prophylaxis	1.39	(0.55, 3.48)	0.49	2.11	(0.48, 3.04)	0.70
Emergency contraception	1.43	(0.61, 3.38)	0.41	1.61	(0.68, 3.80)	0.29
Services and resources						
Medical forensic kit	3.55	(1.54, 8.15)	<0.01*	2.90	(1.26, 6.66)	0.02*
Sexual assault advocate	2.28	(1.07, 4.84)	0.03*	2.60	(1.22, 5.52)	0.02*
Police report	2.25	(1.00, 5.06)	0.05	2.63	(1.17, 5.93)	0.03*
Resource packet		N/A			N/A	
Social worker consult		N/A			N/A	
Safe discharge planning	4.00	(0.23, 70.30)	0.34	3.64	(0.21, 63.91)	0.40

STI, sexually transmitted infections.
*Indicates a *P*-value ≤ 0.05; reference group = non-Sexual Assault Nurse Examiners. Analyses are adjusted for patient arrival time. Odds ratio analysis could not be calculated for N/A entries due to 0 responses in a single group.

Table 4. Odds ratios of services accepted by emergency department patients evaluated after sexual assault from June 1, 2019, through June 30, 2022, by type of care team.

	Unadjusted odds ratio	95% Confidence interval	*P*-value	Adjusted odds ratio	95% Confidence interval	*P*-value
Testing and prophylaxis						
HIV testing	1.94	(0.52, 720)	0.32	2.04	(0.55, 7.58)	0.32
STI testing	2.31	(0.59, 8.99)	0.23	2.04	(0.52, 7.94)	0.33
Pregnancy testing	4.11	(1.09, 15.54)	0.04*	3.59	(0.95, 13.55)	0.08
HIV prophylaxis	1.34	(0.44, 4.10)	0.61	1.07	(0.35, 3.26)	0.92
STI prophylaxis	2.13	(0.64, 7.06)	0.22	1.59	(0.48, 5.29)	0.47
Emergency contraception	3.54	(1.05, 11.78)	0.04*	3.00	(0.90, 9.97)	0.08
Services and resources						
Medical forensic kit		N/A			N/A	
Sexual assault advocate	5.04	(1.16, 21.99)	0.03*	5.51	(1.26, 24.05)	0.03*
Police report	1.98	(0.53, 7.39)	0.31	1.87	(0.50, 6.96)	0.37
Resource packet	2.33	(1.16, 4.65)	0.02*	1.96	(0.98, 3.93)	0.07
Social worker consult	1.21	(0.58, 2.54)	0.59	1.05	(0.50, 2.19)	0.91
Safe discharge planning	1.45	(0.65, 3.23)	0.36	1.34	(0.60, 2.98)	0.49

STI, sexually transmitted infections.
*Indicates a *P*-value ≤ 0.05; Reference group = non-Sexual Assault Nurse Examiners. Analyses are adjusted for patient arrival time. Odds ratio analysis could not be calculated for N/A entries due to 0 responses in a single group.

comprehensive and trauma-informed care to survivors of SA in the ED is vital to the long-term outcomes for these vulnerable patients. However, time constraints, crowding, lack of awareness or training in trauma-informed care, and many other challenges of the ED environment can present major obstacles.

Recent federal and state laws have been passed or proposed to try to address this problem, requiring certain standards for all visits for SA. For example, the Illinois SASETA act created universal care and reporting guidelines and requires EDs to have continuous coverage by a SANE or a clinician with equivalent training.[4] Guidelines from the American College of Emergency Physicians on management of patients presenting after SA emphasize the importance of "specially trained, non-physician medical personnel," which may include SANEs, and "access to appropriate medical, technical, and psychological support" for patients.[18] In addition, with the recent increasing popularity of the value-based reimbursement model, there will be financial incentives for hospitals to provide services to SA survivors beyond basic medical care.[19] Similarly, there may be financial penalties or legal ramifications for hospitals that do not meet these quality metrics in states that have implemented laws like SASETA.

The SANE programs have been proposed to fill these gaps, using dedicated care personnel with specialized training in caring for survivors of SA. These programs have been shown to reduce patient wait times, increase quality of examination and evidence collection, and provide overall comprehensive and compassionate care in a timely manner.[20] Despite growing evidence and guidelines supporting SANE services, SANE utilization and availability are highly variable. One study found that 35.5% of hospitals had no access to SANE services at all.[13] Hiring and retaining a specially trained group of nurses to be available at all times, if needed, is expensive and challenging. For hospitals without the means to expand SANE coverage, community efforts have laid the groundwork for telehealth SANE coverage in rural areas.[21]

While there is a growing body of evidence demonstrating the benefits of SANE care, thus far little has been published on the effect of SANE care on quality metrics, which are important both for individual patient outcomes and regulatory and financial reasons. Evidence of an association between SANE care and improved service delivery could encourage expanded support for the development and adoption of SANE programs. Prior studies suggest that specialized training may help nurses approach patients about receiving medical services for a SA in a manner that encourages engagement in care.[11,22] When care is provided by a SANE, patients report positive psychological outcomes, such as feelings of empowerment and compassion.[11,22]

One study found that SANEs go beyond "collecting evidence," and that "the manner in which it was being done" made a positive impact on patients.[10] Patients interviewed in that study found that SANEs provided a "clear and thorough explanation of the exam process and findings."[10] In the present study, more survivors completed treatment in the ED when care was provided by a SANE. This may reflect the additional training in trauma-informed care or the lack of concurrent clinical duties during SANE care, both of which may lead patients to engage more in their care. Additionally, when services were offered to survivors, they were accepted at much higher rates when offered by a SANE. This likely reflects the way in which the resource was presented or described to the survivor, which certainly could be affected by training and awareness.

Involvement of SANES in care is associated with more medical services provided, more forensic kits collected, and more police reports filed.[23] The same trend was identified for SANE care in cases of pediatric SA.[24] In the current study, after adjusting for patient arrival time, police reports were completed during SANE encounters at a significantly higher rate. The police reporting options for patients are complex, there can be significant delays waiting for police to arrive to file a report, and non-SANE nurses may not be familiar with all the options, which may lead to missed opportunities to file a police report.

Non-SANE nurses caring for SA survivors have a checklist of services to offer and, therefore, theoretically should offer these services at the same rate. However, SANEs receive substantial additional training that may afford them a better understanding of the importance of these resources and the skills to discuss them sensitively with a traumatized patient. A SANE-trained nurse may have a more positive attitude toward SA survivors in general.[13] They may also have more time to talk with the patients, as they are not responsible for any other patient care duties at the same time; or the higher resource acceptance rates among SANE patients may simply reflect the fact that SANE nurses have self-selected for additional training due to an interest in helping SA survivors, which may allow them to provide more sensitive care. Regardless of the reason, given mounting evidence to support the benefits of SANE care to patient and quality outcomes, SANE programs should be expanded and supported whenever possible.

LIMITATIONS

The major limitation of this study was the reliance on retrospective, routine care data collected from the EHR. It is possible that some services or resources were offered and/or accepted by patients and simply not documented, and it is unknown whether one group was more likely to document than the other. Any service not documented was considered to not have been offered or received for the purposes of the analysis, which may have affected the outcomes if a large proportion of those services not documented were either not applicable or were actually provided. Additionally, there were five individuals who presented for SA twice during the study period. Each encounter was analyzed independently, but it is possible that the first ED experience impacted their choices during the second encounter. However, given that these individuals represented such a small proportion of the sample, it is unlikely that their inclusion significantly affected

the results of the study. Due to the small sample size, the effects of survivor gender could not be fully explored, as gender differences between groups were not statistically significant. It is possible that the larger proportion of cisgender men in the non-SANE cohort affected outcomes, or that their gender affected either the likelihood of SANE care or their likelihood of accepting services, as men may be less trusting of their care team due to significant stigma.[24,25]

Furthermore, much of the study period included the COVID-19 pandemic, which may have impacted clinical documentation, availability of ED services, or willingness of patients to remain in the ED while waiting for results or referrals, although these should have impacted both SANE and non-SANE groups similarly. Lastly, this was a single-site study. While it is likely that the results are generalizable to other large, urban, adult EDs, further studies are needed to validate these results in other ED settings.

CONCLUSION

This study revealed that sexual assault survivors in the ED who received care from a Sexual Assault Nurse Examiner were more likely to be offered and to accept standard-of-care SA services and resources. This may reflect the increased sensitivity and expanded skillset afforded by SANE training, or the ability of a dedicated SANE to work outside the time, space, and workflow constraints of a busy ED. While arranging for continuous SANE coverage in the ED can be logistically and financially challenging, it may not only benefit patient outcomes but allow hospitals to meet recommended quality metrics, which may be required by governing bodies or even tied to reimbursement in the value-based care model. Legislative support for SANE coverage should be expanded nationally, with parallel increases in funding to help hospitals implement continuous SANE coverage. This will positively impact the quality of care for survivors of SA, who may then be more likely to receive the services and treatment that they need after a traumatic event.

Address for Correspondence: Meredith Hollender, MPP, University of Chicago, Pritzker School of Medicine, 924 E 57th Street, Chicago, IL 60637. Email: mhollender@uchicagomedicine.org

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.

REFERENCES

1. Short NA, Lechner M, McLean BS, et al. Health care utilization by women sexual assault survivors after emergency care: results of a multisite prospective study. *Depress Anxiety*. 2021;38(1):67–78.
2. *Survivors' Bill of Rights Act of 2016*. 114th Congress. Available at: https://www.congress.gov/bill/114th-congress/house-bill/5578. Accessed March 28, 2023.
3. *No Surprises for Survivors Act of 2022*. 117th Congress. Available at: https://www.congress.gov/bill/117th-congress/house-bill/8891/. Accessed March 28, 2023.
4. *Sexual Assault Survivors Emergency Treatment Act (SASETA)*. Illinois General Assembly. Available at: https://www.ilga.gov/legislation/ilcs/ilcs3.asp?ActID=1531&ChapterID=35. Accessed March 28, 2023.
5. Vogt EL, Jiang C, Jenkins Q, et al. Trends in US emergency department use after sexual assault, 2006-2019. *JAMA Netw Open*. 2022;5(10):e2236273–e2236273.
6. Patel A, Panchal H, Piotrowski ZH, et al. Comprehensive medical care for victims of sexual assault: a survey of Illinois hospital emergency departments. *Contraception*. 2008;77(6):426–30.
7. Patel A, Roston A, Tilmon S, et al. Assessing the extent of provision of comprehensive medical care management for female sexual assault patients in US hospital emergency departments. *Int J Gynaecol Obstet*. 2013;123(1):24–8.
8. Ahrens CE, Campbell R, Wasco SM, et al. Sexual Assault Nurse Examiner (SANE) programs: alternative systems for service delivery for sexual assault victims. *J Interpers Violence*. 2000;15(9):921–43.
9. Chandramani A, Dussault N, Parameswaran R, et al. A needs assessment and educational intervention addressing the care of sexual assault patients in the emergency department. *J Forensic Nurs*. 2020;16(2):73–82.
10. Fehler-Cabral G, Campbell R, Patterson D. Adult sexual assault survivors' experiences with Sexual Assault Nurse Examiners (SANEs). *J Interpers Violence*. 2011;26(18):3618–39.
11. Campbell R, Patterson D, Adams AE, et al. A participatory evaluation project to measure SANE nursing practice and adult sexual assault patients' psychological well-being. *J Forensic Nurs*. 2008;4(1):19–28.
12. Poldon S, Duhn L, Camargo Plazas P, et al. Exploring how sexual assault nurse examiners practise trauma-informed care. *J Forensic Nurs*. 2021;17(4):235–43.
13. Nielson M, Strong L, Stewart J. Does sexual assault nurse examiner (SANE) training affect attitudes of emergency department nurses toward sexual assault survivors? *J Forensic Nurs*. 2015;11(3):137–43.
14. Thiede E, Miyamoto S. Rural availability of Sexual Assault Nurse Examiners (SANEs). *J Rural Health*. 2021;37(1):81–91.
15. Dworkin ER, DeCou CR, Fitzpatrick S. Associations between sexual assault and suicidal thoughts and behavior: a meta-analysis. *Psychol Trauma*. 2022;14(7):1208–11.
16. Young-Wolff KC, Sarovar V, Klebaner D, et al. Changes in psychiatric and medical conditions and health care utilization following a diagnosis of sexual assault: a retrospective cohort study. *Med Care*. 2018;56(8):649–57.

17. Santaularia J, Johnson M, Hart L, et al. Relationships between sexual violence and chronic disease: a cross-sectional study. *BMC Public Health*. 2014;14(1):1286.
18. American College of Emergency Physicians. Management of the Patient with the Complaint of Sexual Assault. Available at: https://www.acep.org/patient-care/policy-statements/management-of-the-patient-with-the-complaint-of-sexual-assault/. Accessed March 28, 2023.
19. Crook HL, Zheng J, Bleser WK, et al. How are payment reforms addressing social determinants of health? Policy implications and next steps issue brief. Available at: https://www.milbank.org/wp-content/uploads/2021/02/Duke-SDOH-and-VBP-Issue-Brief_v3.pdf. Accessed March 28, 2023.
20. Littel K. Sexual Assault Nurse Examiner (SANE) programs: improving the community response to sexual assault victims. U.S. Department of Justice, Office of Justice Programs, Office for Victims of Crime. Available at: http://www.vawnet.org/sites/default/files/assets/files/2016-09/OVC_SANE0401-186366.pdf. Accessed March 28, 2023.
21. Miyamoto S, Thiede E, Dorn L, et al. The Sexual Assault Forensic Examination Telehealth (SAFE-T) Center: a comprehensive, nurse-led telehealth model to address disparities in sexual assault care. *J Rural Health*. 2021;37(1):92–102.
22. Campbell R, Patterson D, Lichty L. The effectiveness of sexual assault nurse examiner programs: a review of psychological, medical, legal, and community outcomes. *Trauma Violence Abuse*. 2005;6(4):313–29.
23. Crandall C, Helitzer D. Impact evaluation of a Sexual Assault Nurse Examiner (SANE) program. Available at: https://www.ojp.gov/pdffiles1/nij/grants/203276.pdf. Accessed March 28, 2023.
24. Bechtel K, Ryan E, Gallagher D. Impact of sexual assault nurse examiners on the evaluation of sexual assault in a pediatric emergency department. *Pediatr Emerg Care*. 2008;24(7):442–7.

Exploring Muslim Women's Reproductive Health Needs and Preferences in the Emergency Department

Anum Naseem, MD*
Morgan Majed, MSPH*
Samantha Abdallah, MD*
Maysa Saleh, BSN†
Meghan Lirhoff, MD†
Ahmad Bazzi, MD†
Martina T. Caldwell, MD, MS†

*Wayne State University School of Medicine, Department of Emergency Medicine, Detroit, Michigan
†Henry Ford Hospital Department of Emergency Medicine, Detroit, Michigan

Section Editor: Mark I. Langdorf, MD, MHPE
Submission history: Submitted September 19, 2022; Revision received April 27, 2023; Accepted May 1, 2023
Electronically published August 22, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.58942

Objective: We explored individual Muslim women's reproductive healthcare experiences, preferences, beliefs, and behaviors in the emergency department (ED) and in general.

Methods: This was a qualitative study conducted at a community ED using semi-structured interviews with a piloted interview guide. We interviewed participants awaiting care in the ED with the following criteria: female gender; English or Arabic speaking; aged ≥18 years; and self-identified as Muslim. We conducted interviews in both English and Arabic until thematic saturation was reached. Transcripts were coded using an iteratively developed codebook, maintaining intercoder agreement greater than 80%. We used an inductive thematic analysis to identify themes, and results were interpreted in the context of interview language and patient's age.

Results: We interviewed 26 Muslim-identified female ED patients. We found that cultural representation and sensitivity among ED staff mitigated discrimination and promoted inclusion for Muslim ED patients. However, assumptions about Muslim identity also impacted the participants' healthcare. Most participants endorsed a preference for a female clinician for their reproductive healthcare in general, but not necessarily for other areas of medicine. Clinician cultural concordance was not always preferred for participants in the ED due to fears about the loss of confidentiality. Marital status impacted beliefs about reproductive and sexual health in the context of Muslim identity. Overall, family planning was acceptable and encouraged in this patient population.

Conclusion: The themes elucidated in this study may guide clinicians in developing culturally sensitive practices when providing reproductive healthcare to the Muslim population. [West J Emerg Med. 2023;24(5)983–992.]

INTRODUCTION

Racial and ethnic minorities continue to have inequitable healthcare access and outcomes, from preventive measures to the treatment of acute illness.[1–4] With an increasingly diverse patient population, much focus has been on improving patient-clinician cross-cultural interactions to prevent stereotyping, biases, and lack of trust that impede the delivery of quality care.[2] Models of cultural competence emphasize a patient-centered approach to enhance healthcare delivery to minority groups with cultural and linguistic differences.[5] This is especially important in the emergency department (ED), a safety-net care setting in which clinicians do not typically have established relationships with patients.[6,7]

Health outcomes and cultural preferences of the Muslim population are not well established in the healthcare literature or practice guidelines.[8] An estimated 3.3 million Muslims live in the United States today, making Islam the third most prominent religion in the country.[9] The Muslim population is growing and projected to reach 8.1 million by 2050, largely due to increased immigration.[10] Considering the prevalence of Muslims nationally, it is important that clinicians are well trained in delivering care that is sensitive to the unique perspectives and beliefs of these patients.

Ensuring that clinicians are knowledgeable about Muslim patients' preferences regarding reproductive health is especially important in the ED where patients often present for obstetric or gynecological complaints and there is no established patient-clinician relationship.[11] Although best practices for care of Muslim patients in the ED have been published, there is a lack of literature that is derived from patient preferences that specifically focuses on reproductive healthcare for female Muslims in the ED.[11–14] Moreover, the Muslim population constitutes a very heterogenous population that includes many different ethnic groups, and in which religious identity is often confounded by specific cultural values. Understanding perspectives of individual patients can help elucidate how to best address the diversity of identity within this population.[15] Therefore, we aimed to explore Muslim women's reproductive healthcare experiences, preferences, beliefs, and behaviors in the ED and in general.

Population Health Research Capsule

What do we already know about this issue?
Best practice care models for Muslim patients that have been published to improve cultural competency among clinicians are not derived from patient preferences.

What was the research question?
We aimed to explore Muslim women's reproductive healthcare experiences and preferences in the ED and in general.

What was the major finding of the study?
Most women preferred a female clinician for their reproductive healthcare, but cultural concordance was not always desired due to fears about confidentiality. Family planning was acceptable, and desired in this patient population.

How does this improve population health?
The themes elucidated here may guide clinicians in developing culturally sensitive practices when providing reproductive healthcare to this population.

METHODS

Study Design and Setting

We conducted semi-structured, face-to-face interviews using a piloted interview guide with female Muslim patients of reproductive age presenting to a community ED located in a midwestern suburb with a large Muslim population. The study was approved by the institutional review board at the institution where data collection occurred. To ensure our interview guide was culturally sensitive, we performed cognitive interviews in English while piloting the interview guide.

Two team members (AN and MS) conducted all study activities in English or Arabic according to the participant's preference. AN, a third-year medical student, conducted all of the English interviews, and MS worked as a registered nurse at the study site and conducted all of the Arabic interviews. Both AN and MS are reproductive-aged, cisgender females who identify as Muslim, but neither wear the hijab. AN is South Asian and is familiar with the community through her medical education activities and volunteerism. MS is Lebanese and a life-long member of the local Muslim community. Both were new to qualitative research and were trained by MC, who has extensive training and experience in qualitative methods and community-based participatory research. Note that all Arabic research documents were professionally transcribed and certified by the health system's approved company, as well as reviewed by multiple Arabic-speaking members of the study team.

Selection of Participants

While patients awaited medical treatment in the ED, a study team member screened the electronic health record (EHR) track board for inclusion in this study and approached potentially eligible participants. Participants who met the following criteria were included: 1) female gender per the EHR; 2) age ≥18 years per the EHR; and (3) self-identified as Muslim. Any individual who was identified by the EHR to meet the first two inclusion criteria were approached and asked whether they self-identified as Muslim to avoid profiling. Individuals who met the following criteria were excluded: 1) in physical, mental, or emotional distress, including Emergency Severity Index 1 (the highest acuity); 2) prisoners; 3) cognitively delayed; or 4) could not understand and converse about reproductive health in English or Arabic. Interviews were conducted in the ED patient rooms without the presence of family members in the majority of cases.

Measurements

Participants completed a brief screening questionnaire to obtain demographic information. Written informed consent was obtained from all participants in their preferred language. Participants received a $20 cash compensation for participating in the 30- to 40-minute interviews. Interviews were audio recorded, transcribed, and de-identified by a professional transcription company. Arabic transcripts were subsequently translated into English and verified by MH and AB, who are Arabic-speaking, Muslim resident physicians. Interviewers documented field notes of their observations and experiences for each interview, which were used to contextualize interview data during analysis.

Analysis

Interviews were collected until thematic saturation was reached or when recurring themes were identified in the manuscripts, which was found to be at 26 interviews. No repeat interviews needed to be conducted. The study team developed a codebook using axial and open coding, resolving disagreements using a consensus process. The codebook was iteratively revised throughout coding to include emerging content. Prior to coding, and every five transcripts thereafter, coders performed an intercoder agreement trial and maintained intercoder agreement at or above 80%. Using qualitative data analysis software Dedoose version 7.0.23 (SocioCultural Research Consultants, LLC, Los Angeles, CA), two trained coders (MM, a Muslim graduate student and SA, a Muslim medical student) employed codes from the codebook to the transcribed and de-identified interviews. AN used an inductive thematic process to analyze the text data. Findings were validated by the entire research team, which is comprised of mostly Muslim members and two non-Muslims. Thematic results were converged with demographic data obtained in the questionnaire.

RESULTS

Characteristics of Study Subjects

We interviewed 26 participants, of whom 14 were English-speaking and 12 were Arabic-speaking (Table 1). The majority of participants (16) were of reproductive age, defined as 18–50 years old; 19 were US citizens; 23 had publicly funded health insurance; and 14 identified as having more traditional Islamic religious views. The Arabic-speaking group was older than the English-speaking interviewees (39 vs 33 years old). All the Arabic-speaking participants were born outside the US, and this group had lower educational levels with 41.6% reporting an eighth-grade education or less. The English-speaking population mostly identified as Lebanese (11), whereas the ethnicity most often represented among the Arabic-speaking group was Yemeni (six participants).

Main Results

We grouped themes into two main categories: 1) impact of Muslim identity on reproductive health experiences in general; and 2) impact of Muslim identity on reproductive health preferences, beliefs, and behaviors (Table 2). The supporting quotes are formatted as follows: interview language (E = English, A = Arabic); participant number; and participant age in years (y).

Impact of Muslim Identity on Reproductive Health Experiences in General

I. Cultural representation and cultural sensitivity mitigate experiences of discrimination and promote feelings of inclusion. The most prevalent theme in the interviews addressed discrimination, cultural representation, and cultural sensitivity in healthcare in general. When interviewers asked participants whether they had ever felt discriminated against while receiving reproductive health services because of their religion, the majority of participants denied such experiences in the ED and in healthcare at large. For example, many participants seemed to agree that "I don't see any difference [in receiving reproductive healthcare] whether I wear a hijab or not. They treat us the same way" (A2, 34y). Put more explicitly, "I'm treated the same by every doctor and nurse that I encounter, so I think [discrimination] is not a problem" (E15, 24y).

Many participants alluded to the unique cultural representation in the local community as being a major protective factor against discrimination and bias. One participant said, "coming in [to the ED] and seeing Muslim people . . . it just makes me more comfortable" (E15, 24y). Another participant described how "[in this hospital], since they know there's a lot of Arabs and stuff, and they always have Arab nurses, they can communicate, so here it's better" (E7, 35y) indicating that cultural representation is an important part of building comfort with clinicians. Additionally, some participants also suggested that, "a lot of the American doctors [in this community] . . . know our culture . . . but if you go outside like Florida and stuff . . . I heard that they would treat [Muslims] differently" (E7, 35y).

Notable exceptions to this theme seemed related to language and religious clothing, such as the hijab. One participant stated, "I've heard [a lot of stories of discrimination] and it usually [involved] women who didn't speak English" (E8, 27y). Another participant concurred that "probably because [another Muslim woman] had an accent and [she] couldn't speak English well, [the clinicians] were kind of rude to [her]" (E7, 35y). One participant shared a story of her support of another Muslim woman who wore a hijab, describing, "a little scarf lady . . . she couldn't defend herself, so I had to defend her because [the clinicians were] talking like she's stupid" (E6, 27y). One of the English-speaking participants explained that she had never

Table 1. Participant demographics of English- and Arabic-speaking interviews conducted in the emergency department.*

	English (n = 14)	Arabic (n = 12)	Total (N = 26)
Average age, years	33	39	38
ED visits in the last 12 months, mean	1.6	2.9	2.7
Place of birth (%)			
In the United States	42.8 (6)	0 (0)	23.0 (6)
Outside the United States	57.2 (8)	83.3 (10)	69.2 (18)
Citizenship (%)			
US citizen, by birth	50 (7)	0 (0)	26.9 (7)
US citizen, by naturalization	28.5 (4)	50 (6)	38.4 (10)
US citizen, born abroad by parents who are US citizen	14.2 (2)	0 (0)	7.6 (2)
Not a U.S. citizen	7.1 (1)	41.6 (5)	23 (6)
Health insurance (%)			
Public insurance	92.8 (13)	83.3 (10)	88.4 (23)
Private insurance	7.1 (1)	16.6 (2)	11.5 (3)
Ethnicity (%)			
Iraqi	14.2 (2)	25 (3)	19.2 (5)
Lebanese	78.5 (11)	16.6 (2)	50 (13)
Palestinian	0 (0)	8.3 (1)	3.8 (1)
Yemeni	7.1 (1)	50 (7)	26.9 (8)
Marital status (%)			
Never married	28.6 (4)	8.3 (1)	19.2 (5)
Married	50 (7)	66.7 (8)	57.6 (15)
Divorced	14.3 (2)	8.3 (1)	11.5 (3)
Separated	0 (0)	8.3 (1)	3.8 (1)
Widowed	7.1 (1)	0 (0)	3.8 (1)
Religiosity (%)			
Traditional	64.3 (9)	41.6 (5)	53.8 (14)
Neither traditional nor non-traditional	21.4 (3)	25 (3)	23 (6)
Non-traditional	7.1 (1)	16.6 (2)	11.5 (3)
Highest grade/degree completed (%)			
8th grade or less	7.1 (1)	41.6 (5)	23 (6)
High school graduate/GED	50 (7)	8.3 (1)	30.8 (8)
Some college or associate's degree	28.6 (4)	33.3 (4)	30.8 (8)
Bachelor's degree or higher	14.3 (2)	8.3 (1)	11.5 (3)
Difficulty for you or your household to pay bills in last 12 months, (%)			
Hard	50 (7)	33.3 (4)	42.3 (11)
Neither hard nor easy	35.7 (5)	0 (0)	19.2 (5)
Easy	7.1 (1)	50 (6)	26.9 (7)

ED, emergency department; *GED*, General Educational Development.
*Not all data add up to 100% because of missing data or rounding.

encountered discrimination due to her Muslim religion, "maybe because I don't wear a head scarf, it's different. And I come out speaking English - you wouldn't mistake me for a Muslim." Despite her own experiences, she had heard stories of other Muslims being treated "rude and disrespectful" (E4, 30y).

The Arabic-speaking participants did not share experiences of language bias and had overwhelmingly

Table 2. Supporting quotes from study participants.

Themes	Illustrative quotes
I. Cultural representation and cultural sensitivity mitigate experiences of discrimination and promote feelings of inclusion	• "They're very understanding, especially around here in the community" (E13, 34y). • "I feel like if I were to go out of state or anywhere, everybody would look at me differently, just because I'm a Muslim" (E9, 20y). • "Where we go we see racism so we don't feel comfortable. Everywhere, not only in the hospital. Thank God, I wasn't treated with racism in the hospital. They treat everyone equally" (A1, 29y). • "I have been here for a very long time, [doctors] never differentiate [between a non-Muslim and a Muslim]" (A12, 49y). • "[The doctors] are nice and they have mercy, it doesn't make a difference for them if we are Muslims or not . . . they have more mercy than we do" (A4, 60y). • "I feel that [the doctors] are good . . . they deal in a nice way, they don't discriminate whether you are Sunni, Shia, American or Arab" (A7, 27y). • "We all get treated the same [in the ED]" (E3, 33y). • "When I came [to the ED], they treated me in a very nice way, in gynecology, they respect that I wear a Hijab and they take care of me" (A12, 49y). • "They're very understanding [of my Hijab] especially around here in the community. Most of the doctors know and they're aware of all that, so they do whatever they can to accommodate it (E13, 34y).
II. Assumptions about Muslim identity	• "When you walk in and you're covered . . . a male doctor will walk in, they do get a little 'Are you okay with [me being here]?' or 'Do you want us to, you know–?' . . . but not if it wasn't a covered woman or a Muslim woman" (E2, 31y). • "Just because they see you covered up doesn't mean you don't speak their language. I think they have that mentality, but it's far from the truth" (E8, 27y). • "If they see I don't have a wedding ring on and I'm Muslim, they're like 'Oh, so you're not pregnant for sure . . . she's a virgin. She doesn't drink. I'm going to quickly go over this question' . . . whereas people can be varying levels of religiosity depending on whether they wear the headscarf or not" (E15, 24y).
III. Preference for a female clinician tends to be specific to reproductive health	• "Some problems should only be discussed with a female doctor . . . woman to woman there's nothing to hide" (A5, 37y). • "If they have to do the vaginal test, yes [would prefer a woman] . . . because we are Muslims" (E11, 31y). • "Because he is a stranger, you know that in our religion that's not acceptable, it is Haram unless if it is an emergency and her life is in danger, then it is acceptable . . . .I am only talking about genital organs, but it is fine in other specialties." (A8, 47y). • "I think [clinician gender] doesn't matter except if I am going to have a gynecological exam" (A8, 47y). • "If it is a female doctor, I feel more comfortable because we are the same" (A2, 34y). • "When I gave birth to my eldest son, the female doctor wasn't there, and I had to deal with a male doctor, it was embarrassing but I accepted it because it was an emergency case" (A1, 29y).
IV. Preference for non-Muslim/non-Arab clinician	• "I know that most of my race, subconsciously they will judge you regardless of if they tell you they don't . . . I don't like to be criticized or judged or looked at in a certain way just because of how I look or what I'm here for . . . what my blood results will come out to" (E2, 31y). • "They prefer to go to a Caucasian or any other race of psychologists than one just like them, in fear or worry that I will gossip in the community . . . and it works both ways. Like I would be scared too" (E15, 24y). • "I think there are a lot of girls that are younger. They get abortions. But they don't have nobody to talk to . . . especially being Arab, you can't. You have to go somewhere nobody knows about . . . The problem isn't with the doctor. The problem is with the . . . whole environment. You really can't say much in Dearborn" (E3, 33y). • "If I had done something or wanted to talk about it, I'll be worried . . . if there's people listening in the hallway, or if someone recognizes me" (E15, 24y).
V. Marital status impacts ideas about intercourse	• "In the past maybe like before I got married [preferred female doctor], before I had kids. But after all that it's like, they've seen everything. You're just open about it. You don't care anymore" (E13, 34y). • "[Intercourse] is [not permissible] in our religion . . . only with her husband" (A8, 47y). • "Muslim girls don't wear tampons if they're not married yet" (E15, 24y). • "You're not supposed to do [pelvic exams] until basically you're married" (E9, 20y).
VI. Religious permissibility for contraception	• "I didn't know that [birth control] had anything to do with religion" (E2, 31y). • "I would never take birth control nor would I want my daughters to . . . it's not that [Islam is] against it. It's not natural but then again, it is their choice but I would advise them don't take it" (E10, 54y). • "[Birth control] is not something people talk about that much, but people our age, I think it's not a big deal for us" (E15, 24y).

(*Continued on next page*)

Table 2. Continued.

Themes	Illustrative quotes
	• "It is normal to take birth control pills, if I don't want to get pregnant, it is totally fine to take birth control pills" (A7, 27y). • "If the woman is weak and can't support a new pregnancy because of several previous miscarriages, she should use birth control pills to protect her health or if the woman has enough children, she should use them as well" (A8, 47y). • "I've used contraceptive pills and that's okay [in my religion]" (A11, 67y). • "I don't know what Islamic religion says about birth control pills but personally I used to take them when I was in Lebanon. I didn't think about religion at that time, but it is a bad thing to bring a baby to this world if you can't take care of him" (A12, 49y). • "Religion is not against birth control pills . . . in fact it's quite the opposite. It's for these things, because you can't risk getting pregnant every day" (A9, 57y).

A, Arabic-speaking participant; *E*, English-speaking participant; *ED*, emergency department; *y*, age in years.

positive experiences to share when asked about feelings of discrimination. One participant explained, "I don't feel that [non-Muslims are treated better] no . . . to be honest I would like to thank the Americans in this regard . . . they respect you" (A6, 47y). Another participant agreed saying, "I have been here 17 years and I have never felt [discriminated against in healthcare]" (A2, 34y). All of these sentiments applied to their reproductive healthcare, as well as their healthcare experiences in general.

II. Assumptions about Muslim identity. Although most participants did not feel religiously discriminated against, some shared feeling stereotyped by clinicians. Participants explained how visible religious expressions, such as wearing the hijab, led to clinicians making assumptions about their preferences. "When you walk in and you're covered . . . a male doctor will walk in, they do get a little 'Are you okay with [me being here]?' . . . but not if it wasn't a covered woman or a Muslim woman" (E2, 31y). Another participant shared "just because they see you covered up doesn't mean you don't speak their language. I think they have that mentality but it's far from the truth" (E8, 27y). These assumptions may affect the care Muslim patients receive, as one participant mentioned "if they see I don't have a wedding ring on and I'm Muslim, they're like 'Oh, so you're not pregnant for sure . . . she's a virgin. She doesn't drink. I'm going to quickly go over this question' . . . whereas, people can be of varying levels of religiosity depending on whether they wear the headscarf or not" (E15, 24y).

Impact of Muslim Identity on Reproductive Health Preferences, Beliefs and Behaviors

I. Preference for a female clinician tends to be specific to reproductive health. Most participants preferred a female clinician for discussions about reproductive health and reproductive physical examinations. Participants explained that "it is difficult for Arab women and especially those who wear hijab to discuss [reproductive health] with male doctors" (A1, 29y). Another participant agreed: "I always prefer if it's a woman if they are going to check private parts and stuff" (E5, 50y).

The Arabic-speaking participants were more fixed than the English-speaking participants about their preferences for reproductive health clinician gender. As one participant said, "I can't expose my genital area to a male doctor. That's impossible . . . that is not acceptable" (A8, 47y). Another participant indicated that in the past because of a male clinician "[I] did [refuse a gynecological exam] one time" (A5, 37y). Another Arabic-speaking participant explained how the preference was influenced by traditions more than just personal choice as, "some women don't accept if the doctor is male because of their traditions. In Iraq, if we have an emergency, we accept to be examined by a male doctor but when it comes to labor or gynecological emergencies, some women can't accept because their husband don't accept or because their religion or families" (A1, 29y). However, participants overwhelmingly agreed that in an emergency "if there is only a male doctor, I would accept that. I have no choice" (A2, 34y). Other exceptions to the preference for a female clinician only appeared in the English interviews, as two participants mentioned that they actually preferred male clinicians because "they're very gentle" (E4, 30y) and "women have a tendency to overthink" (E10, 54y). They did not provide further context into these beliefs.

When participants were asked to describe the best person to care for their reproductive health, almost all participants discussed character traits rather than gender. These included traits like "listen[ing] and understand[ing]" (E12, 47y) and "as long as they're qualified and have a heart and can understand what I'm going through" (E10, 54y). Gender preference seemed to be related only to reproductive health, as most participants reported that "if I am having a gynecological exam, it should be a female doctor. But for any other problems, there is no difference between male or female doctors" (A3, 57y). Another participant concurred that "outside of the emergency [sic], if it is something related to OBGYN, I would prefer a female doctor only. But for any

other health problems, it doesn't matter if it is a male doctor" (A7, 27y).

II. Preference for a non-Muslim/non-Arab clinician. Multiple participants discussed a desire for a non-Muslim/non-Arab clinician while receiving reproductive healthcare, citing concerns about privacy. One participant explained that discussing her reproductive health with a Muslim or Arab clinician would cause "fear or worry [about] gossip in the community" (E15, 24y). Another participant agreed that "subconsciously . . . [Muslim or Arab clinicians] will judge you regardless of if they tell you they won't" (E2, 31y).

Some participants shared beliefs that clinicians who did not come from their community were better. For example, one participant suggested that "people are so judgmental, and I'm Arabic, so trust me I know how they are . . . I love my race . . . but I'd rather have a [clinician be a] nice white lady or a nice black guy, Chinese, whatever . . . they're good" (E6, 47y). Another participant concurred, "I think that Americans have more mercy than Arabs" (A8, 47y).

III. Marital status impacts ideas about reproductive health. For many participants, marital status was vitally important to reproductive health, because it provides an important context for the role intercourse plays in their religion, health, and healthcare. Many interviewees emphasized that "[intercourse] is [generally not permissible] in our religion . . . only with her husband" (A8, 47y). For some participants, women who "had sex and [weren't] married . . . there's no way in hell [they] could tell that to anybody" (E3, 33y), indicating that the subject of sexual activity is taboo and may not be discussed readily, if at all, by some Muslim women. Another participant explained this further, describing, "I broke my virginity and I wasn't married. But I would still go talk to my gynecologist [who was] an old white guy . . . And I made sure that I didn't know nobody that worked at that office" (E3, 33y). Similarly, marital status also influenced ideas about general reproductive health topics like menstruation since "Muslim girls don't wear tampons if they're not married yet" (E15, 24y). Another participant agreed, "you're not supposed to do [pelvic exams] until basically you're married" (E9, 20y).

IV. Religious permissibility for contraception. When participants were specifically asked how their religious beliefs impacted their choices around contraception, the responses were overwhelmingly positive and emphasized religious permissibility. As one participant explained, "No, [birth control] won't be considered against God or religion because God knows how my health is. He knows that I can no longer tolerate another pregnancy . . . We all know ourselves, maybe we aren't able to raise the children and to be responsible about them. These pills aren't against Islam at all" (A2, 34). Another participant emphasized how these choices are personal since, "I rather not [use birth control] because I think [if a pregnancy is] meant to be, then it's meant to be . . . [These feelings are] just personal. If birth control works for you then use it" (E6, 27). Not only did participants express religious permissibility, but one participant articulated religious necessity for the non-contraceptive effects of contraception. "When I was like 14, we went to the Islamic pilgrimage, Hajj. And to do that, I had to get on birth control so that I don't get my period there and miss the opportunity to pray there" (E15, 24).

DISCUSSION

In this study, we aimed to explore Muslim women's reproductive healthcare experiences, preferences, beliefs, and behaviors. We were able to elucidate key themes from participants that can inform culturally sensitive care for this population. More specifically, this exploration highlighted the high proportion of Muslim representation in healthcare in the community we sampled, which helped mitigate discrimination and promoted inclusion. Previous studies in minority populations have highlighted the need for cultural representation and sensitivity as tools to better serve a community.[16] Yet there were drawbacks to the insular nature of this community, such as the potential for loss of confidentiality that may lead to stigma around reproductive health behaviors. This influenced preferences for non-Muslim clinicians for some participants. Other studies have shown that minority communities receive better care from members of their own community, but that cultural concordance is not always possible.[16–19] When not possible, environments should be intentional in hiring a diverse workforce to help increase the cultural knowledge of clinicians outside the minority population. All clinicians, including those who are religiously and culturally concordant, should explore and be sensitive to their patients' concerns about privacy, especially for taboo subjects like reproductive and sexual health.

Interestingly, there were major differences that dichotomized the results between English- and Arabic-speaking participants, emphasizing the diversity of the Muslim population. The concerns about privacy and judgment were almost exclusively conveyed by the English-speaking participants. The English-speaking group was younger, more educated, and more likely to be native to the US compared to the Arabic-speaking group. In this way, the English-speaking participants may exhibit less traditional beliefs and behaviors than other subgroups in their community, such as older or immigrant women. The fact that members of the Arabic-speaking group were more fixed in their preference for a female clinician supports the idea that this group may be more traditional. Although religiosity was explicitly explored in our demographic survey, this is a term that is both subjective and relative, making it difficult to measure. This potentially explains the discrepancy between our hypothesis and the results finding that the

English-speaking group reported more traditional religious beliefs.

Additionally, the Arabic-speaking participants overall did not endorse feelings of discrimination while receiving reproductive healthcare, despite the English-speaking participants reporting that language barriers played a role in their observation of discrimination against Arabic-speaking Muslim women. The Arabic-speaking group was exclusively born outside the US and likely had more experiences receiving reproductive healthcare overseas. Their positive reproductive healthcare experiences, contextualized in this US-based study setting, may be attributed to social desirability bias or ideas about superior healthcare in the US.[20] Furthermore, since the English-speaking group predominantly identified as Lebanese, whereas the Arabic-speaking group were largely Yemeni, it is difficult to elucidate whether these differences were truly related to Muslim identity and religiosity or rather inherent ethnic dissimilarities. Although this study was focused on exploring the experiences of Muslim women, it is important to consider the challenges in capturing data that can be purely attributed to religious identity without being confounded by ethnic or cultural nuances.

The majority of participants desired a female clinician for reproductive healthcare in the ED unless it was an emergency situation, consistent with previous studies that have demonstrated this preference in almost all groups, regardless of race or religion.[21] Yet many of the participants discussed certain personality traits, such as empathy and good listening skills, as the most important attributes when describing the best clinician for reproductive healthcare in the ED. This is an idea that has been established in previous studies, suggesting that it is not unique to Muslim patients to prioritize clinician qualities over gender for reproductive healthcare.[22,23] Additionally, most participants agreed that they did not have a gender preference when receiving non-reproductive healthcare. Therefore, clinicians should avoid assumptions about gender preference in the Muslim patient population. This also emphasizes the need for gender diversity in healthcare when possible and creating policies to support patient clinician preferences for reproductive health when it can be feasibly accommodated.

Marital status was also found to dictate what was permissible regarding reproductive health. Participants discussed how sexual activity outside of marriage was largely considered taboo with major potential consequences within the Muslim community. This also influenced concerns about menstruation and pelvic exams compromising virginity. This is important knowledge for clinicians because they may be a patient's only confidant on these subjects. It is also an area where clinicians can provide sexual health education and address misinformation with sensitivity to deeply held beliefs.

Lastly, this study helped elucidate Muslim women's attitudes toward family planning, an area well known to be influenced by religious and cultural norms.[24–26] Participants conveyed beliefs about the religious permissibility of contraception, as well as in some cases, religious necessity. This is in line with a recent self-reported survey that examined American Muslim's contraception utilization patterns, which demonstrated that Muslim respondents reported higher contraception use than the national proportion.[27] Participants also emphasized that choices about contraception were personal and should not be influenced by others' beliefs. These are important takeaways because they demonstrate that family planning counseling should be tailored to an individual's motivations and goals, rather than based on assumptions about cultural or religious belief.[28]

Previous literature that has focused on cultural competency in providing medical care to the Muslim population has largely included generalizations about the Muslim population, such as preference for a female clinician or assumptions about sexual activity before marriage.[29–31] This study focused on individual experiences that at times contradicted these generalizations. Our finding aligns with the cultural empowerment model of cultural competence that emphasizes the dynamic nature of cultural competency.[15] More specifically, "because of the specific nature of each patient-clinician interaction within its particular social and political environment, culturally competent behavior in one context may be culturally incompetent in another."[15] This provides a framework for providing care to the Muslim population who exhibit a large range of diversity—such as race, ethnicity, and language—that may heavily influence the way one practices their religion.

LIMITATIONS

This study had several limitations. We enrolled English- and Arabic-speaking patients from a single ED within a predominantly Middle Eastern community; therefore, the results may not be generalized to all Muslims. However, the qualitative approach was designed to be exploratory and generate hypotheses and future research questions that may be evaluated for generalizability in the future. The demographic survey and interviews in Arabic may have been affected by participant comprehension and literacy or translation nuances that changed the meaning of concepts, which is a limitation of the study. Additionally, the demographics of the interviewers may have affected the sentiments our study participants felt comfortable sharing due to social desirability bias. More specifically, AN was younger and not visibly Muslim, so participants may have spoken more freely about stigmatizing topics with her than with MS, a lifelong member of the local Muslim community who is a nurse at the study site.

CONCLUSION

Our findings contribute to the growing body of literature focusing on cultural sensitivity in treating the Muslim population. We found that cultural representation and sensitivity among ED staff mitigated discrimination and promoted inclusion for Muslim ED patients. However, assumptions about Muslim identity also impacted the participants' healthcare. Most participants endorsed a preference for a female clinician for their reproductive healthcare in general, but not necessarily for other areas of medicine. Clinician cultural concordance was not always preferred by participants in this ED study due to fears about the loss of confidentiality. Marital status impacted beliefs about reproductive and sexual health in the context of Muslim identity. Overall, family planning was acceptable and encouraged in this patient population.

This study is unique because it emphasizes patient preferences and focuses on female Muslims' reproductive health preferences, an area of clinical importance that has not been thoroughly explored. Ultimately, our findings underscore the need for future work to capture a more diverse perspective of Muslim women and better elucidate the reproductive health preferences and needs that are unique to this population.

Address for Correspondence: Anum Naseem, MD, Wayne State University School of Medicine, Department of Emergency Medicine, 540 E. Canfield Ave, Detroit, Michigan, 48201. Email: mmajed2@hfhs.org

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.

REFERENCES

1. Wheeler SM. Racial and ethnic disparities in health and health care. *Obstet Gynecol Clin North Am*. 2017;44:1–11.
2. Owen CM, Goldstein EH, Clayton JA, et al. Racial and ethnic health disparities in reproductive medicine: an evidence-based overview. *Semin Reprod Med*. 2013;31:317–24.
3. Association of American Medical Colleges. What you don't know: the science of unconscious bias and what to do about it in the search and recruitment process. Available at: https://www.aamc.org/initiatives/leadership/recruitment/178420/unconscious_bias.html. Accessed April 12, 2020.
4. Committee on Health Care for Underserved Women. ACOG Committee Opinion No. 649: Racial and ethnic disparities in obstetrics and gynecology. *Obstet Gynecol*. 2015;126:e130–34.
5. Butler M, McCreedy E, Schwer N, et al. Improving Cultural Competence to Reduce Health Disparities [Internet]. Rockville (MD): Agency for Healthcare Research and Quality (US); 2016 Mar. (Comparative Effectiveness Reviews, No. 170.) Table 21, Cultural competence models.
6. American College of Emergency Physicians. Cultural awareness and emergency care. *Ann Emerg Med*. 2008;52:189.
7. Soares WEIII, Knowles KJII, Friedmann PD. A thousand cuts: racial and ethnic disparities in emergency medicine. *Med Care*. 2019;57:921–3.
8. Padela AI, Gunter K, Killawi A, et al. Religious values and healthcare accommodations: voices from the American Muslim community. *J Gen Intern Med*. 2012;27:708–15.
9. Mohamed B. A new estimate of the U.S. Muslim population. Available at: http://www.pewresearch.org/fact-tank/2016/01/06/a-new-estimate-of-the-u-s-muslim-population/. Accessed March 1, 2017.
10. de la Cruz GP, Brittingham A. The Arab population: 2000. Available at: https://www.census.gov/prod/2003pubs/c2kbr-23.pdf. Accessed January 25, 2021.
11. Ezenkwele UA, Roodsari GS. Cultural competencies in emergency medicine: caring for Muslim-American patients from the Middle East. *J Emerg Med*. 2013;45:168–74.
12. Padela AI, Curlin FA. Religion and disparities: considering the influences of Islam on the health of American Muslims. *J Relig Health*. 2013;52:1333–45.
13. Yosef ARO. Health beliefs, practice, and priorities for health care of Arab Muslims in the United States. *J Transcult Nurs*. 2008;19:284–91.
14. Padela AI, del Pozo PR. Muslim patients and cross-gender interactions in medicine: an Islamic bioethical perspective. *J Med Ethics*. 2011;37:40–44.
15. Garrett PW, Dickson HG, Whelan AK, et al. What do non-English-speaking patients value in acute care? Cultural competency from the patient's perspective: a qualitative study. *Ethn Health*. 2008 Nov 1;13(5):479–96. doi: 10.1080/13557850802035236. PMID: 18850371.
16. Cooper LA, Roter DL, Johnson RL, et al. Patient-centered communication, ratings of care, and concordance of patient and physician race. *Ann Intern Med*. 2003;139:907–15.
17. Swartz TH, Palermo AS, Masur SK, et al. The science and value of diversity: closing the gaps in our understanding of inclusion and diversity. *J Infect Dis*. 2019;220:S33–S41.
18. LaVeist TA, Nuru-Jeter A, Jones KE. The association of doctor-patient race concordance with health services utilization. *J Public Health Policy*. 2003;24:312–23.
19. Strumpf EC. Racial/ethnic disparities in primary care: the role of physician-patient concordance. *Med Care*. 2011;49:496–503.

20. Bergen N, Labonté R. "Everything is perfect, and we have no problems": detecting and limiting social desirability bias in qualitative research. *Qual Health Res*. 2020;30:783–92.
21. Derose KP, Hays RD, McCaffrey DF, et al. Does physician gender affect satisfaction of men and women visiting the emergency department? *J Gen Intern Med*. 2001;16:218–26.
22. Turrentine M, Ramirez M, Stark L, et al. Role of physician gender in the modern practice of obstetrics and gynecology: do obstetrician-gynecologists perceive discrimination from their sex? *South Med J*. 2019;112:566–70.
23. Tam TY, Hill AM, Shatkin-Margolis A, et al. Female patient preferences regarding physician gender: a national survey. *Minerva Ginecol*. 2020;72:25–9.
24. Pinter B, Hakim M, Seidman DS, et al. Religion and family planning. *Eur J Contracept Reprod Health Care*. 2016;21:486–95.
25. Jackson AV, Karasek D, Dehlendorf C, et al. Racial and ethnic differences in women's preferences for features of contraceptive methods. *Contraception*. 2016;93:406–11.
26. Hill NJ, Siwatu M, Robinson AK. "My religion picked my birth control": the influence of religion on contraceptive use. *J Relig Health*. 2014;53:825–33.
27. Budhwani H, Anderson J, Hearld KR. Muslim women's use of contraception in the United States. *Reprod Health*. 2018;15:1.
28. Dehlendorf C, Grumbach K, Schmittdiel JA, et al. Shared decision making in contraceptive counseling. *Contraception*. 2017;95:452–455. Erratum in: Contraception. 2017;96:380.
29. Hasnain M, Connell KJ, Menon U, et al. Patient-centered care for Muslim women: provider and patient perspectives. *J Womens Health (Larchmt)* 2011;20:73–83.
30. Hammoud MM, White CB, Fetters MD. Opening cultural doors: providing culturally sensitive healthcare to Arab American and American Muslim patients. *Am J Obstet Gynecol* 2005;193:1307–11.
31. Attum B, Hafiz S, Malik A, et al. Cultural Competence in the Care of Muslim Patients and Their Families. [Updated 2021 Jul 7]. In: *StatPearls [Internet]. Treasure Island* (FL): StatPearls Publishing; 2021 Jan.

Mixed-methods Evaluation of an Expedited Partner Therapy Take-home Medication Program: Pilot Emergency Department Intervention to Improve Sexual Health Equity

Emily E. Ager, MD, MPH* [*]University of Michigan, School of Medicine, Department of Emergency Medicine, Ann Arbor, Michigan
William Sturdavant, MD*
Zoe Curry, MD[†] [†]Vanderbilt University Medical Center, School of Medicine, Department of Emergency Medicine, Nashville, Tennessee
Fahmida Ahmed, MD*
Melissa DeJonckheere, PhD* [‡]University of Michigan, Michigan Medicine, Department of Clinical Quality, Ann Arbor, Michigan
Andrew A. Gutting, BS[‡]
Roland C. Merchant, MD, MPH, ScD[§] [§]Icahn School of Medicine at Mount Sinai, New York, New York
Keith E. Kocher, MD, MPH*[‖] [‖]University of Michigan, Institute for Healthcare Policy and Innovation, Ann Arbor, Michigan
Rachel E. Solnick, MD, MSc, MS[§]

Section Editors: Erik Anderson, MD, and Mark Langdorf, MD, MHPE
Submission history: Submitted November 28, 2023; Revision received May 31, 2023; Accepted June 1, 2023
Electronically published August 25, 2023
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.59506

Background: Treatment for partners of patients diagnosed with sexually transmitted infections (STI), referred to as expedited partner therapy (EPT), is infrequently used in the emergency department (ED). This was a pilot program to initiate and evaluate EPT through medication-in-hand ("take-home") kits or paper prescriptions. In this study we aimed to assess the frequency of EPT prescribing, the efficacy of a randomized best practice advisory (BPA) on the uptake, perceptions of emergency clinicians regarding the EPT pilot, and factors associated with EPT prescribing.

Methods: We conducted this pilot study at an academic ED in the midwestern US between August–October 2021. The primary outcome of EPT prescription uptake and the BPA impact was measured via chart abstraction and analyzed through summary statistics and the Fisher exact test. We analyzed the secondary outcome of barriers and facilitators to program implementation through ED staff interviews (physicians, physician assistants, and nurses). We used a rapid qualitative assessment method for the analysis of the interviews.

Results: During the study period, 52 ED patients were treated for chlamydia/gonorrhea, and EPT was offered to 25% (95% CI 15%–39%) of them. Expedited partner therapy was prescribed significantly more often (42% vs 8%; $P < 0.01$) when the interruptive pop-up alert BPA was shown compared to not shown. Barriers identified in the interviews included workflow constraints and knowledge of EPT availability. The BPA was viewed positively by the majority of participants.

Conclusion: In this pilot EPT program, expedited partner therapy was provided to 25% of ED patients who appeared eligible to receive it. The interruptive pop-up alert BPA significantly increased EPT prescribing. Barriers identified to EPT prescribing should be the subject of future interventions to improve provision of EPT from the emergency department. [West J Emerg Med. 2023;24(5)993–1004.]

INTRODUCTION

In 2020, there were 677,769 cases of gonorrhea in the United States, an increase of 111% since 2009,[1] and 1.58 million cases of chlamydia. Emergency department (ED) visits for bacterial sexually transmitted infections (STI) in the US are also increasing in frequency.[2] The ED is a critical access point for STI care. Patients presenting to the ED for a possible STI are more likely to be positive for a STI than those visiting an outpatient clinic.[3] Treatment of a patient's partner is also crucial, particularly for female reproductive health, as there is an estimated 14% rate of chlamydia reinfection,[4] which can lead to severe complications.[5]

Expedited partner therapy (EPT) is one method to reduce STI re-infection. It is a safe and effective harm-reduction practice of treating the sex partner(s) of patients with STIs without a clinical examination.[6] Large, multisite, randomized trials have shown that EPT is superior in preventing reinfection compared to standard partner referral,[7,8] and meta-analyses[9,10] have found that patients offered EPT had a reduction in persistent or recurrent gonorrhea or chlamydia infections; notably, two of these studies involved ED patients.[7,8] Additionally, EPT may decrease population increases in chlamydia at the state level.[11]

Expedited partner therapy is supported by health organizations[5] including the American College of Emergency Physicians.[12] There have been no adverse drug events reported in prior studies of EPT[9] or in over a decade of monitoring by the California Department of Health.[13] While used in most publicly funded family planning clinics in the US,[14] EPT is infrequently provided in the inpatient setting[15–17] or in EDs.[18] Medical directors have reported poor knowledge of how to prescribe EPT,[18] and emergency clinicians' ability to prescribe EPT medications can vary greatly.[18] Many state regulations prohibit EPT medication costs from being charged to an index patient's health insurance policy. To address the barrier of a partner's access to STI treatment, two promising approaches for EDs include either to distribute medication-in-hand ("take-home") kits or paper prescriptions for the patient to give to their sex partner(s). However, research evaluating these approaches in the ED is lacking.

To investigate possible solutions to EPT implementation in EDs we implemented a pilot program at a single ED to dispense both take-home kits and paper prescriptions. Emergency clinicians were interviewed about their perceptions of the pilot and assessed the frequency of EPT prescribing. In addition, we examined the efficacy of a best practice advisory (BPA) to encourage prescribing. Lastly, we explored variations in EPT prescribing by patient demographic factors, health insurance status, clinician type, and STI testing results.

Population Health Research Capsule

What do we already know about this issue?
Despite rising rates of sexually transmitted infections (STI), EDs rarely use expedited partner therapy (EPT), which can decrease recurrent STIs.

What was the research question?
What are the barriers and facilitators of take-home EPT and the effect of a best practice advisory (BPA) on EPT use?

What was the major finding of the study?
In 25% of eligible patients EPT was used—more when BPA was shown vs when not, 42% vs 8%, $P < 0.01$.

How does this improve population health?
Partnering with a local health department to offer take-home EPT to patients empirically treated for STIs would expand treatment to high-risk populations.

METHODS

Setting and Participants

The pilot study was conducted between August–October 2021 at an academic ED in the midwestern US with a patient volume of over 100,000 visits per year. In Michigan, EPT is legal and encouraged by the Michigan Department of Health and Human Services (MDHHS) for chlamydia, gonorrhea, and trichomoniasis.[19] Before the onset of this pilot study, the MDHHS began a US Centers for Disease Control and Prevention (CDC) grant-funded initiative to increase statewide use of EPT, which included donating EPT medications to several EDs in the state for index patients to deliver to their partner(s) via take-home kits. The EPT medications were based on CDC guidelines on the presumptive treatment of gonorrhea and chlamydia using an oral-only regimen.[6]

The MDHHS obtained these medications from a pharmacy distributor and repackaged them into pre-labeled kits with information and instructions for EPT. To abide by drug safety regulations regarding the transfer of medications, a T3 document in which a drug manufacturer details all product information to a new recipient, was obtained and approved by the ED pharmacy. The take-home kits were then delivered to the ED in packages for either potentially pregnant (containing cefixime and azithromycin) or not

pregnant (containing cefixime and doxycycline) patients. Pregnancy status was based on ED serum or urine testing. This study was approved by the study site's institutional review board (HUM00199376) and (HUM00196451).

Pilot Expedited Partner Therapy Program

The mechanism of the EPT pilot is detailed via a swim-lane process map (Figure 1). As part of a larger quality improvement initiative, a sexual health EHR orderset was created to assist emergency clinicians with ordering lab tests and treatment for patients being evaluated for STIs (Appendix 3). The orderset provided a link to an EPT protocol and the following: 1) standardized EPT prescriptions for printing on plain paper; 2) progress note to indicate the provision of EPT; and 3) EPT discharge instructions and resources to find local low or no-cost sexual health clinics.

With assistance from ED pharmacy leadership, an ED-specific protocol was designed to dispense EPT kits. For the "take-home" medication kits, the clinician printed the EPT prescriptions, brought the prescriptions to the ED pharmacy located adjacent to the clinician's workspace, and then the pharmacist took the kit to the patient and provided medication counseling. Emergency clinicians could offer patients EPT paper prescriptions as an alternative to the kits. At the time of the pilot, Michigan law still allowed plain paper prescriptions for non-controlled substances.[20] Clinicians could choose either approach per the protocol.

A best practice advisory (BPA) was also created as an interruptive alert designed to appear when clinicians empirically treated patients for gonorrhea and chlamydia (Appendix 4a). The interruptive BPA appeared with the following trigger criteria: 1) patient was ≥18 years in age; 2) gonorrhea or chlamydia test was ordered; and 3) ceftriaxone and azithromycin or ceftriaxone and doxycycline were ordered. Metronidazole ordering was initially included as a BPA trigger criterion but was later removed as it too frequently triggered the BPA for patients treated for bacterial vaginosis. Additionally, a non-interruptive alert appeared in the EHR Discharge Navigator for all trigger criteria patients if EPT had not been ordered to notify clinicians that the patient was eligible for EPT (Appendix 4b). Prescribing clinicians received the BPA;

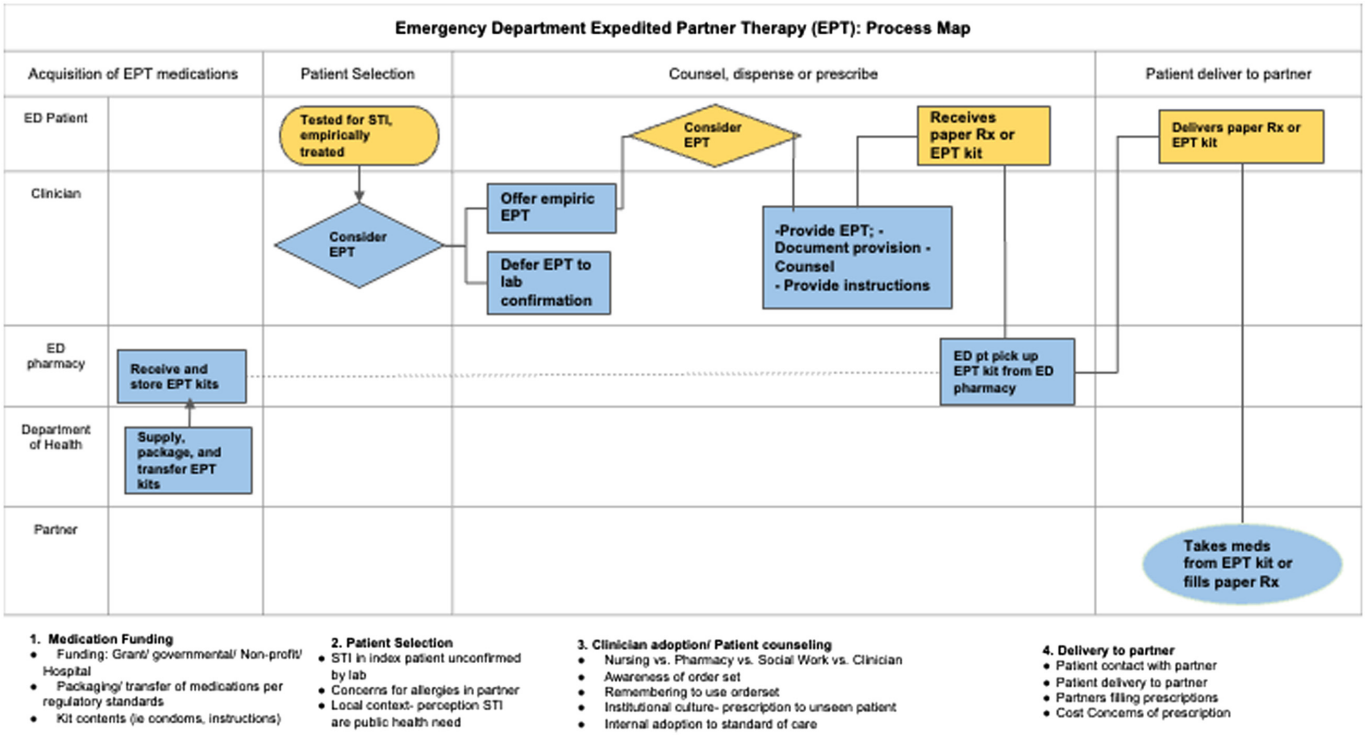


Figure 1. Swim-lane process map of the expedited partner therapy (EPT) pilot program.
This swim-lane process map depicts the EPT program responsibilities represented by horizontal swim lanes organized by the role of the stakeholder: emergency department (ED) patient, clinician, ED pharmacy, Department of Health, and partner. Based on the interviews and additional discussion with the Michigan Department of Health and Human Services MDHHS and ED pharmacy over the course of the project, four phases for pilot implementation are displayed across the top of the process map by major activity domains: 1) supply and preparation, 2) patient selection, 3) clinician adoption and patient counseling, 4) patient delivery to partner. Captions underneath the map summarize key points of the corresponding section.
STI, sexually transmitted infection; *EPT*, expedited partner therapy; *ED*, emergency department; *Rx*, prescription.

nurses did not receive the BPA. To evaluate the efficacy of the interruptive BPA, it was programmed to appear randomly for approximately half of ED visits that met trigger criteria (1:1 randomization of visits, BPA alert, or no BPA alert appearance).

Before the BPA introduction, the pilot EPT program elements were presented at ED faculty, nursing, and physician assistant (PA) meetings and EM residency didactics, followed by emails of presented materials. In addition, ED pharmacy staff posted the protocol and educational materials on a bulletin board in a high-trafficked area of the ED.

ED Staff Interviews About the Pilot EPT Program

Structured interviews were conducted with emergency clinicians caring for EPT-eligible patients to explore barriers and reasons for EPT uptake. We used purposive sampling to interview the attendings, residents, PAs, and nurses who cared for EPT-eligible patients. Each clinician was invited via email to a telephone interview within 72 hours of the patient's visit. Participants could participate in only one interview, even if they had provided care to multiple EPT-eligible patients.

An independently generated, semi-structured interview guide was prepared using elements from the Consolidated Framework for Implementation Research (CFIR)[21] and published manuscripts on EPT implementation.[22–24] There is currently no validated interview guide related to EPT. The interview guide was pilot-tested and iteratively revised with three clinicians unaffiliated with this project by conducting cognitive-based assessments using the "think-aloud"[25] approach to ensure comprehension and fidelity to the question intent (Appendix 1). Each telephone interview began with questions on the participant's background, as well as their EPT knowledge and beliefs. Participants were then asked about their recent EPT-eligible patient encounter, including reasons for prescribing or not prescribing EPT and any barriers or facilitating factors they encountered with the EPT process. The final portion of the interview included questions regarding the BPA. Three multiple-choice questions were also incorporated to introduce each interview topic. Interviews were recorded using a Health Insurance Portability and Accountability Act (HIPAA)-compliant audio call (Zoom Video Communications, Inc, San Jose, CA), auto-transcribed via Zoom closed captioning, and saved to a password-protected website for 150 days. Participants were aware of the subject of the interview before agreeing to participate. They were not compensated. Each interview was 10–15 minutes in duration.

The lead researcher RS is an emergency physician with formal training in qualitative methods and health services research. The interview team was composed of nine individuals: one expert in qualitative methodology who guided the analytical approach (MD); three resident physicians (AK, EA, WS); and four medical students (AR, JL, LD, ZC). All interview team members received training in the rapid assessment qualitative methodology from the lead researcher. RS did not conduct any of the interviewers. None of the interviewers had a supervisory role related to participants. Interviewers were not compensated.

Outcomes

The primary outcome was EPT provision and the impact of the BPA on EPT use. We examined variations in EPT ordering by patient demographic factors, insurance status, clinician type, and STI testing results as an exploratory outcome. The secondary outcomes were barriers and facilitators to EPT program implementation, which were assessed through ED clinician interviews. These methods are described in further detail below.

Analysis of Expedited Partner Therapy Provision

An electronic health report (EHR) prompt (EPIC Systems Corporation, Verona, WI) was created to automatically send same-day, daily emails to the research team about ED visits that met the previously described criteria for the interruptive pop-up alert BPA. Each of these ED visits' EHR Assessment and Plan section were reviewed by a research assistant to confirm that the patient was being treated for a presumed STI rather than for another bacterial infection. For ED visits that met these study criteria, research assistants extracted the following data elements: patient demographics (age, gender, race/ethnicity, insurance payer, STI testing results); clinician demographics (resident, attending or PA); and whether the clinician had been exposed to the interruptive BPA for EPT. Summary statistics are reported with the frequency of each category by EPT ordering. We conducted univariable analysis with the Fisher exact test comparing distributions by receipt of EPT. Proportions are calculated with a logit transformed 95% confidence interval (CI). We performed statistical analyses using Stata version 16 (StataCorp LLC, College Station, TX).

Analysis of Interviews with Emergency Department Staff

We analyzed data using a rapid assessment method.[26] During the interviews, researchers paraphrased responses in real-time or transcribed select quotes verbatim immediately following the interview, with assistance from the auto-transcription and Zoom recording. Interviewers also coded the data immediately following each interview. Interviewees were emailed a list of their reported verbatim quotes and asked to comment on the accuracy of their quotes and provide any needed corrections. Codes were created according to a CFIR-based coding scheme and prior relevant EPT literature.[22,23,27,28] Interviewers iteratively added codes to reflect new ideas not included in the a priori coding scheme until data saturation was achieved. Themes were derived deductively and organized by CFIR domains, with

additional themes added based on patterns in the coding elements. Two reviewers (EA, WS) independently evaluated the coded data to identify patterns, while a third (RS) reconciled any discrepancies. We used the Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) and Consolidated Criteria for Reporting Qualitative Research (COREQ) reporting guidelines as a framework for reporting data (Appendix 2).[29,30]

RESULTS

Expedited Partner Therapy Provision

During the study period, 52 ED patients were tested and empirically treated for STIs at the study institution. Their demographic characteristics are provided in Table 1. Only physician residents or PAs were the prescribing clinician type, which is typical at this academic institution. Of the 52 patients, 14 patients (27%; 95% CI 16–41%) had a lab-confirmed test for either gonorrhea, chlamydia, or trichomoniasis, and 13 patients (25%; 95% CI 15–39%) were provided with EPT. Of the 14 patients with a lab-confirmed test for either gonorrhea, chlamydia, or trichomoniasis, three (21%; 95% CI 6–53%) received EPT. The EPT prescribing did not differ by demographics, the type of emergency clinician involved in the patient's ED visit, or whether the patient had a lab-confirmed test for either gonorrhea, chlamydia, or trichomoniasis. However, EPT was prescribed significantly more frequently when the prescribing clinician had been randomly shown the interruptive pop-up alert BPA

Table 1. Expedited partner therapy utilization and characteristics of ED patients presumptively treated for sexually transmitted infections.

	Total % (*n*)	EPT not ordered % (*n*)	EPT ordered % (*n*)	*P*-value
	N = 52	75% (39)	25% (13)	
Patient factors				
Age	30 (9)	30 (10)	29 (5)	0.66
Female	56% (29)	54% (21)	62% (8)	0.75
Race				0.090
White	48% (25)	56% (22)	23% (3)	
Black	40% (21)	33% (13)	62% (8)	
Asian	6% (3)	5% (2)	8% (1)	
Other	4% (2)	3% (1)	8% (1)	
Missing	2% (1)	3% (1)	0% (0)	
Insurance				0.37
Private	48% (25)	51% (20)	38% (5)	
Medicaid	31% (16)	31% (12)	31% (4)	
Medicare	4% (2)	3% (1)	8% (1)	
Self-Pay	4% (2)	3% (1)	8% (1)	
Missing	13% (7)	13% (5)	15% (2)	
Has PCP	54% (27)	53% (20)	58% (7)	1.00
Lab-confirmed STI	27% (14)	28% (11)	25% (3)	1.00
Chlamydia	10% (5)	8% (3)	15% (2)	0.59
Gonorrhea	12% (6)	13% (5)	8% (1)	1.00
Trichomoniasis	8% (4)	10% (4)	0% (0)	0.56
		Clinician factors		
ED Prescribing clinician type				
Physician resident	44% (23)	36% (14)	69% (9)	0.054
PA	46% (24)	51% (20)	31% (4)	0.34
Exposure to BPA				
Shown BPA	50% (26)	38% (15)	85% (11)	0.009
Not shown BPA	50% (26)	62% (24)	15% (2)	

P-value is calculated from the Fisher exact test.
EPT, expedited partner therapy; *PCP*, primary care physician; *PA*, physician assistant, *BPA*, best practice advisory; *STI*, sexually transmitted infection.

(11/26; 42%) compared to when there was no BPA shown (2/26; 8%) ($P < 0.01$).

Interviews with Emergency Department Staff About Expedited Partner Therapy

Of the 106 emergency clinicians invited to be interviewed, 20 participated (Table 2). Of the 20 interviewees, 11 were attending physicians, five were emergency medicine residents, two were PAs, and two were nurses. Thirteen were female. Additional representative quotes are displayed in Table 3, and key considerations are summarized by their respective roles on the process map (Figure 1).

Outer Setting (Patient Needs and Resources, External Policy and Incentives)

Improving STI Treatment

Many participants noted the public health benefit of EPT and the unique role the ED has in caring for underserved patients. Most remarked that it was important for EDs, in general, to prevent STI reinfection and that EPT is effective in preventing STI reinfection in ED patients.

Table 2. Characteristics of physicians, physician assistants, and nurses who participated in clinician interviews.

Participant characteristic	Number (%)
Self-identified gender	
Male	13 (65)
Female	7 (35)
Age (years), median (range; IQR)	35 (27–61; 32–43)
20–29	3 (15)
30–39	11 (55)
40–49	2 (10)
50–59	2 (10)
60–69	2 (10)
70+	0 (0)
Role in ED	
MD/MBBS	16 (80)
Physician (attending)	11 (69)
Physician (resident)	5 (31)
Physician assistant	2 (10)
Registered nurse	2 (10)
Years in practice post-residency (years), median (range; IQR)	3.5 (0–37; 0–13)
0	5 (25)
1–9	9 (45)
10–19	3 (15)
20+	3 (15)

ED, emergency department; *MBBS*, Bachelor of Medicine, Bachelor of Surgery; *IQR*, interquartile range.

> I think this could be really helpful to lots of EDs; we see limited encounters for this indication, but for those we do see it has the potential to be very valuable especially if we bring this to patients in a non-judgmental way. [EPT is] very important - we see lots of folks that don't have a primary care doctor or gynecologist. We have the opportunity to educate, treat, [and] prevent the long-term sequelae of these types of infections. (Participant 9)

Inner Setting (Culture, Structural Characteristics, Access to Knowledge and Information, Implementation Climate)

Unfamiliarity, Increased Workload

Frequently mentioned inner-setting characteristics included knowledge of the basic concept of EPT and time constraints in using it. Almost all participants were able to accurately or at least partially define EPT. Although most participants were familiar with the concept, only about half knew how to order EPT at the study site.

> I didn't know the program existed and did not know how to use the order set or that it was available. (Participant 8)

While the majority were supportive of having EPT available as an option, the extra work involved in education was cited by several participants as a barrier. They stated that some patients may not understand STIs and thus need extra counseling. Especially in a busy ED, the extra time involved in bridging these knowledge gaps was undesirable.

> [A barrier is] explaining to the patient how to explain to partner, which can be challenging . . . not insurmountable. (Participant 19)

Culture at the study site was also frequently cited as a barrier. These clinicians stated that EPT is not a common practice and it was challenging to remember to use it. Further, several participants viewed EPT as less impactful in EDs with a lower volume of STI visits.

> It feels strange to write a prescription without a name on it. Giving it to someone you've never met or interacted with feels strange; it's a change in practice. (Participant 1)

Participants also mentioned ways to change this culture. Two clinicians stated that incorporating EPT into the standard of practice is the best long-term solution for clinicians to order EPT consistently.

> I think everyone just needs to do it once, and then it will be a part of our practice. The volume of us seeing an exposure needs to grow and then just knowing to do it from now on. (Participant 6)

Table 3. Representative clinician quotes regarding expedited partner therapy organized by CFIR* domain and constructs.

CFIR domain	CFIR constructs	Topic	Representative quote
Outer setting	Patient needs and resources, external policy and incentives	Improving STI treatment	*It is super important [to prevent STI reinfection] to public health and to the health of our patients, and to lowering the barriers they have to medical care. (Participant 5)*
			[We] see patients who don't interact with the medical system frequently – we are a point of contact for them and have the opportunity to give them this intervention that improves public health. (Participant 20)
			I think it's capturing a group of patients we don't always see in the ED. (Participant 18)
			I think it would be helpful from a community health perspective, and [it] would help limit the spread of disease. (Participant 10)
Inner setting	Culture, structural characteristics, access to knowledge and information, implementation climate	Unfamiliarity, increased workload	*[A barrier is] thinking about doing it. (Participant 5)*
			Unfortunately, [a barrier is] just the extra work involved. (Participant 16)
			I still think it's weird to write a prescription for someone I haven't seen as a patient but I am not opposed to doing it. (Participant 1)
			It's not entirely up to the ED but we should play a role and take advantage of the tools available to us, including EPT. (Participant 16)
			The long-term answer is that it becomes [the] standard of care. (Participant 4)
Characteristics of individuals	Knowledge and beliefs about the intervention	Unseen partner, uncertain delivery	*I'm concerned mostly for safety – if they are allergic, [have a] drug reaction, or some type of kidney disease that's undiagnosed. (Participant 15)*
			I think if they leave with medications in hand that's better because there's less steps. (Participant 17)
			More options are better. I like the idea of giving medication more as getting medications seems easier. (Participant 5)
			It would be great if it makes it to the intended individual. Do they actually get the medication? (Participant 12)
			What would happen if you gave a script to someone whose allergies you can not check? (Participant 19)
Intervention characteristics	Complexity, cost	Take-home program, distribution	*This BPA should exist because it is for [an] intervention that, without a hard-stop reminder, it would not be prescribed otherwise. (Participant 20)*
			[The] take-home med kit is preferable; [it] reduces extra step for [the] patient to give [the] partner a prescription [and] to fill that prescription. (Participant 20)
			The patient was discharged and was in a hallway spot waiting for 30–40 minutes waiting for the medications; the patient almost left without medications because he was ready to go. (Participant 15)

(*Continued on next page*)

Table 3. Continued.

CFIR domain	CFIR constructs	Topic	Representative quote
	Design quality and packaging	Orderset, best practice advisory	*As I recall the orderset was pretty straightforward. (Participant 12)*
			BPAs would be the best reminder; if you want people to pay attention and do something you need a BPA. (Participant 8)
			I'm sure it's helpful but more BPAs are painful. The more times I'm interrupted the more I'm likely to make a mistake on the thing I wanted to do. (Participant 4)

**CFIR,* Consolidated Framework for Implementation Research; *STI,* sexually transmitted infection; *MBBS,* Bachelor of Medicine, Bachelor of Surgery; *IQR,* interquartile range; *BPA,* best practice advisory.

Characteristics of Individuals (Knowledge and Beliefs About the Intervention)

Unseen partner, uncertain delivery

One clinician expressed reluctance related to treating a patient's partner when the index patient had an unconfirmed STI status.

> A limitation is that we don't have confirmed test results and so without results, I may at times feel reluctant to send a partner home with a kit. (Participant 5)

Medication cost when filling paper prescriptions was also listed as a reason for a reluctance to order EPT.

> I have concerns that the medications cost a lot of money and we may be adding a burden to the patient. (Participant 8)

A minority of clinicians were concerned about prescribing for someone they hadn't evaluated as a patient and adverse medication effects or allergies. When asked about the EPT take-home kit, a participant stated,

> Some [doctors] may be reluctant to do that because they haven't been able to examine the patient's partner. (Participant 10)

Intervention Characteristics (Complexity, Cost)

Take-home Program, Distribution

Participants preferred the take-home EPT kits over paper prescriptions due to the fewer steps for treatment of sex partners but recognized it was likely a shared decision between patient and clinician.

> It depends on the patient's situation. You need to discuss with the patient if they are willing or want to dispense medication to a partner or if a prescription will be effective. (Participant 16)

A process barrier observed by some participants was a delay in the ED pharmacist filling the take-home EPT kit, with one clinician noting that the patient had to wait 30 minutes after discharge for the kit.

Factors outside the control of emergency clinicians, including the patient's actions, were frequently cited as barriers to the implementation of EPT. Half of the participants were concerned that the success of EPT depended on patient factors, such as delivering the take-home kit to their sex partner or filling the paper prescription. They worried that the patient would no longer have contact with their sex partner or would not deliver the take-home kit or prescription to their sex partner.

> The biggest [barrier] is if they can't get in touch with their partner again - I don't even know this partner so I'm not going to give them the prescription. (Participant 6)

Intervention Characteristics (Design Quality and Packaging)

Orderset, Best Practice Advisory

Participants noted the simplicity of finding and navigating the EPT EHR orderset. When asked "what went well with the EPT process in the ED," a quarter indicated it was "easy to use." Participants stated that the orderset was straightforward, well-designed, and easy to find in the EHR. The EPT-specific discharge instructions were also considered efficient and helped with patient education.

Perspectives on BPAs were mixed but generally positive. Almost half of the participants suggested using a BPA when asked how to implement ED-based EPT. When asked, "how do you feel about a reminder BPA for EPT that pops up when you order empiric therapy," there were 13 responses for "appreciate it as a reminder," seven responses for "like," and four responses for "don't like." Participants also stated that they support BPAs that are more "patient-centered" rather than intended for financial or medicolegal purposes.

> I think the BPA is the most streamlined way to do it; if there wasn't a hard stop I may not have written the prescription in this circumstance; I know some people are against BPAs in general but I liked it. I think if we're really trying to implement this, a hard-stop BPA is the best way to not miss these prescriptions. It is probably the most effective way. (Participant 18)

Several participants had conflicted feelings toward a "hard-stop" BPA, stating that clinicians already encounter numerous BPAs, which can be disruptive to clinician workflow. Conversely, several stated they would support a "hard-stop" BPA since the intervention may be otherwise forgotten.

> I'm conflicted about it. I dislike BPAs probably because of how many we have. So, adding another one makes me cringe. But if there's a way to do it at the time of discharge rather than during the encounter then I wouldn't hate it. (Participant 17)

Additional non-BPA-based suggestions for early adoption included encouraging attendings to remind residents to use EPT, involving the ED pharmacist more extensively in the EPT process, and having a "standing nursing order" to order EPT medications.

DISCUSSION

This pilot study demonstrates the feasibility of a novel ED-based, EPT take-home medication pilot program and the effectiveness of EHR interventions to facilitate adoption. We examined EPT use among all patients being presumptively treated for gonorrhea or chlamydia, as well as the efficacy of an interruptive BPA for EPT. While the BPA greatly increased EPT prescribing, EPT was only offered to 25% of EPT-eligible ED patients. This low level of EPT prescribing was surprising, especially given that most interviewees accurately conveyed the concept of EPT and supported its provision from the ED.

The low level of EPT ordering may be due to several factors. First, there was an educational gap in how to order EPT; half of the participants stated that they did not know how to order EPT. Second, patients offered EPT may have declined, which this study could not measure. In a survey of pediatric ED patients, participants uninterested in EPT cited that they were concerned for partner safety, wanted the partner to get a diagnosis, or felt EPT would detract from the partner's accountability.[31] Third, low use may have been related to logistical difficulties involved in providing take-home medications. Although clinicians preferred take-home kits over paper prescriptions, they also recalled the long process of kit distribution, possibly due to pharmacists' unfamiliarity with the process.

In the future, this will be an essential consideration, as delays in providing the medication in hand are a potential back-end issue. Addressing this concern may not only increase order rates among clinicians but increase efficiency and prevent delays in care. Fourth, emergency clinicians could have forgotten to prescribe EPT, as evidenced by interviewees who reported that remembering to prescribe EPT was challenging. The interruptive BPA likely reduced this issue. The non-interruptive BPA in the Discharge Navigator used in this project was probably overlooked, as none mentioned seeing it.

Despite mixed feelings among clinicians toward BPAs in general, the majority supported an EPT-specific BPA, with nearly half suggesting using a BPA to increase EPT ordering. Further, the over two-fold increase in EPT ordering during BPA-exposed visits supports its efficacy for EPT implementation. This study adds to the growing research on clinician acceptability[32] of using BPAs to improve patient care.[33–38] A study from an urban ED including 75,901 patients demonstrated that a targeted BPA increased syphilis screening by 124% compared to clinician-initiated testing.[39] However, BPAs are known to contribute to alarm fatigue[40] and must be designed to minimize inappropriate interruptions.[41] Future work on EPT prescribing may investigate when to discontinue a BPA as clinician familiarity increases.

Only three patients out of the 13 provided EPT had a lab-confirmed STI, suggesting presumptive EPT may lead to overprescribing. A potential solution to improve the accuracy of ED-based EPT provision is rapid testing for chlamydia and gonorrhea.[42–45] On the other hand, EPT could still be appropriate even when lab testing is negative if the patient was tested before the test could accurately detect the infection (ie, a "window period" after exposure). Without rapid testing, many EDs have developed dedicated follow-up teams to address positive test results after ED discharge. Offering EPT during such follow-up interactions could help target EPT to patients with lab-confirmed infections.

An innovative aspect of this EPT program was the ability to provide "take-home" EPT kits. While EPT has been demonstrated to increase follow-up rates with the index patient's partner and reduce reinfection rates among the index patient,[46] prior studies have found that the total rate of treatment of the patient's partner is still relatively low, owing in part due to low prescription filling rates, sometimes found to be less than 50%.[47,48] This study demonstrates one method for addressing this back-end issue: providing take-home medications rather than a written prescription. This would reduce the impact of one major limiting factor in the completion of treatment. For this reason, the CDC recommendations on EPT state a preference for take-home medications.[6] Other studies have shown the benefit of "med to bed" or "take-home" programs to facilitate medication compliance when there is concern about a patient's

access, such as in anticoagulants and medications for opioid use disorder.[49–51]

Although other ED "take-home" medications may be charged to a patient's healthcare insurance plan, this mechanism is not currently possible for EPT, as most health insurers will not pay for medication for anyone other than the covered individual. One known exception is California, where, since February 2020, the state Medicaid provider – including Medi-Cal and Family PACT insurance – must cover partner EPT medications for low-income patients.[52,53] Additionally, certain family planning clinics, health department STI clinics, and Federally Qualified Health Centers pay for EPT medications via governmental grants.[54] Given disparities in healthcare access among patients who receive STI care in EDs,[55,56] expanding ED-EPT medication funding mechanisms (such as the Michigan Department of Health's provision of medications in this current study), and insurance regulatory changes (such as California's Medicaid regulations) to other states would increase EPT provision.

LIMITATIONS

Limitations of this study include the small sample size, which reduced the ability to identify differences between groups if they existed. External validity is limited because the study was conducted at one ED whose population, setting, and resources may be different from other settings. Additionally, the overall low response rate to the interview invitation introduced the potential for selection bias. Due to limitations in data collection based on daily EHR reports, data was collected only on how many patients received EPT rather than how many patients may have been offered but then declined EPT. In addition, the ability of this EPT program to provide paper prescriptions could be unique. Electronic medication prescription is the norm in the US,[57] although some states allow paper prescriptions for EPT.[58] In addition, the BPA did not trigger for patients being treated for trichomonas, as this infection was too infrequently diagnosed in this ED and keeping metronidazole as a trigger criterion significantly decreased the sensitivity of the screening for eligible patients.

Given the limits of this pilot study methodology, patients' compliance to provide the "take-home" kits or paper prescriptions to their partners, if the paper prescriptions were filled, or if the medications were taken is unknown. The lack of follow-up limited our ability to confirm medication adherence and completion of treatment in this patient population. Prior randomized control trials with follow-up that also tracked subsequent STI infections have found a range in the number needed to treat (NNT) to prevent recurrent or persistent chlamydia or gonorrhea in the index patient, from five in a study of heterosexual men[46] to 33 in a study of women and heterosexual men.[7] Our current study lacks the follow-up to make any conclusions on NNT or completion of treatment once provided.

CONCLUSION

In this pilot, expedited partner treatment program, EPT was provided to 25% of ED patients who appeared eligible to receive it. The interruptive best practices advisory increased EPT prescribing more than two-fold. Multiple barriers to EPT prescribing from this ED were identified, which can be the subject of future interventions to improve provision of EPT to patients in the ED.

ACKNOWLEDGEMENTS

We thank Bianca Clarke MPH from the Michigan Department of Health, as well as Aaron Krumheuer MD, Asavari Rajpurkar MD, Jefferine Li MD, Laura Durecka PA-C, Rich Medlin MD, MSIS, and Joyce Lee MD, MPH for their contributions to this project.

Address for Correspondence: Rachel E. Solnick, MD, MSc, The Mount Sinai Hospital/Icahn School of Medicine, Department of Emergency Medicine – Research Division, 555 West 57th Street 5th Floor Suite 5-25, New York, New York 10019. Email: Rachel.Solnick@mountsinai.org

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. Dr. Solnick was supported by the Institute for Healthcare Policy and Innovation at the University of Michigan National Clinician Scholars Program during a portion of this study. There are no conflicts of interest or sources of funding to declare.

REFERENCES

1. Centers for Disease Control and Prevention. Sexually Transmitted Disease Surveillance 2020. Atlanta: US Department of Health and Human Services; 2022. Available at: https://www.cdc.gov/std/statistics/2020/2020-SR-4-10-2023.pdf. Accessed October 27, 2022.
2. Pearson WS, Peterman TA, Gift TL. An increase in sexually transmitted infections seen in US emergency departments. *Prev Med*. 2017;100:143–4.
3. Jamison CD, Greenwood-Ericksen M, Richardson CR, et al. Association between chlamydia and routine place for healthcare in the United States: NHANES 1999-2016. *PLoS ONE*. 2021;16(5):e0251113.
4. Hosenfeld CB, Workowski KA, Berman S, et al. Repeat infection with chlamydia and gonorrhea among females: a systematic review of the literature. *Sex Transm Dis*. 2009;36(8):478–89.
5. Hillis SD, Owens LM, Marchbanks PA, et al. Recurrent chlamydial infections increase the risks of hospitalization for ectopic pregnancy

and pelvic inflammatory disease. *Am J Obstet Gynecol.* 1997;176(1 Pt 1):103–7.
6. Walensky R, Houry D, Jernigan D, et al. Sexually transmitted infections treatment guidelines, 2021. *MMWR Recomm Rep.* 2021;70(4):1–187.
7. Golden MR, Whittington WLH, Handsfield HH, et al. Effect of expedited treatment of sex partners on recurrent or persistent gonorrhea or chlamydial infection. *N Engl J Med*. 2005;352(7):676–85.
8. Schillinger JA, Kissinger P, Calvet H, et al. Patient-delivered partner treatment with azithromycin to prevent repeated chlamydia trachomatis infection among women: a randomized, controlled trial. *Sex Transm Dis*. 2003;30(1):49–56.
9. Trelle S, Shang A, Nartey L, et al. Improved effectiveness of partner notification for patients with sexually transmitted infections: systematic review. *BMJ*. 2007;334(7589):354.
10. Ferreira A, Young T, Mathews C, et al. Strategies for partner notification for sexually transmitted infections, including HIV. *Cochrane Database Syst Rev*. 2013;(10):CD002843.
11. Mmeje O, Wallett S, Kolenic G, et al. Impact of expedited partner therapy (EPT) implementation on chlamydia incidence in the USA. *Sex Transm Infect*. 2018;94(7):545–7.
12. American College of Emergency Physicians (ACEP). Expedited Partner Therapy for Selected Sexually Transmitted Infections. Policy Statements. Available at: https://www.acep.org/patient-care/policy-statements/expedited-partner-therapy-for-selected-sexually-transmitted-infections. Accessed October 27, 2022.
13. California Department of Public Health. Patient-delivered partner therapy (PDPT) for chlamydia, gonorrhea, and trichomeniasis: guidance for medical providers in California. 2016. Available at: https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/ClinicalGuidelines_CA-STD-PDPT-Guidelines.pdf. Accessed October 27, 2022.
14. Zolna MR, Frost JJ. Publicly funded family planning clinics in 2015: patterns and trends in service delivery practices and protocols. Guttmacher Institute. 2016. Available at: https://www.guttmacher.org/report/publicly-funded-family-planning-clinic-survey-2015. Accessed October 27, 2022.
15. Cramer R, Martinez N, Roberts C, et al. Use of expedited partner therapy for sexually transmitted diseases in college and university health centers in the United States, 2011-2012. *Sex Transm Dis*. 2015;42(10):580–4.
16. Isola M, Francis J. Use of Expedited partner therapy for treatment of chlamydia in adolescents. *J Pediatr Adolesc Gynecol*. 2018;31(2):178.
17. Taylor MM, Reilley B, Yellowman M, et al. Use of expedited partner therapy among chlamydia cases diagnosed at an urban Indian health centre, Arizona. *Int J STD AIDS*. 2013;24(5):371–4.
18. Solnick RE, Cortes R, Chang E, et al. A national study of expedited partner therapy use in emergency departments: a survey of medical director knowledge, attitudes and practices. *medRxiv*. 2023. Available at: https://www.medrxiv.org/content/10.1101/2023.04.01.23287999v1.article-info. Accessed October 27, 2022.
19. Division of HIV and STI Programs, Field Services and STI Prevention Section. *Guidance for Health Care Providers: Expedited Partner Therapy (EPT) for Chlamydia, Gonorrhea, and Trichomoniasis*. [Michigan Department of Health and Human Services]; 2021.
20. Michigan Licensing and Regulatory Affairs Bureau of Professional Licensing. Electronic Prescribing FAQ. 2022. Available at: https://www.michigan.gov/lara/-/media/Project/Websites/lara/bpl/Health-Professional-Licensing-page/Electronic-Prescribing-Frequently-Asked-Questions.pdf?rev=308cccd61a7748099a0f30199b9edc9f. Accessed October 27, 2022.
21. Damschroder LJ, Aron DC, Keith RE, et al. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implement Sci*. 2009;4:50.
22. McCool-Myers M, Smith ADY, Kottke MJ. Expert interviews on multilevel barriers in implementing expedited partner therapy for chlamydia. *J Public Health Manag Pract.* 2020;26(6):585–9.
23. Faherty E, Boraas C, Smith K, et al. Expedited partner therapy for sexually transmitted infections in Minnesota: a mixed-methods review of current practices and barriers to implementation. *Value Health*. 2021;24:S103.
24. Wong J, Zakher B, Consolacion T, et al. Facilitators and barriers to expedited partner therapy: results from a survey of family physicians. *Sex Transm Dis*. 2020;47(8):525–9.
25. Artino ARJr, La Rochelle JS, Dezee KJ, et al. Developing questionnaires for educational research: AMEE Guide No. 87. *Med Teach*. 2014;36(6):463–74.
26. Sobo EJ, Simmes DR, Landsverk JA, et al. Rapid assessment with qualitative telephone interviews: lessons from an evaluation of California's Healthy Families Program & Medi-Cal for Children. *Am J Eval*. 2003;24(3):399–408.
27. Solnick R, Cortes R, Chang E, et al. 175 A national study of barriers and facilitators of expedited partner therapy use in emergency departments: a qualitative study. *Ann Emerg Med*. 2021;78(4):S70.
28. Niccolai LM, Winston DM. Physicians' opinions on partner management for nonviral sexually transmitted infections. *Am J Prev Med*. 2005;28(2):229–33.
29. Ogrinc G, Davies L, Goodman D, et al. SQUIRE 2.0 (Standards for Quality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. *BMJ Qual Saf*. 2016;25(12):986–92.
30. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*. 2007;19(6):349–57.
31. Shamash Z, Catallozzi M, Dayan PS, et al. Preferences for expedited partner therapy among adolescents in an urban pediatric emergency department: a mixed-methods study. *Pediatr Emerg Care*. 2019;37(3):e91–6.
32. Trinkley KE, Blakeslee WW MDD. Clinician preferences for computerised clinical decision support for medications in primary care: a focus group study. *BMJ Health Care Inform.* 2019;26(1).

33. Cohen S, Bostwick JR, Marshall VD, et al. The effect of a computerized best practice alert system in an outpatient setting on metabolic monitoring in patients on second-generation antipsychotics. *J Clin Pharm Ther*. 2020;45(6):1398–404.
34. Bejjanki H, Mramba LK, Beal SG, et al. The role of a best practice alert in the electronic medical record in reducing repetitive lab tests. *Clinicoecon Outcomes Res*. 2018;10:611–8.
35. Palatnik A, Tillis B, Tsaih SW, et al. 674 Effect of a best-practice alert on the rates of smoking cessation during pregnancy. *Am J Obstet Gynecol*. 2021;224(2):S423–4.
36. Najafi N, Cucina R, Pierre B, et al. Assessment of a targeted electronic health record intervention to reduce telemetry duration: a cluster-randomized clinical trial. *JAMA Intern Med*. 2019;179(1):11–5.
37. DeSilva MB, Kodet A, Walker PF. A best practice alert for identifying hepatitis B-infected patients. *Am J Trop Med Hyg*. 2020;103(2):884–6.
38. Funke M, Kaplan MC, Glover H, et al. Increasing naloxone prescribing in the emergency department through education and electronic medical record work-aids. *Jt Comm J Qual Patient Saf*. 2021;47(6):364–75.
39. Ford J, Chechi T, Otmar M, et al. Emergency department syphilis screening practices before and after the implementation of an electronic health record-based best-practice alert. *Suppl Ann Emerg Med: ACEP Research Forum*. 2020;76:s54.
40. Embi PJ, Leonard AC. Evaluating alert fatigue over time to EHR-based clinical trial alerts: findings from a randomized controlled study. *J Am Med Inform Assoc*. 2012;19(e1):e145–8.
41. Fry C. Development and evaluation of best practice alerts: methods to optimize care quality and clinician communication. *AACN Adv Crit Care*. 2021;32(4):468–72.
42. Lehto E, Anderson B, Reed J, et al. Impact of rapid testing for gonorrhea and chlamydia in an urban pediatric emergency department. *J Adolesc Health*. 2022;70(6):910–4.
43. Gaydos CA, Ako MC, Lewis M, et al. Use of a rapid diagnostic for chlamydia trachomatis and Neisseria gonorrhoeae for women in the emergency department can improve clinical management: report of a randomized clinical trial. *Ann Emerg Med*. 2019;74(1):36–44.
44. Rothman R, Dugas A, Lewis M. Rapid Testing for chlamydia and gonorrhea in emergency departments. American Sexual Health Association. Available at: http://chlamydiacoalition.org/rapid-testing-for-chlamydia-and-gonorrhea-in-emergency-departments/. Accessed October 27, 2022.
45. May L, Ware CE, Jordan JA, et al. A randomized controlled trial comparing the treatment of patients tested for chlamydia and gonorrhea after a rapid polymerase chain reaction test versus standard of care testing. *Sex Transm Dis*. 2016;43(5):290.
46. Kissinger P, Mohammed H, Richardson-Alston G, et al. Patient-delivered partner treatment for male urethritis: a randomized, controlled trial. *Clin Infect Dis*. 2005;41(5):623–9.
47. Slutsker JS, Tsang LYB, Schillinger JA. Do prescriptions for expedited partner therapy for chlamydia get filled? Findings from a multi-jurisdictional evaluation, United States, 2017–2019. *Sex Transm Dis*. 2020;47(6):376–82.
48. Schillinger J, Slutsker J, Tsang LY, et al. P076 Do prescriptions for expedited partner therapy get filled? Findings from a multi-jurisdictional evaluation, US, 2017–2018. *Sex Transm Infect*. 2019;95(Suppl 1):A107.
49. Hayes BD, Zaharna L, Winters ME, et al. To-go medications for decreasing ED return visits. *Am J Emerg Med*. 2012;30(9):2011–4.
50. Blome A, Kaigh C, Shaffer C, et al. Emergency department medication dispensing reduces return visits and admissions. *Am J Emerg Med*. 2020;38(11):2387–90.
51. Kabrhel C, Vinson DR, Mitchell AM, et al. A clinical decision framework to guide the outpatient treatment of emergency department patients diagnosed with acute pulmonary embolism or deep vein thrombosis: Results from a multidisciplinary consensus panel. *J Am Coll Emerg Physicians Open*. 2021;2(6):e12588.
52. Essential Access Health: California State Policy. Essential Access Health. Available at: https://www.essentialaccess.org/advocacy/policy-priorities. Accessed October 27, 2022.
53. Anthem BlueCross. Expedited partner therapy for the prevention of STI reinfections. 2021. Available at: https://providers.anthem.com/docs/gpp/CA_CAID_PU_partnertherapySTIreinfections.pdf?v=202106011845. Accessed October 27, 2022.
54. About Title X. Essential Access Health. Available at: https://www.essentialaccess.org/programs-and-services/about-title-x. Accessed October 27, 2022.
55. Pearson WS, Tromble E, Jenkins WD, et al. Choosing the emergency department as an alternative for STD care: potential D=disparities in access. *J Health Care Poor Underserved*. 2022;33(3):1163–8.
56. Ware CE, Ajabnoor Y, Mullins PM, et al. A retrospective cross-sectional study of patients treated in US EDs and ambulatory care clinics with sexually transmitted infections from 2001 to 2010. *Am J Emerg Med*. 2016;34(9):1808–11.
57. E-Prescribing State Laws. Available at: https://mdtoolbox.com/eprescribe-map.aspx?AspxAutoDetectCookieSupport=1. Accessed October 27, 2022.
58. Exceptions to Electronic Prescribing. Available at: https://www.health.ny.gov/professionals/narcotic/electronic_prescribing/exceptions_to_ep.htm. Accessed October 27, 2022.

JOIN CAL/AAEM!

CALAAEM
CALIFORNIA CHAPTER DIVISION OF THE AMERICAN ACADEMY OF EMERGENCY MEDICINE

Championing individual physician rights and workplace fairness

BENEFITS

- *Western Journal of Emergency Medicine* Subscription
- CAL/AAEM News Service email updates
- Free and discounted registration to CAL/AAEM events
- And more!

CAL/AAEM NEWS SERVICE

- Healthcare industry news
- Public policy
- Government issues
- Legal cases and court decisions

In collaboration with our official journal

WestJEM Integrating Emergency Care with Population Health

Join the CAL/AAEM Facebook Group to stay up-to-date:
www.facebook.com/groups/calaaem

www.aaem.org/calaaem

CALIFORNIA ACEP
AMERICAN COLLEGE OF EMERGENCY PHYSICIANS

MEDI-CAL RATE INCREASE

CALIFORNIA ACEP SECURED $200M ANNUALLY TO INCREASE MEDI-CAL REIMBURSEMENT FOR EMERGENCY PHYSICIANS!

EMERGENCY MEDICINE IS THE ONLY SPECIALTY WITH ITS OWN BUDGET ALLOCATION.

@CALIFORNIAACEP www.californiaacep.org