Western Journal of Emergency Medicine

VOLUME 23, NUMBER 1, March 2022

PAGES 108-291

WestJEM

Volume 23, Number 2, March 2022 Open Access at *West*JEM.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

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 Osteopathic Emergency Physicians

www.acoep.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, 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, 333 City Blvd, West, Rt 128-01, 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, 333 City Blvd, West, Rt 128-01, Orange, CA 92866, 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**

This open access publication would not be possible without the generous and continual financial support of our society sponsors, department and chapter subscribers.

Professional Society Sponsors

American College of Osteopathic Emergency Physicians

California ACEP

California Chapter Division of American Academy of Emergency Medicine

Academic Department of Emergency Medicine Subscriber

Albany Medical College
Albany, NY

Allegheny Health Network
Pittsburgh, PA

American University of Beirut
Beirut, Lebanon

AMITA Health Resurrection Medical Center
Chicago, IL

Arrowhead Regional Medical Center
Colton, CA

Baystate Medical Center
Springfield, MA

Bellevue Hospital Center
New York, NY

Beth Israel Deaconess Medical Center
Boston, MA

Boston Medical Center
Boston, MA

Brigham and Women's Hospital
Boston, MA

Brown University
Providence, RI

Carl R. Darnall Army Medical Center
Fort Hood, TX

Conemaugh Memorial Medical Center
Johnstown, PA

Crozer-Chester Medical Center
Upland, PA

Desert Regional Medical Center
Palm Springs, CA

Eastern Virginia Medical School
Norfolk, VA

Einstein Healthcare Network
Philadelphia, PA

Eisenhower Medical Center
Rancho Mirage, CA

Emory University
Atlanta, GA

Geisinger Medical Center
Danville, PA

Grand State Medical Center
Allendale, MI

Hennepin County Medical Center
Minneapolis, MN

Henry Ford Medical Center
Detroit, MI

INTEGRIS Health
Oklahoma City, OK

Kaiser Permenante Medical Center
San Diego, CA

Kaweah Delta Health Care District
Visalia, CA

Kennedy University Hospitals
Turnersville, NJ

Kent Emergency Medical Residency Program
Warwick, RI

Kern Medical
Bakersfield, CA

Lakeland HealthCare
St. Joseph, MI

Lehigh Valley Hospital and Health Network
Allentown, PA

Loma Linda University Medical Center
Loma Linda, CA

Louisiana State University Health Sciences Center
New Orleans, LA

Madigan Army Medical Center
Tacoma, WA

Maimonides Medical Center
Brooklyn, NY

Maine Medical Center
Portland, ME

Massachusetts General Hospital
Boston, MA

Mayo Clinic College of Medicine
Rochester, MN

Mercy Health - Hackley Campus
Muskegon, MI

Merit Health Wesley
Hattiesburg, MS

Midwestern University
Glendale, AZ

New York University Langone Health
New York, NY

North Shore University Hospital
Manhasset, NY

Northwestern Medical Group
Chicago, IL

Ohio State University Medical Center
Columbus, OH

Ohio Valley Medical Center
Wheeling, WV

Oregon Health and Science University
Portland, OR

Penn State Milton S. Hershey Medical Center
Hershey, PA

Regions Hospital Emergency Medicine Residency Program
St. Paul, MN

Rhode Island Hospital
Providence, RI

Robert Wood Johnson University Hospital
New Brunswick, NJ

Rush University Medical Center
Chicago, IL

St. Luke's University Health Network
Bethlehem, PA

Spectrum Health Lakeland
St. Joseph, MI

Stanford
Stanford, CA

SUNY Upstate Medical University
Syracuse, NY

Temple University
Philadelphia, PA

Texas Tech University Health Sciences Center
El Paso, TX

University of Alabama, Birmingham
Birmingham, AL

University of California, Davis Medical Center
Sacramento, CA

University of California, Irvine
Orange, CA

University of California, Los Angeles
Los Angeles, CA

University of California, San Diego
La Jolla, CA

University of California, San Francisco
San Francisco, CA

UCSF Fresno Center
Fresno, CA

University of Chicago
Chicago, IL

University of Florida
Gainesville, FL

University of Florida, Jacksonville
Jacksonville, FL

University of Illinois at Chicago
Chicago, IL

University of Iowa
Iowa City, IA

University of Louisville
Louisville, KY

University of Maryland
Baltimore, MD

University of Massachusetts
Amherst, MA

University of Michigan
Ann Arbor, MI

University of Missouri, Columbia
Columbia, MO

University of Nebraska Medical Center
Omaha, NE

University of Nevada, Las Vegas
Las Vegas, NV

University of Southern Alabama
Mobile, AL

University of Southern California
Los Angeles, CA

University of Tennessee, Memphis
Memphis, TN

University of Texas, Houston
Houston, TX

University of Washington
Seattle, WA

University of Wisconsin Hospitals and Clinics
Madison, WI

Virginia Commonwealth University Medical Center
Richmond, VA

Wake Forest University
Winston-Salem, NC

Wake Technical Community College
Raleigh, NC

Wayne State
Detroit, MI

Wright State University
Dayton, OH

York Hosptial
York, ME

State Chapter Subscriber

Arizona Chapter Division of the American Academy of Emergency Medicine

California Chapter Division of the American Academy of Emergency Medicine

Florida Chapter Division of the American Academy of Emergency Medicine

Great Lakes Chapter Division of the American Academy of Emergency Medicine

Tennessee Chapter Division of the American Academy of Emergency Medicine

Uniformed Services Chapter Division of the American Academy of Emergency Medicine

Virginia Chapter Division of the American Academy of Emergency Medicine

International Society Partners

Emergency Medicine Association of Turkey

Lebanese Academy of Emergency Medicine

Mediterranean Academy of Emergency Medicine

Norwegian Society for Emergency Medicine

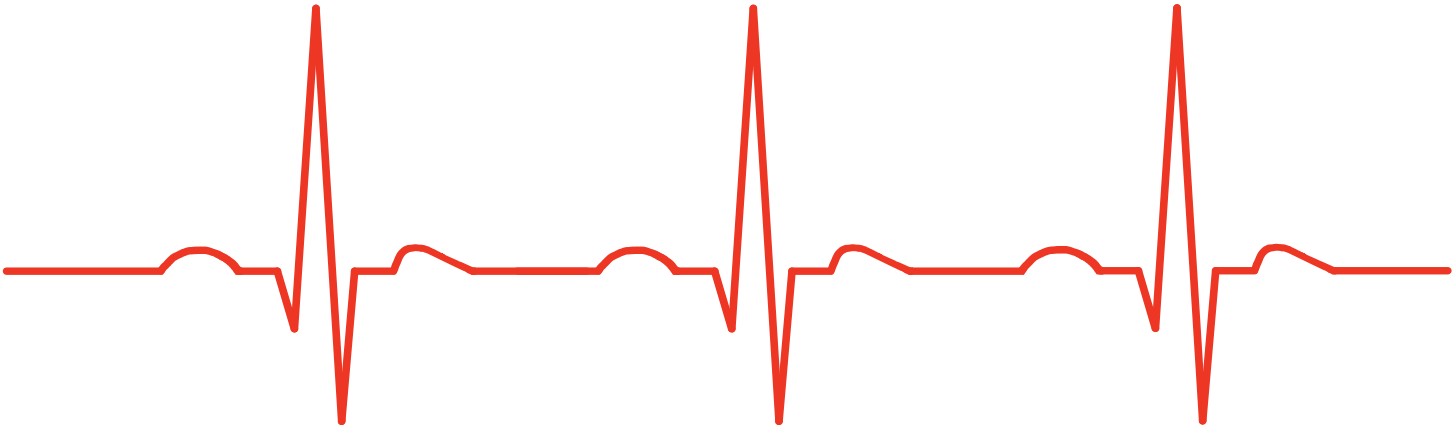
Sociedad Argentina de Emergencias

Sociedad Chileno Medicina Urgencia

Thai Association for Emergency Medicine

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

WestJEM

Integrating Emergency Care with Population Health

CALL FOR DECISION EDITOR

Submit your CV to editor@westjem.org today!

Hepatitis C Virus Reflex Testing Protocol in an Emergency Department

Jacob J. Manteuffel, MD*
Madison S. Lee, BS*
Rebecca M. Bussa, BS*
Noor L. Sabagha, RPH, MPH*
Kaleem Chaudhry, BA, MPH*
Jacob E. Ross, BS*
Megan R. Cook, MD*
Jo-Ann K. Rammal, BS*
Karthik Sridasyam, BS*
Howard A. Klausner, MD*
Linoj P. Samuel, MD†
Joseph B. Miller, MD*

*Henry Ford Hospital, Department of Emergency Medicine, Detroit, Michigan
†Henry Ford Hospital, Department of Pathology, Detroit, Michigan

Section Editor: Stephen Liang, MD
Submission history: Submitted March 15, 2021; Revision received August 5, 2021; Accepted October 11, 2021
Electronically published February 28, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.10.52468

Introduction: Our aim was to measure hepatitis C virus (HCV) screening and linkage-to-care rates in an urban emergency department (ED) before and after implementing an HCV viral RNA (vRNA) reflex testing protocol within a HCV screening program for at-risk patients. Our hypothesis was that using a reflex testing protocol would increase HCV testing rates of at-risk patients in the ED, which would increase the linkage-to-care rate.

Methods: In August 2018, our institution implemented an automated, electronic health record-based HCV screening protocol in the ED for at-risk patients. In January 2019, we implemented an HCV vRNA reflex testing protocol (reflex testing) for all positive HCV antibody (Ab) tests that were initiated through the screening protocol. We compared completion rates of HCV vRNA testing and the rate of linkage to care for patients with positive HCV Ab test results before and after implementation of reflex testing (five months per study period).

Results: Prior to reflex testing implementation, 233/425 (55%) patients with a positive HCV Ab test had an HCV vRNA test performed, whereas 270/323 (84%) patients with a positive HCV Ab test result had vRNA testing after reflex testing implementation (odds ratio [OR], 4.2; 95% confidence interval (CI): 3.0-6.0; P < 0.001). Of the eligible patients with positive HCV Ab test results who could be linked to care, 45 (10.6%) were linked to care before HCV reflex implementation and 46 (14.2%) were linked to care with reflex testing (OR, 1.4; 95% CI: 0.9-2.2; P = 0.13).

Conclusion: Implementing a reflex testing initiative into an HCV screening program in the ED can result in an increase of the percentage of patients who receive an HCV vRNA test after having had a positive HCV Ab. Hepatitis C virus vRNA reflex testing was not associated with a statistically significant increase in linkage-to-care rates for HCV Ab-positive patients; however, further studies are required. [West J Emerg Med. 2022;23(2)108–114.]

INTRODUCTION

The hepatitis C virus (HCV) is a major cause of chronic liver disease and cirrhosis.[1] In the United States, it is the most common chronic bloodborne pathogen, affecting almost 2% of the population.[2] Globally, almost 71 million people have chronic HCV, with many people being unaware of their infection status[3,4]; almost 400,000 people worldwide die each year of complications from cirrhosis or hepatocellular carcinomas caused by HCV.[4] Reports estimate that between 1-12% of eligible adults are tested for HCV,[5] and if current rates of identification remain constant, the estimated HCV-related morbidity and mortality could quadruple over the next decade.[3] Thus, the World Health Organization (WHO) has established a goal to reduce new viral hepatitis infections by 90% and reduce deaths due to HCV by 65% by 2030.[4] To achieve these goals, expanding and improving HCV screening processes will be critical.

The most common route of HCV transmission has historically been through blood transfusions.[6] However, blood donations are now regularly screened for HCV and donors are asked questions about HCV risk factors. Currently, the most common HCV transmission route in high-income countries is intravenous (IV) drug use.[7] Other routes of HCV transmission occur less frequently.[7] For example, transmission from an infected mother to a child occurs in about 5-10% of pregnancies and is more likely to occur when women are infected with human immunodeficiency virus (HIV).[6] Hepatitis C virus can also be transmitted through workplace needle-stick injuries[6,7] and can be sexually transmitted. Additionally, individuals receiving tattoos, those infected with HIV, and men who have sex with men are considered at-risk groups.

Prior to April 2020, the US Centers for Disease Control and Prevention (CDC) recommended HCV testing for current or former IV drug users, those born between 1945–1965, recipients of blood transfusions before 1992, healthcare workers who had work-related needle sticks with blood products, people with HIV, and children born to mothers with HCV. In 2020, the recommendations were augmented to include testing for pregnant women and at least one lifetime HCV test for adults 18 years and older.[8] The American Association for the Study of Liver Diseases recommends annual HCV screening for IV drug users and men who have sex with men.[1]

The Frontlines of Communities in the United States (FOCUS) program is a quality improvement (QI) effort that was created in 2010 to tackle the HIV epidemic.[9] It was designed to align screening practices in the emergency department (ED) with CDC guidelines and to promote linkage-to-care practices in the ED. In light of the recommendations from the CDC and the stated goals of the WHO to significantly reduce new HCV infections, FOCUS was expanded in 2014 to develop CDC-compliant HCV screening, diagnosis, and linkage-to-care practices. Linkage to care is the process by which patients infected with HCV are identified through virus screening, notified of their HCV diagnosis, and "linked" to healthcare providers who can offer HCV treatment and care.

Population Health Research Capsule

What do we already know about this issue?
The emergency department (ED) patient population in the United States has a relatively high burden of undiagnosed hepatitis C virus (HCV) infection.

What was the research question?
Does viral RNA (vRNA) reflex testing within an HCV screening program improve screening and linkage-to-care rates in the ED?

What was the major finding of the study?
The percentage of ED patients who received an HCV vRNA test after having had a positive HCV antibody test result increased.

How does this improve population health?
Screening for HCV with reflex vRNA testing in the ED has the potential to identify and treat patients with HCV and decrease the morbidity and mortality related to infection.

Diagnosing HCV is a two-step process. First, an anti-HCV antibody (Ab) test is performed, which can reveal an active infection or a previous infection that has resolved.[6] The most common anti-HCV Ab test is an enzyme-linked immunosorbent assay,[6] which has 95% sensitivity and specificity and can detect Ab from 4–10 weeks after infection.[6] After a positive Ab test, an HCV viral RNA (vRNA) polymerase chain reaction assay assesses whether the infection is active and determines viral load.[1,6] To ensure complete and timely diagnosis of HCV for at-risk patients, reflex testing is recommended. In laboratory reflex testing, positive HCV Ab test results trigger an automatic vRNA test on the same patient sample, provided that the sample volume is sufficient.[10] Studies of ED HCV screening programs have referenced reflex testing,[11] and others have reported that reflex testing leads to a high percentage of positive HCV Ab tests with a reflexive vRNA test result.[12] However, to our knowledge, no studies have examined whether implementation of HCV reflex testing improves institutional HCV screening rates and linkage-to-care program utilization.

Our aim was to measure HCV screening and successful

linkage-to-care rates in an urban emergency department (ED) before and after implementing an HCV vRNA reflex testing protocol within an HCV screening program for at-risk patients. Our hypothesis was that using a reflex testing protocol would increase HCV testing rates of at-risk patients in the ED, which would increase the linkage-to-care rate. Ultimately, robust HCV screening and efficient linkage to care are needed to improve patient quality of life and lower HCV transmission. Our single-institution, QI pilot study was performed to establish proof of principle for HCV reflex testing utility in improving HCV screening and linkage to care in the ED.

METHODS

Study Design and Setting

This QI study was approved by the Henry Ford Hospital Institutional Review Board, and the requirement for informed consent was waived. Annual ED patient volume at our institution is approximately 100,000. In August 2018, our institution implemented an automated electronic health record (EHR)-based HCV screening protocol in the ED for at-risk patients. In January 2019, we implemented a HCV vRNA reflex testing protocol (reflex testing) for all positive HCV Ab tests that were initiated through the screening protocol. We compared completion rates of HCV vRNA testing and the rate of linkage to care for patients with positive HCV Ab test results before and after implementation of reflex testing (five months per study period).

Study Protocol

The EHR-based HCV screening protocol implemented in August 2018 was designed for minimal disruption to the ED workflow, so as not to prolong ED length of stay. A previous study[13] has suggested that limiting HCV screening to patients for whom emergency clinicians already intend to order a blood test performed would not increase ED length of stay. This study suggests that HCV screening can be linked to frequently and commonly ordered tests (such as a complete blood count) to minimally impact nursing workflow. Our protocol automates HCV screening when an emergency clinician orders a complete blood count in the institution's EHR system Epic (Epic Systems, Verona, WI), which verifies whether the patient was born between 1945–1965 and whether the patient has a history of IV drug use. These criteria were selected based on CDC HCV screening recommendations. We also customized Epic to exclude this order if patients had previously completed a test for HCV Ab or had a history of HCV.

For patients eligible for automated ordering, a best practice advisory (BPA) alert suggests that the patient qualifies for HCV Ab testing prior to a clinician signing the order (Figure 1). The BPA is a box that appears on the emergency clinician's Epic screen with text stating that the patient has "Risk Factors for Hepatitis C. Please order a Hepatitis C Antibody. The FOCUS team will follow up on the result." The BPA is pre-populated by default to "order" the test; however, the option "do not order" is provided, giving the clinician flexibility to accept or dismiss the order (Figure 2). If the order is accepted, it is added to the list of orders for the clinician to sign. Patients were given the option to decline testing prior to blood draw. Emergency clinicians were not required to wait for test results before admitting or discharging the patient so as not to prolong ED length of stay. The clinicians were educated on how to notify patients of positive HCV Ab tests and were directed to emphasize that positive Ab screening tests require confirmatory HCV vRNA testing for diagnosis.

As part of the QI project, we received a weekly Epic-generated report of the preceding week's HCV test results. Positive Ab tests were identified in this report, and we contacted patients to return for further HCV vRNA testing and linkage to outpatient HCV care as needed. In January 2019, our institution implemented HCV vRNA reflex testing to the HCV screening program. During reflex testing, serum from blood samples that had tested positive for HCV Ab were automatically sent for HCV vRNA testing. The laboratory validated serum as an alternative specimen type and performed testing to determine that there was no risk of cross-contamination in using the same sample for both HCV Ab and HCV vRNA. The HCV Ab testing was performed on a Siemens Centaur (Siemens Healthcare, Malvern, PA) instrument, and HCV vRNA reflex testing was performed using the Roche Cobas Ampliprep/Taqman HCV vRNA assay (Roche Diagnostics, Indianapolis, IN).

We quantified the staff time effort that was needed to link patients to care and compared effort time before and after HCV reflex testing implementation. To do this, we broke down the process of follow-up and linkage to care into eight steps and had team members perform time estimates for each step. If a patient attended their appointment, they were designated as "linked to care." After three attempts to contact a patient via telephone with no response, the patient was designated as lost to follow-up. Using these times, we estimated the time needed to link patients to care per patient before and after the implementation of HCV vRNA reflex testing.

We performed a chart review of patients deemed linked to care to determine whether the patient followed up in our health system. For patients following up in our health system we determined whether the patient was treated and cured of HCV, indicated by a negative HCV vRNA test result after initiation of treatment for HCV.

Data Analysis

Analysis consisted of descriptive statistics and univariate comparisons. For the primary outcome of analysis, we used chi-square analysis to compare the proportion of HCV Ab-positive patients linked to care before and after HCV vRNA reflex testing. We present unadjusted odds ratios (OR) with corresponding 95% confidence intervals (CI).

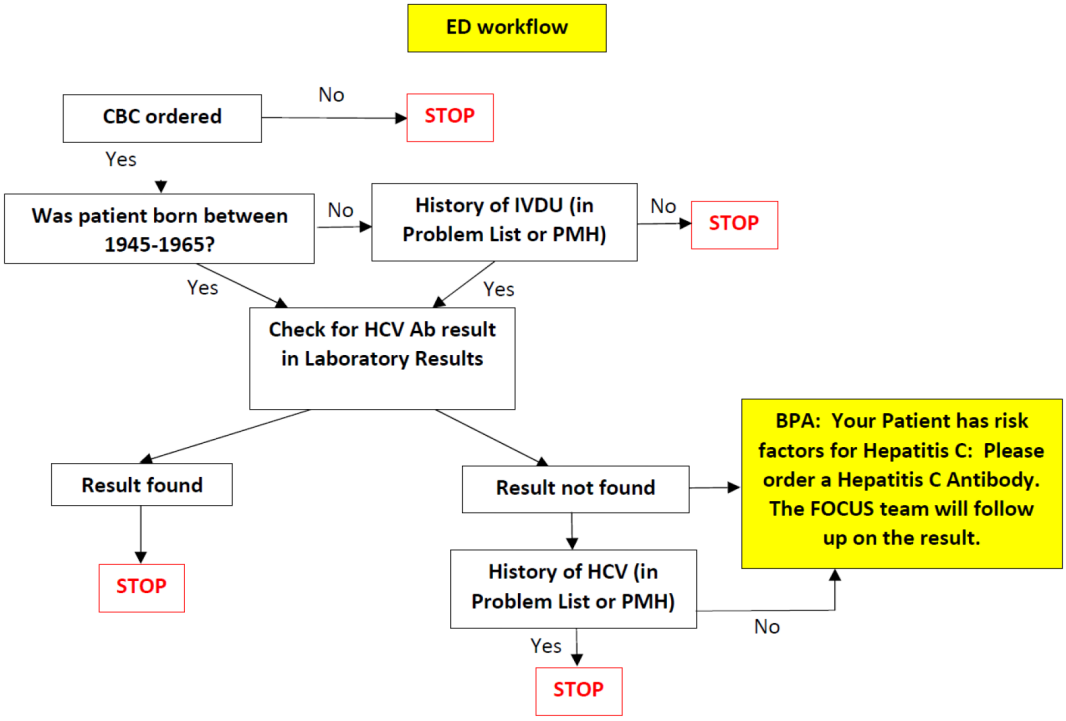


Figure 1. Electronic health record algorithm when a clinician in the emergency department orders a complete blood count. *ED*, emergency department, *CBC*, compete blood count; *Ab*, antibody; *BPA*, best practice advisory; *HCV*, hepatitis C virus; *IVDU*, intravenous drug use; *PMH*, past medical history.

Figure 2. Example of the best practice advisory notice that appears when a complete blood count is ordered. *FOCUS*, Frontlines of Communities in the United States; *Hep*, hepatitis.

Analysis was performed with SAS 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

From August 1, 2018–May 31, 2019, a total of 10,812 patients were screened with the BPA-initiated HCV screening protocol, triggering 6702 completed HCV Ab tests (62%). A total of 4077 of 7080 (58%) eligible patients were tested for HCV Ab before and 2625 of 3732 (70%) eligible patients were tested for HCV Ab after reflex testing was begun (Table 1). The rate at which clinicians in the ED accepted the BPA suggestion to order the HCV Ab test increased from 58% in the five-month period before reflex testing was started to 70% in the five-month period after reflex testing was begun. Prior to reflex testing implementation, 233/425 (55%) patients with a positive HCV Ab test had an HCV vRNA test performed, whereas 270/323 (84%) patients with a positive HCV Ab test result had vRNA testing after reflex testing implementation (OR, 4.2; 95% CI, 3.0-6.0; P <0.001).

For all patients included in this analysis, the HCV Ab positivity rate was 11.2% (748/6702), whereas the HCV vRNA positivity rate was 62.6% (315/503). Rates of positive HCV Ab and HCV vRNA were similar before and after reflex testing implementation (Table 1). Of the potentially eligible patients with positive HCV Ab test results who could be linked to care, 45 (10.6%) were linked to care before HCV reflex implementation and 46 (14.2%) were linked to care with reflex testing (OR, 1.4; 95% CI, 0.9-2.2; P = 0.130). Of the 91 patients linked to care, 58 patients were linked to care within our health system. Of those 58 patients linked to care in our health system, 22 (38%) patients had negative HCV vRNA testing after initiation of HCV treatment indicating cure of disease. Team member estimates of the time spent coordinating linkage to care prior to reflex testing was 51 minutes per patient before reflex testing compared to 28 minutes per patient after reflex testing was initiated. The time

Table 1. Hepatitis C virus screening and linkage to care before and after initiation of reflex testing. *P < 0.001, chi-square test comparing viral RNA tests completed pre- and post-reflex testing.

	Study phase		
	Pre-reflex testing August 1, 2018-December 31, 2018 No. (%)	Post-reflex testing January 1, 2019-May 31, 2019 No. (%)	Entire study period August 1, 2018-May 31, 2019 No. (%)
HCV Ab BPA fires	7,080	3,732	10,812
HCV Ab BPA triggered orders	4,077 (58)	2,625 (70)	6,702 (62)
HCV Ab tests positive (% of orders triggered)	425 (10.4)	323 (12.3)	748 (11.2)
HCV vRNA tests completed (% of those ordered)	233 (55)	*270 (87)	503 (67)
HCV vRNA tests positive (% of those completed)	145 (62.2)	170 (63)	315 (63)
Patients linked-to-care (% of positive Ab tests)	45 (10.6)	46 (14.2)	91 (12.2)

Ab, antibody test; *BPA*, best practices advisory; *HCV*, hepatitis C virus; *vRNA*, viral RNA.

saved was largely due to eliminating steps required to contact patients and have them return to the laboratory for HCV vRNA testing prior to linkage to care.

DISCUSSION

In this study, we observed that after implementing a reflex testing initiative into an HCV screening program in the ED, the percentage of patients who received an HCV vRNA test after having had a positive HCV Ab test result significantly increased. We also saw that HCV vRNA reflex testing was associated with a numerical increase in linkage to care for HCV Ab-positive patients; however, these results did not reach statistical significance. Additionally, we saw that the team member time spent to link patients to care was decreased when reflex testing was used. Given that HCV vRNA test results were positive for 62.6% of our patients who had a positive HCV Ab test result, our rate of linking 14.2% of HCV Ab-positive patients to care after implementing reflex testing represents just under one quarter of patients who could potentially have been linked to care. The importance and value of HCV vRNA reflex testing with an HCV screening program is yet to be described in the literature, and our pilot quality improvement study suggests that it may be a good strategy for improving HCV surveillance and care.

In the United States, there is a paucity of published literature addressing the importance and efficacy of HCV vRNA reflex testing. Studies in Spain have reported an increased prevalence of HCV vRNA reflex testing in Spanish hospitals after specialty societies advocated for reflex testing and improvement of patient linkage to care after implementation of reflex testing.[14,15] Reflex testing has been noted to promote a high percentage of HCV vRNA tests for patients with positive HCV Ab tests in an ED HCV screening program; however, the relative increase in HCV vRNA tests done, the impact on linkage to care, and quantification of time saved were not quantified.[16] The high percentage of HCV vRNA tests done in that study (approaching 98%) is a testament to the thoughtfulness and pre-planning undertaken prior to the implementation of their HCV screening program.

Over our 10-month study period, the BPA-initiated, EHR-based HCV screening program showed an increase in the rate at which the emergency clinicians accepted the BPA suggestion to order an HCV Ab test. Our overall BPA acceptance rate of 62% compares favorably to another study that measured this metric.[16] This is likely the result of increased clinician familiarity and confidence with the HCV screening program. Because some clinicians may be uncomfortable ordering tests that are not directly relevant to the patient's presenting concern, ongoing education regarding the HCV screening program among residents, staff physicians, and mid-level healthcare staff is important for the success of the program. In addition, follow-up and sharing of patient success stories with healthcare clinicians and nursing staff are critical to a successful program.

In our study, fewer HCV Ab tests were performed after the start of reflex testing than were done before reflex testing, which might be explained by a smaller cohort of eligible patients after program initiation; however, despite the lower number of tests done, a higher percentage of patients with a positive Ab test had vRNA testing performed when reflex testing was active. The screening program was designed so that after a patient has had HCV Ab testing in their record, a BPA will no longer prompt the emergency clinician to order testing. We now intend to expand the HCV screening protocol to correspond to new CDC guidelines, which recommend screening all patients 18 years and older at least once in a

lifetime. For those at higher risk, such as patients who use IV drugs, we will program the EHR algorithm to prompt for a new test annually, even if the patient has a negative HCV Ab test result in the health record.

While HCV vRNA reflex testing is designed to be implemented for 100% of HCV Ab-positive samples, our results showed an 84% completion rate. This was almost entirely due to inadequate volume of the initial sample as indicated by the laboratory comment "quantity not sufficient," which suggests that initial testing protocols can be improved to reduce technical problems in the testing pipeline. The HCV Ab test requires 50 microliters (μL) of serum while HCV vRNA testing requires a minimum of 700 μL of serum or plasma. A 2014 study using a simulation model to assess interventions that might improve HCV treatment rates suggested the need for interventions that focus on multiple points within the trajectory of care,[17] and this observation highlights the need for attention to even small details such as sample acquisition.

Our institution strives to increase the percentage of HCV patients linked to care and decrease the number of patients lost to follow-up, but a range of issues makes this challenging. Restricting the eligible clinicians who treat HCV (limited to hepatology and infectious disease) can create extended appointment wait times and limit efforts at establishing linkage to care. Also, our patient population generally has limited access to certain resources, such as a lack of communication devices, transportation, and social support, as well as having concomitant poverty and substance use disorders, which could hinder linkage-to-care efforts. Sobriety restrictions on treatment medications also hinder the overall goal of eliminating HCV. Current efforts to overcome our challenges in linkage to care include a text message campaign to contact patients and the development of a real-time, EHR-based notification process to notify the project team when patients previously deemed lost to follow-up register to be seen in our ED. Telehealth and e-visits could also potentially increase the likelihood that patients can be linked to care. These efforts, combined with increased collaboration with our local and state health departments, are underway to improve our linkage-to-care rates.

While our time estimates for linkage to care from the team member survey are admittedly rudimentary, estimating the amount of time needed for team member staff to successfully implement and operate an HCV screening program is critical to future efforts to eliminate HCV. Additionally, given our time estimates, an HCV vRNA reflex component added to an HCV screening program may cut necessary staff time by nearly half and, therefore, should be considered an essential component to implementation of a program. Our time calculations represented the minimal amount of time needed to follow the linkage-to-care process and did not address the multitude of challenges that come with this process. Challenges include patient transportation issues, missed appointments, language barriers, and often multiple telephone call attempts needed for each step in the process.

With respect to cost, our institution charges $7 for each HCV Ab test and $120 for each HCV vRNA test. We performed 6702 HCV Ab tests and 503 HCV vRNA tests in this analysis with total laboratory charges of $107,274. Of the 91 patients linked to care, 58 had follow-up in our health system allowing for further chart review and 22 (38%) of those had negative HCV vRNA testing after HCV treatment, indicating cure of disease. Extrapolation of that percentage to all patients linked to care would yield approximately 35 patients cured of disease. Therefore, the cost of HCV screening would be approximately $1179 per patient linked to care and $3064 per patient cured of disease. It is important to note that private and public insurers typically pay a fraction of charged costs; thus, true financial costs are likely lower than these estimates. Differences in prevalence of disease in other settings would impact these estimates.

Reimbursement for the services of healthcare navigators might be another cost-effective measure to create a self-sustaining HCV screening program and make strides in efforts to eliminate HCV. The long-term goal for our HCV screening program is to create a self-sustaining program that aids the common goal of eliminating HCV. Implementing HCV vRNA reflex testing could significantly decrease cost, time, and effort needed to reach the goal of self-sustainability.

LIMITATIONS

There are several limitations to this study that are inherent to the nature of public health qualitive improvement initiatives. Study members were not blinded to outcomes, which may have generated bias in the linkage-to-care rate. It is also possible that a small percentage of the patients in the cohort after HCV vRNA reflex implementation had their HCV vRNA tests run using the pre-implementation algorithm, as their samples may have returned as "quantity not sufficient." Reliable contact information for patients was also a limitation and may have resulted in incomplete data collection. The methods used to estimate the time needed to link the patients to care may not be generalizable and may vary by healthcare clinician, depending on ability and level of training. Due to limitations of data collection methods, we were unable to obtain the statistics to determine the percentage of patients the BPA fired for due to age cohort criteria vs IV drug use criteria.

CONCLUSION

Implementing a reflex testing initiative into an HCV screening program in the ED can result in an increase of the percentage of patients who receive an HCV vRNA test after having had a positive HCV Ab. Therefore, reflex testing should be considered as part of an ED-based HCV screening program. The HCV vRNA reflex testing was not associated with a statistically significant increase in linkage-to-care rates for HCV Ab-positive patients; however, further studies are required.

Preliminary results from this study were accepted for presentation at the Society of Academic Emergency Medicine 2020 Virtual Meeting, May 12-15, 2020.

ACKNOWLEDGMENTS

The authors would like to thank the Gilead Sciences FOCUS team and specifically Monique Rucker for her partnership in this work. Additionally, the authors would like to thank Karla Passalacqua, PhD, of Henry Ford Hospital Graduate Medical Education for her extensive editorial support. Lastly, the authors would like to thank Stephanie Stebens, MLIS, of Henry Ford Hospital Sladen Library for her expertise in formatting the manuscript.

Address for Correspondence: Jacob J. Manteuffel, MD, Henry Ford Hospital, Department of Emergency Medicine, 2799 W. Grand Blvd CFP 253, Detroit, MI 48202. Email: jmanteu1@hfhs.org.

Conflicts of Interest: By the WestJEM 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 work was supported in part by grant funding through the Frontlines of Communities in the United States (FOCUS), Gilead Sciences. FOCUS funding supports HIV, HCV, and HBV screening and linkage to the first medical appointment after diagnosis. FOCUS partners do not use FOCUS awards for activities beyond linkage to the first medical appointment. Dr. Manteuffel and Dr. Miller have received partial salary support from the Gilead Sciences FOCUS grant.

REFERENCES

1. Wilkins T, Akhtar M, Gititu E, et al. Diagnosis and management of hepatitis C. *Am Fam Physician.* 2015;91(12):835-42.
2. U. S. Preventive Services Task Force, Owens DK, Davidson KW, et al. Screening for hepatitis C virus infection in adolescents and adults: US Preventive Services Task Force Recommendation Statement. *JAMA.* 2020;323(10):970-5.
3. Sidlow R, Msaouel P. Improving hepatitis C virus screening rates in primary care: a targeted intervention using the electronic health record. *J Healthc Qual.* 2015;37(5):319-23.
4. World Health Organization. Hepatitis C fact sheet. 2020. Available at: http://www.who.int/mediacentre/factsheets/fs164/en/ Accessed February 23, 2021.
5. Linas BP, Hu H, Barter DM, et al. Hepatitis C screening trends in a large integrated health system. *Am J Med.* 2014;127(5):398-405.
6. Mehta N, Carey W, Alkhouri N, et al. Hepatitis C. 2017. Available at: http://www.clevelandclinicmeded.com/medicalpubs/diseasemanagement/hepatology/hepatitis-C/. Accessed February 24, 2021.
7. Shepard CW, Finelli L, Alter MJ. Global epidemiology of hepatitis C virus infection. *Lancet Infect Dis.* 2005;5(9):558-67.
8. Schillie S, Wester C, Osborne M, et al. CDC recommendations for hepatitis C screening among adults - United States, 2020. *MMWR Recomm Rep.* 2020;69(2):1-17.
9. Sanchez TH, Sullivan PS, Rothman RE, et al. A novel approach to realizing routine HIV screening and enhancing linkage to care in the United States: protocol of the FOCUS Program and early results. *JMIR Res Protoc.* 2014;3(3):e39.
10. Ryerson AB, Schillie S, Barker LK, et al. Vital Signs: Newly reported acute and chronic hepatitis C cases - United States, 2009-2018. *MMWR Morb Mortal Wkly Rep.* 2020;69(14):399-404.
11. Blackwell JA, Rodgers JB, Franco RA, et al. Predictors of linkage to care for a nontargeted emergency department hepatitis C screening program. *Am J Emerg Med.* 2020;38(7):1396-1401.
12. Calner P, Sperring H, Ruiz-Mercado G, et al. HCV screening, linkage to care, and treatment patterns at different sites across one academic medical center. *PLoS One.* 2019;14(7):e0218388.
13. White DA, Anderson ES, Pfeil SK, et al. Hepatitis C virus screening and emergency department length of stay. *PLoS One.* 2016;11(10):e0164831.
14. Crespo J, Lazaro P, Blasco AJ, et al. Hepatitis C reflex testing in Spain in 2019: a story of success. *Enferm Infecc Microbiol Clin.* 2021;39(3):119-26.
15. Casas MP, García F, Freyre-Carrillo C, et al. Towards the elimination of hepatitis C: implementation of reflex testing in Andalusia. *Rev Esp Enferm Dig.* 2020;112(7):515-9.
16. Schechter-Perkins EM, Miller NS, Hall J, et al. Implementation and preliminary results of an emergency department nontargeted, opt-out hepatitis C virus screening program. *Acad Emerg Med.* 2018;25(11):1216-26.
17. Linas BP, Barter DM, Leff JA, et al. The hepatitis C cascade of care: identifying priorities to improve clinical outcomes. *PLoS One.* 2014;9(5):e97317.

Cloud-Based Influenza Surveillance System in Emergency Departments Using Molecular-Based Testing: Advances and Challenges

Kathryn Shaw-Saliba, ScM, PhD* *Department of Emergency Medicine, Johns Hopkins University School of Medicine, Baltimore, Maryland
Bhakti Hansoti, MBChB, MPH, PhD*
Howard Burkom, MS† †Applied Physics Laboratory, Johns Hopkins University, Laurel, Maryland
Diego A. Martinez, MSc, PhD*‡ ‡School of Industrial Engineering, Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile
Anna DuVal, BA, MPH*
Brian Lee, MPH§¶ §Office of the Chief Information Officer, Office of the Chief Operating Officer, Centers for Disease Control and Prevention, Atlanta, Georgia
Phong Chau, BS, MBA‖ ¶Department of Engineering and Software, Cepheid, Sunnyvale, California
Breanna McBride, BSc*
Yu-Hsiang Hsieh, MS, PhD* ‖Biomedical Advanced Research and Development Authority, US Department of Health and Human Services, Washington, District of Columbia
Vidiya Sathananthan, MD#
David Persing, MD, PhD‖ #Johns Hopkins University School of Medicine, Department of Emergency Medicine, Baltimore, Maryland
Michael Turnlund, MS‖
Roxanne Shively, MS** **National Emergency Department Influenza Consortium Site Leads: Greg Moran, David Talan (UCLA Olive View, Sylmar California), Frank Lovecchio (Maricopa Medical Center, Phoenix, Arizona), Mark Steele (Truman Medical Center, Kansas City, Missouri)
Andrea Dugas, MD, PhD*
Richard E. Rothman, MD, PhD*

Section Editor: Jeffrey Druck, MD
Submission history: Submitted April 10, 2021; Revision received July 27, 2021; Accepted September 18, 2021
Electronically published February 14, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.9.52741

Introduction: Electronic influenza surveillance systems aid in health surveillance and clinical decision-making within the emergency department (ED). While major advances have been made in integrating clinical decision-making tools within the electronic health record (EHR), tools for sharing surveillance data are often piecemeal, with the need for data downloads and manual uploads to shared servers, delaying time from data acquisition to end-user. Real-time surveillance can help both clinicians and public health professionals recognize circulating influenza earlier in the season and provide ongoing situational awareness.

Methods: We created a prototype, cloud-based, real-time reporting system in two large, academically affiliated EDs that streamed continuous data on a web-based dashboard within hours of specimen collection during the influenza season. Data included influenza test results (positive or negative) coupled with test date, test instrument geolocation, and basic patient demographics. The system provided immediate reporting to frontline clinicians and to local, state, and federal health department partners.

Results: We describe the process, infrastructure requirements, and challenges of developing and implementing the prototype system. Key process-related requirements for system development included merging data from the molecular test (GeneXpert) with the hospitals' EHRs, securing data, authorizing/authenticating users, and providing permissions for data access refining visualizations for end-users.

Conclusion: In this case study, we effectively integrated multiple data systems at four distinct hospital EDs, relaying data in near real time to hospital-based staff and local and national public health entities, to provide laboratory-confirmed influenza test results during the 2014-2015 influenza season. Future innovations need to focus on integrating the dashboard within the EHR and clinical decision tools. [West J Emerg Med. 2022;23(2)115–123.]

INTRODUCTION

There are approximately 140,000-710,000 hospitalizations and 12,000-56,000 deaths from seasonal influenza, and influenza-related cases occur annually in the US.[1,2] The severity of a given influenza season varies widely and is determined by a myriad of factors, including characteristics of circulating viruses, the timing of the season, vaccine utilization, and vaccine effectiveness.[2,3] Physician awareness of the diagnosis associated with rapid influenza diagnostics has been shown to significantly reduce the number of laboratory tests and radiographs ordered. Furthermore, diagnostic awareness is associated with decreased antibiotic use rates, increased use of antivirals, and decreased length of time to discharge from the emergency department (ED).[4,5]

Given the seasonality of influenza, real-time situational awareness serves to inform clinical decision-making and helps with preparedness within the institution and community, as well as nationally. For example, in response to the US Centers for Disease Control and Prevention (CDC) efforts to strengthen global influenza surveillance, 39 countries participated in a program that strengthened their ability to use national influenza data in decision-making in several ways: 1) drive updates to national pandemic preparedness plans; 2) create evidence-based vaccine guideline; 3) determine the best use of antiviral medications; and 4) determine the need for community mitigation measures such as school closures.[6,7]

The CDC tracks the severity of each influenza season through compilation and analysis of various data types, including laboratory test results from respiratory specimens (virologic surveillance); outpatient reports of influenza-like illness (ILI) (syndromic surveillance); influenza-associated deaths (mortality surveillance); laboratory-confirmed influenza-associated hospitalizations (hospitalization surveillance); and estimated geographic spread of influenza activity by state (geographic surveillance).[8,9] This data is collected from disparate organizations and then sent to and collated by the CDC. Notably, a systematic review of ED-based surveillance reported delays of up to 21 days before sentinel surveillance data is shared and up to 24 days before virological confirmation, which reports data with age stratification.[10] Even cloud-based surveillance strategies, such as Wikipedia, have intrinsic delays of up to 10 days, related in part to the need for manual data uploads.[11]

Reducing reporting lag-time is key to real-time surveillance. Two reporting systems based on ILI have been described: the autoregressive electronic health record support vector machine (ARES), which couples ILI visit data with historical patterns of influenza activity; and Flu Near You, a crowdsourcing method that relies on self-reported ILI.[12,13] Even though both systems report real-time data, their reliance on ILI (vs direct laboratory diagnostic test data) is limiting, given that the influenza cases reported have not been confirmed. Recently, several cloud-based reporting systems, which take advantage of newer, real-time molecular diagnostic assays, have been reported.[6,14] These systems represent an important step forward since they permit more timely aggregate molecular diagnostic assay results. Limitations still remain, including lack of field testing of these systems in EDs and limitations in data reporting (ie, lack of incorporation of demographic data in association with influenza test results).[6,7,15,16]

Given the above shortfalls, investigators at Johns Hopkins University worked with scientists at Cepheid (Sunnyvale, CA), a molecular diagnostics company, and the Biomedical Advanced Research and Development Authority of Health and Human Services (BARDA/HHS) to create a prototype cloud-based, real-time influenza surveillance system, which was implemented in four US EDs. The system was designed with the expressed goal of integrating data from ED triage with near point-of-care molecular testing from multiple EDs, using a data aggregation platform that permitted sharing basic demographic data elements from the electronic health record (EHR). Data was made immediately available to relevant end-users (ie, frontline clinicians, hospital administrators, and local and national public health entities) on a secure, web-based interface. In this report, we describe the methods and challenges encountered with the creation of a multicenter, cloud-based influenza reporting system and discuss opportunities for future development.

Population Health Research Capsule

What do we already know about this issue?
Real-time pandemic surveillance is necessary and important to support clinical decision-making.

What was the research question?
What are the structural challenges to connecting laboratory results to clinical data and making it available to end-users in real time?

What was the major finding of the study?
An essential services for interoperability framework can be used effectively to overcome design challenges, to build solutions that are effective across facilities.

How does this improve population health?
Real-time acess to surveillance data can aid clinical and public health decision-making to improve patient outcomes and inform preparedness activities.

METHODOLOGY

Case Description

This is a case study of a prototype integrated surveillance strategy that combines molecular testing data with clinical demographics. The objective of this pilot system was to build a data management and connectivity process across multiple data systems while also linking multiregional EDs, their neighboring health departments, and epidemiologists at the CDC. The secondary objective of this activity was to document the process for system integration and develop a blueprint for implementation. The overarching goal is to enable aggregation and interpretation of data across multiple sites for real-time molecular surveillance of influenza employing a cloud-based reporting system. This pilot system leveraged the National Emergency Department Influenza Consortium made up of four large, urban academically affiliated adult EDs: Johns Hopkins Hospital (JHH) (Baltimore, MD); Truman Medical Center (TMC) (Kansas City, Mo); Maricopa Medical Center (MMC) (Phoenix, AZ); and Olive View-UCLA Medical Center (UCLA) (Sylmar, CA).

Here we first describe the source data and then the regulatory and practical steps employed in pre-implementation and implementation, and review implementation challenges. The study was approved by the institutional review boards (IRB) at each site as an exempt study. The procedures within this activity were deemed a part of a quality improvement initiative.

Source Data

The study was conducted over two consecutive influenza seasons. The system was first developed and refined with feedback from end-users at two lead sites, JHH and UCLA, during the 2013-2014 influenza season. The final version of the system was subsequently rolled out at all four sites (adding TMC and MMC) during the 2014-2015 influenza season and included a clinical decision guideline that was integrated into each hospital's EHR to guide influenza testing, with sharing of demographic data into the cloud.[17] A comparison of the sites is provided in Table 1. All adult patients presenting to these EDs were systematically screened by nurses during triage. Nasopharyngeal specimens were collected from patients who met screening criteria and were immediately sent to the onsite laboratory for testing with Cepheid's on-demand molecular Xpert Flu assay, a rapid and highly sensitive polymerase chain reaction-based assay approved by the US Food and Drug Administration, which permitted differentiation of influenza A, B, and 2009 H1N1.[18,19] The test instruments were connected to a cloud-based data aggregation system with a secure, web-based interface allowing for the automatic upload of date and time of test completion and geolocation of the test instrument in addition to test results.

Pre-implementation: Site Preparation and Approvals

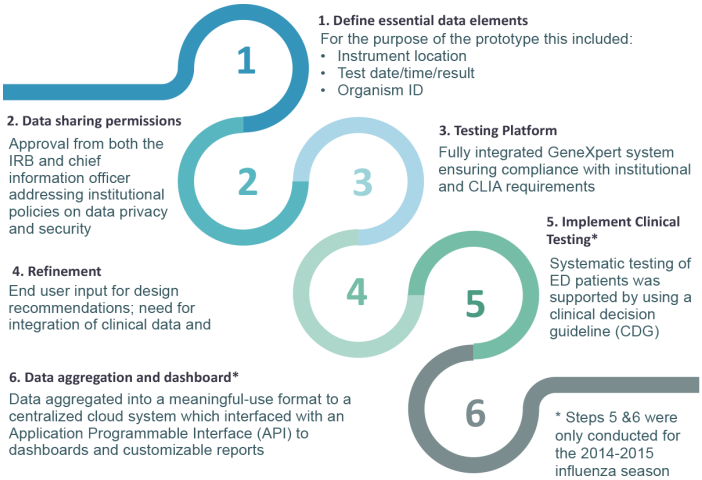


Figure 1. Preparatory steps for surveillance implementation.

The establishment of this prototype cloud-based influenza surveillance system required a series of preparatory steps (Figure 1) carried out across both influenza seasons. A participatory design approach was used to determine a priori end-user input for design recommendations to maximize the system utility during the 2013-2014 season at the two lead sites. Using an iterative approach, the system was then refined to include the collation of demographic data for the 2014-2015 flu season across all four sites. Each site obtained legal approval from their institutional information security

Table 1. Comparison of demographics, EMR, testing strategy and reporting by study sites.

Facility	Annual volume	Electronic health record	Influenza testing strategy pre-implementation	Data reporting pre-implementation
Site 1	66,000	EPIC	Physician gestalt, ie, testing based on the clinical determination of the treating physician (resident or attending).	Weekly reporting to Maryland DOH
Site 2	65,000	ORCHID		Weekly reporting to LAC DPH
Site 3	60,000	EPIC		Weekly report AZ DHS
Site 4	62,000	Cerner		Weekly reporting to KDHEKS

DOH, Department of Health; *LAC DPH*, Los Angeles County Department of Public Health; *AZ DHS*, Arizona Department of Health Services; *KDHEKS*, Kansas Department of Health & Environment.

office and their IRBs to permit sharing of de-identified project data with designated clinical and external public health partners' sites. Each site also worked with a representative from Cepheid to install the GeneXpert platform, creating the pathway for communicating GeneXpert test results with the laboratory information system software (LIS) and verifying local, secure, web-based connections between the GeneXpert platform and the RemoteXpert cloud.

Implementation: Data Aggregation and Visualization

Data from the Cepheid GeneXpert platform was automatically uploaded to the RemoteXpert cloud within two hours of specimen collection, and made immediately available via a web-based interface to affiliated end-users who were part of the study (Figure 2). The aggregated data in the RemoteXpert was stored in a secure, third-party hosting facility, which met the required national data security and protection guidelines and included failover features to minimize system downtime. An operational overview of the system is provided in Figure 3.

The RemoteXpert interface displayed full test results, including an interactive map with testing results by geographic location, test instrument, and other visualizations of results by subtype and location. Test results from the four EDs allowed real-time analysis of regional differences in disease burden and identified where current epidemics were occurring. Figure 4 shows a representation of each component of the dashboard, including the geocoding of the sites and a trendline of testing volume and result (Figure 4 Panel 1), a snapshot of testing results aggregated by demographics (Figure 4 Panel 2), a snapshot of influenza activity (Figure 4 Panel 3), and a trendline that compared current vs historical influenza activity (Figure 4 Panel 4). For more in-depth analyses, a "medical dashboard" was created, which permitted end-users to customize views of aggregated data. The portal provided specific instructions for formatting, displaying, and downloading data for local analysis. Additionally, full test-result listings with associated data were available for download in .csv format at any time, depending on end-user privileges.

The insert below (Figure 4) shows an example rendering of the data visualizations that includes the following: A. Daily summary of influenza activity; B. Monthly summary of influenza; C. Comparison of influenza daily activity over two years: and D. Demographics of positive influenza cases. In the pilot dashboard (data was provided by clinical sites) we were able to provide daily test results from the previous 14 days, as well as comparative data from the previous two years and the prior month; this allowed clinicians to quickly identify trends and frame with historical perspective. It was also possible to aggregate data by flu type and demographics, which we believe would influence clinical decision-making.

Access privileges to the system's web-based interface were defined at each site as follows: 1) "*Superusers*," the principal investigators and program manager; 2) "*Supernational readers*," staff at JHU, the BARDA, and CDC, who could access data from all sites; 3) *"Site coordinators*" with access to local data, test results, and local user sign-on information; and 4) "*Hospital-based users.*" Access control software provided each user one or more profiles, each associated with specific permissions. Profiles were established, and associated privileges were enabled when each user logged in.

RESULTS

The pilot cloud-based influenza surveillance system successfully displayed in near real-time a combined total of 5937 test results, including 1070 type-specific influenza positives, with associated geolocation, date, and time. Cumulative data on the implementation of the pilot cloud-based influenza surveillance system during the 2014-2015 season at all four study sites is provided in Table 2.

Strategies were implemented to manage the interoperability issues based on the Office of the National

Figure 2. Data flow for cloud-based data aggregation system.

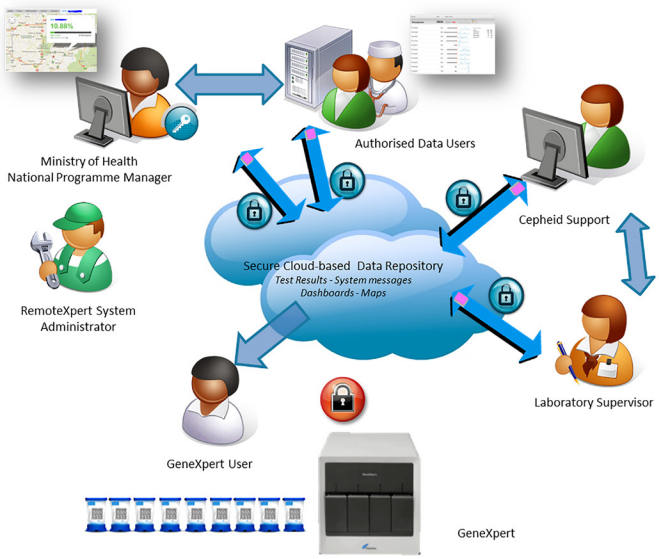


Figure 3. Schematic of architecture and data flow for the operational pilot surveillance system (RemoteXpert).

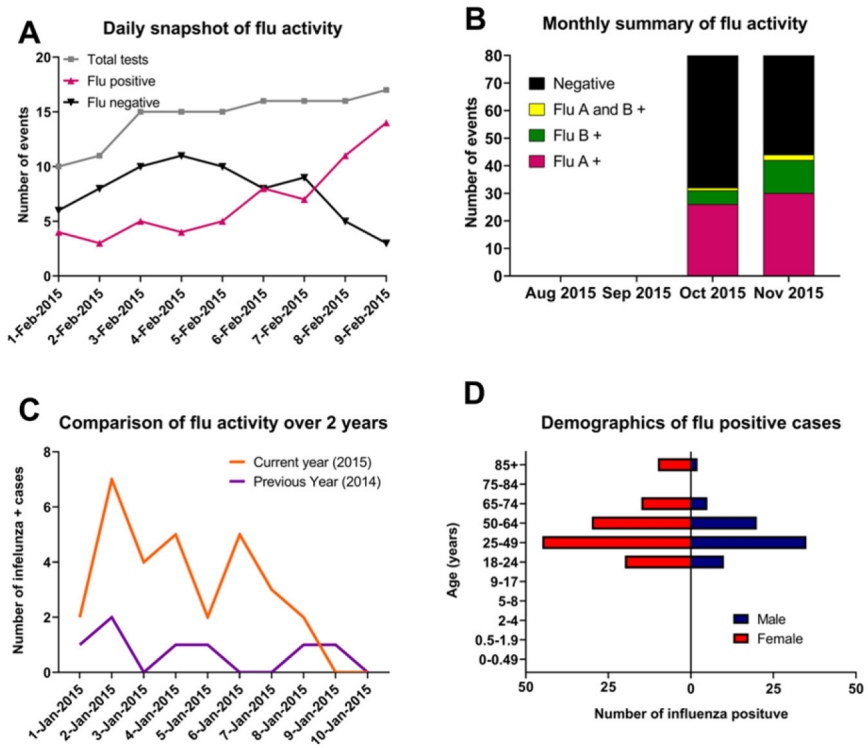


Figure 4. Rendering of the key data elements available on the RemoteXpert dashboard.

Coordinator for Health Information Technology (ONC) of the US Department of Health and Human Services, a summary of which is provided in Table 3. The ONC specifically seeks to enable an interoperable health information technology ecosystem that makes the "right data available to the right people at the right time" to support advances in access to care, quality of care, clinical awareness, and public health situational awareness.

DISCUSSION

We created and implemented a prototype influenza surveillance system that relied on molecular testing from triage workflow across multiple EDs and shared data in real time on a cloud-based server. When this project began, coupling laboratory-based influenza molecular tests with cloud-based reporting systems was in the earliest development phases. Since that time, two systems that specifically integrate respiratory molecular virology testing with cloud-based dashboards for clinicians and local public health users have been described.[6,14] Both systems, as well as the one presented here, represent an advancement in influenza surveillance methodology, decreasing the two-week lag time associated with traditional influenza surveillance approaches. The system's intrinsic architectural design guarantees immediate

Table 2. Cumulative data from the pilot implementation of the integrated influenza surveillance system.

	All sites	JHU	UCLA	MMC	TMC
Patients through department	126,539	33,500	42,091	24,681	26,267
Patients assessed by CDG N(%)	118,916 (94%)	30,516 (91%)	38,741 (92%)	23,603 (96%)	26,056 (99%)
Patient who met criteria N(%)	6,955 (6%)	2,079 (7%)	2,582 (7%)	1,368 (6%)	926 (4%)
Xpert Flu tests ordered N(%)	6,601 (95%)	2,000 (96%)	2,362 (91%)	1,313 (96%)	926 (100%)
Specimens collected N(%)	5,939 (90%)	1,710 (86%)	2,019 (85%)	1,284 (98%)	926 (100%)
Tests resulted N(%)	5,937 (100%)	1,710 (100%)	2,017 (100%)	1,284 (100%)	926 (100%)
Test results appearing in EHR N(%)	5,937 (100%)	1,710 (100%)	2,017 (100%)	1,284 (100%)	926 (100%)
Patients positive for influenza N(%)	1,070 (18%)	323 (19%)	367 (18%)	202 (16%)	178 (19%)

JHU, Johns Hopkins University; *UCLA*, University of California, Los Angeles; *MMC*, Madras Medical College, *TMC*, Texas Medical center; *CDG*, clinical decision guideline; *EHR*, electronic health record.

Table 3. Management of interoperability issues based on guiding principles of the Office of the National Coordinator for Health Information Technology.

ONC's essential services for interoperability	Project-specific task requirement	Issue	Management of issue
Accurately match individuals, providers, and their information across data sources.	Bi-directional data transfer to combine influenza test result, time, the location from GeneXpert with demographics	Required demographic details were stored in different systems (eg, LIS, EHR)	Data were manually entered by research coordinators into a laptop containing the test result data, combined, and uploaded to a cloud-based interface by means of Cepheid software.
Directories of the technical and human-readable endpoints for data sources, so they and the respective data are discoverable.	Provide access to test results from cloud-based systems to distributed user locations	No natural interface because of differences among users' proprietary systems.	Users accessed the system through a password-protected Cepheid site, where they could also designate upload destinations for further analysis.
Authorizing users to access data from the data sources	Provide end-users with a hierarchy of access privileges	None	A logical hierarchy of access privileges.
Authenticating users when they want to access data from data sources	Control access with individual user accounts	A mass invitation provided by Cepheid was rejected by some site firewalls	Access control and definitions were handled via the CanCan Ruby library, which provided a Declarative Authentication DSL for specifying model permissions and enforcing them at the controller level.
Securing the data when it is stored or maintained in the data sources and in transit, ie, when it moves between source and user	De-identified data must remain secure during transmission between local testing site and cloud-based system.	None	Test results entering the Cepheid cloud portal via a secured transport layer security channel were processed by a test results processor service to generate non-sensitive aggregations that the cloud software could leverage for analysis, visualization, technical support, and other administrative functions.
Representing data at a granular level to enable reuse	Transmit to CDC database using HL7 code and be accessible to other end-users via dashboards and comma-delimited files	Visualization and detailed data needs varied among users.	Dashboard designs for visualization were adapted from previous Cepheid systems and made available through a secure website in the Cepheid cloud. Designs were adapted to the needs of influenza surveillance users; for example, a "medical dashboard" allows inspection of data aggregated by location and laboratory.
Handling information from varied information sources in both structured and unstructured formats	The cloud-based system had to receive both test results and demographic data in available formats.	Demographic data were represented in different formats across user sites.	The Cepheid software for uploading and managing data accepted only structured data records; the correct structure from GeneXpert test results was automatic. However, site coordinators had to ensure formatting and completeness of demographic details merged from the LIS systems.

ONC, Office of the National Coordinator for Health Information Technology; *LIS*, laboratory information system software; *EHR*, electronic health record; *DSL*, domain-specific language.

delivery of molecular testing data (herein, from the GeneXpert device) to the varied end-users and eliminates any lag-time delays. The test result, date/time, and geolocation are continually pushed from the GeneXpert database to the RemoteXpert cloud, making test data available to the web application in real time.

One of the major obstacles we encountered was associated with institutional permissions (from the chief information officer) for sending basic demographic data (including gender, age group, and race) into the cloud. Furthermore, hospitals encountered unanticipated technical software connectivity challenges, preventing fully automated data feeds. In addition, while the software engineers from Cepheid were able to interface the GeneXpert instrument with the LIS, a technical obstacle was discovered when attempting to transmit LIS information directly into the cloud. An intermediate software solution was used as a bridge to address that

issue, permitting sites to manually pair demographic data elements with GeneXpert within the Xpert Reporter client user interface in real time prior to sending data into the cloud. Notably, since the time of this study, new software connectivity solutions have been designed (including that developed by Cepheid, coined "Cepheid 360 Sync"), which permits fully automated data feeds with a synchronized transfer of both demographic and molecular test directly into the cloud. This C360 system is now made available for all Cepheid GeneXpert customers as an embedded feature of the GeneXpert software, which comes with the set-up of the Cepheid instrument. The software includes information for laboratory customers to configure how much Protected Health Information (PHI) will be uploaded to the C360 cloud, which can be used both for disease monitoring and advanced analysis based on the specific needs of the end-user. Testing and evaluation of these approaches for research and public health use are now underway.

One notable limitation of the system we describe here was the requirement that end-users log on and access the dashboard. For this prototype evaluation, we did not systematically monitor how frequently that occurred. Nevertheless, informal feedback from users, including the public health stakeholders, was consistently positive, with many indicating that the system filled an important gap associated with timely information-sharing between disparate healthcare organizations. Future innovation should consider removing the requirement for a separate log-in with institutional permissions and/or delivering push notifications to the clinical workspace, ie, provide specific alerts to end-users when pre-specified influenza risk thresholds have been reached. Another limitation of this prototype system that challenged sustainability and uptake is that data access and sharing between local public health users and the CDC required extensive discussion with leadership at each site and the establishment of short-term agreements under a study protocol between entities at the time this project was carried out. Accordingly, while end-users (both clinician and public health) expressed interest in retaining the capability of the cloud-based reporting system, none did so.

Since the time this study was carried out, there have been notable advances in that there are now better established and streamlined pathways for end-user permissions under local, state, and federal jurisdictions.[21] Informally, end-user feedback indicated that one of the most valuable aspects of the system was the ease of use of the simple dashboard display. Most recently, we have seen with the advent of COVID-19 the rapid popularity of the Johns Hopkins University's COVID-19 dashboard, a user-friendly tool designed to track the outbreak as it unfolds. Here, all data collected and displayed have been made freely available initially through Google Sheets and later through a GitHub repository, along with the feature layers of the dashboard, which are now included in the Esri Living Atlas.[22,23]

Looking forward, the Centers for Medicare & Medicaid Services now requires hospitals to electronically share data, including laboratory results and syndromic surveillance data, with local, state, and federal agencies.[24,25] As observed in this study, however, hospitals can still experience technical and administrative barriers to rapid, timely sharing of information, and when seasonal illness rapidly surges, these delays may prove to be fatal flaws. With COVID-19, some advances have been implemented with multiple public health surveillance actions developed to improve detection of severe acute respiratory syndrome coronavirus (SARS-CoV-2) in the US, permitting tracking of its spread, in part through the establishment of national surveillance case definition with the addition of coronavirus disease to the list of notifiable conditions. Challenges in conducting effective case-based surveillance and the public health data supply chain remain, however, and have in part resulted in the relatively slow uptake of public health measures and ultimately failure to effectively curb the pandemic.[26] The ongoing information gaps stand as challenges to the clinical and public health response to influenza and other emerging pandemics. Now is the time and opportunity to implement meaningful surveillance from the frontlines of the healthcare system.

LIMITATIONS

In this paper we successfully present a case study of the implementation of a modular, access-based, secure, real-time influenza surveillance system. We did not seek to evaluate the implementation of the pilot integrated surveillance system and thus are unable to make assertions about the end-user experience, integration, and sustainability measures or impact on patient outcome. Furthermore, since the piloting of this system, several advances to the platforms themselves have been made, as noted in the discussion. Nevertheless, given the recent experience of the COVID-19 pandemic, a renewed focus on real-time surveillance strategies and an understanding of the system challenges to achieve this goal is needed.

CONCLUSION

The principal outcome of this project was the successful implementation of a prototype distributed, modular, access-based, secure, real-time influenza surveillance system that coupled molecular diagnostic test data with basic demographics. This system effectively integrated multiple data systems at four distinct hospital EDs, relaying data in near real time to hospital-based staff and local and national public health entities, which afforded timely local situational awareness of laboratory-confirmed influenza test results during the 2014-2015 influenza season. Future implementation strategies should focus on harnessing the full power of real-time regional and national influenza situational awareness, which could include push notifications to clinical decision-makers using adaptive clinical decision

guidelines informed by surveillance data, and to public health professionals to provide more timely monitoring and response to influenza. This cloud-based surveillance system yields data that is particularly useful for identifying the start of the influenza season, guiding surge management, and informing outbreak response in the event of a pandemic season, and could easily be adapted for other respiratory virus surveillance, such as SARS-COV-2.

Address for Correspondence: Richard Rothman, MD, PhD, Johns Hopkins University, Department of Emergency Medicine, 1800 Orleans Street, Baltimore, MD 21287. Email: rrothma1@jh.edu.

Conflicts of Interest: By the WestJEM 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. The study was supported by US Department of Health and Human Services Biomedical Advanced Research and Development Authority (BARDA) from the Assistant Secretary for Preparedness and Response, Department of Health and Human Services; agreement numbers IDSEP 130014-01-00 and 160031-01-00). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Assistant Secretary for Preparedness and Response or the Centers for Disease Control and Prevention. In addition, the authors would like to acknowledge the roles of David Persing and Michael Turnlund from the Department of Engineering and Software, Cepheid, Sunnyvale, CA; and Roxanne Shively from BARDA, US Department of Health and Human Services, Washington, DC, in making this work possible. Richard E. Rothman previously served on a Cepheid Advisory Board to evaluate the use of molecular diagnostics in ED settings. Dr. Andrea Dugas contributed to this manuscript in her private capacity. The views expressed in this article/speech do not represent the views of or endorsement by the United States Government or the FDA.

REFERENCES

1. Centers for Disease Control and Prevention. Disease Burden of Flu. 2021. Available at: https://www.cdc.gov/flu/about/burden/index.html. Accessed October 15, 2021.
2. Thompson MG, Shay DK, Zhou H, et al. Estimates of deaths associated with seasonal influenza --- United States, 1976-2007. *MMWR Morb Mortal Wkly Rep.* 2010;59(33):1057–62.
3. Skowronski DM, Chambers C, Sabaiduc S, et al. Interim estimates of 2016/17 vaccine effectiveness against influenza A(H3N2), Canada, January 2017. *Euro Surveill*. 2017;22(6):30460.
4. Bonner AB, Monroe KW, Talley LI, et al. Impact of the rapid diagnosis of influenza on physician decision-making and patient management in the pediatric emergency department: results of a randomized, prospective, controlled trial. *Pediatrics.* 2003;112(2):363-7.
5. Blaschke AJ, Shapiro DJ, Pavia AT, et al. A national study of the impact of rapid influenza testing on clinical care in the emergency department. *J Pediatric Infect Dis Soc.* 2014;3(2):112-8.
6. Christensen PA, Olsen RJ, Perez KK, et al. Real-time communication with health care providers through an online respiratory pathogen laboratory report. *Open Forum Infect Dis.* 2018;5(12):2–4
7. Lipsitch M, Finell L, Heffernan RT, et al. Improving the evidence base for decision making during a pandemic: the example of 2009 Influenza A/H1N1. *Biosec Bioterror.* 2011;9:89–115.
8. Centers for Disease Control and Prevention. Flu Activity & Surveillance. 2021. Available at: https://www.cdc.gov/flu/weekly/fluactivitysurv.htm. Accessed October 15, 2021.
9. Thompson WW, Comanor L, Shay DK. Epidemiology of seasonal influenza: use of surveillance data and statistical models to estimate the burden of disease. *J Infect Dis.* 2006;194(Supplement_2):S82-91.
10. Dailey L, Watkins RE, Plant AJ. Timeliness of data sources used for influenza surveillance. *J Am Med Inform Assoc.* 2007;14(5):626-31.
11. Hickmann KS, Fairchild G, Priedhorsky R, et al. Forecasting the 2013–2014 influenza season using Wikipedia. *PLoS Comput Biol.* 2015;11(5):e1004239.
12. Santillana M, Nguyen AT, Louie T, et al. Cloud-based electronic health records for real-time, region-specific influenza surveillance. *Sci Rep.* 2016;6:1–8.
13. Smolinski MS, Crawley AW, Baltrusaitis K, et al. Flu Near You: crowdsourced symptom reporting spanning 2 influenza seasons. *Am J Public Health.* 2015:105(10):2124–30.
14. Meyers L, Ginocchio CC, Faucett AN, et al. Automated real-time collection of pathogen-specific diagnostic data: syndromic infectious disease epidemiology. *JMIR Public Heal Surveill.* 2018;4(3):e59.
15. Thompson WW, Comanor L, Shay DK. Epidemiology of seasonal influenza: use of surveillance data and statistical models to estimate the burden of disease. *J Infect Dis.* 2006;194:S82–S91.
16. Lipsitch M, Riley S, Cauchemez S, et al. Managing and reducing uncertainty in an emerging influenza pandemic. *N Engl J Med.* 2009;361(2):112–5.
17. Dugas AF, Hsieh YH, LoVecchio F, et al. Derivation and validation of a clinical decision guideline for influenza testing in 4 US emergency departments. *Clin Infect Dis.* 2019;70(1):49-58.
18. Dugas AF, Valsamakis A, Gaydos CA, et al. Evaluation of the Xpert Flu rapid PCR assay in high-risk emergency department patients. *J Clin Microbiol.* 2014:52(12):4353–435.
19. Valentin T, Kieslinger P, Stelzl E, et al. Prospective evaluation of three rapid molecular tests for seasonal influenza in patients presenting at an emergency unit. *J Clin Virol.* 2019;111:29–32.
20. Coletta M, Lipskiy N, Birnbaum D, et al. S&I Public health reporting initiative: improving standardization of surveillance. *Online Journal of Public Health Informatics.* 2013;5(1).
21. Ryanb. ryanb/cancan: Authorization Gem for Ruby on Rails. 2009. Available at: https://github.com/ryanb/cancan. Accessed October

15, 2021.

22. Wang MH, Chen HK, Hsu MH, et al. Cloud computing for infectious disease surveillance and control: development and evaluation of a hospital automated laboratory reporting system. *J Med Internet Res.* 2018;20(8):e10886.
23. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real-time. *Lancet Infect Dis.* 2020;20(5):533-4.
24. Moore K, Black J, Rowe S, et al. Syndromic surveillance for influenza in two hospital emergency departments. Relationships between ICD-10 codes and notified cases, before and during a pandemic. *BMC Public Health.* 2011;11:338.
25. Blumenthal D, Tavenner M. The "meaningful use" regulation for electronic health records. *N Engl J Med*. 2010;363(6):501-4.
26. Hamilton JJ, Turner K, Cone ML. Responding to the pandemic: challenges with public health surveillance systems and development of a COVID-19 national surveillance case definition to support case-based morbidity surveillance during the early response. *J Public Health Manag Pract*. 2021;27 Suppl 1:S80-S86.

Clinician Absences and Contributing Factors During a COVID-19 Surge: Potential Areas for Intervention and Planning

Daniel Grahf, MD
Jad Dandashi, MD
John Deledda, MD
Phyllis Vallee, MD
Taher Vohra, MD

Henry Ford Hospital, Department of Emergency Medicine, Detroit, Michigan

Section Editor: Leon Sanchez, MD, MPH
Submission history: Submitted April 7, 2021; Revision received September 13, 2021; Accepted November 3, 2021
Electronically published February 14, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.11.52715

Introduction: Our goal was to quantify healthcare clinician (HCC) absenteeism in the emergency department (ED) during the coronavirus disease 2019 (COVID-19) surge and to identify potential interventions that may mitigate the number of absences.

Methods: This was a retrospective, descriptive record review that included 82 resident physicians, physician assistants, and staff physicians who were scheduled to work more than three clinical shifts during March 2020 in an urban, academic ED that received a high number of coronavirus disease 2019 (COVID-19) patients. Exposure was defined as a healthcare clinician who was not wearing appropriate personal protective equipment (PPE) having contact with a confirmed COVID-19 positive patient in the ED. The main outcome was the number of HCC absences secondary to exposure to or symptoms concerning for COVID-19.

Results: During March 2020, of 82 ED HCCs, 28 (34%) required an absence from clinical duties, totaling 152 absentee calendar days (N = 13 women [46%]; N = 15 men [54%]). Median HCC age was 32 years (interquartile range 28-39), and median number of days absent was four (interquartile range 3-7). While 16 (57%) of the total absences were secondary to a known exposure, 12 (43%) were symptomatic without a known exposure. A total of 25 (89%) absent HCCs received COVID-19 testing (N = 5 positive [20%]; N = 20 negative [80%]) with test results returning in 1-10 days. Eleven (39%) symptomatic HCCs had traveled domestically or internationally in the prior 30 days.

Conclusion: Emergency departments should anticipate substantial HCC absences during the initial surge of a pandemic. Possible interventions to mitigate absences include early and broad use of PPE, planning for many asymptomatic HCC absences secondary to exposures, prioritizing HCC virus testing, and mandating early travel restrictions. [West J Emerg Med. 2022;23(2)124–128.]

INTRODUCTION

Emergency medicine plays an essential role during pandemics and epidemics, especially during initial phases. Without enough healthcare clinicians (HCC) at this critical time, patient care may become compromised.[1] This is also the time in which HCCs are most vulnerable to pathogen exposure.[2] Predictive models have shown that during a pandemic, up to 25-50% of a physician workforce could be absent at any given time secondary to illness and exposure.[3] One database showed that from March 1–May 31, 2020, HCCs accounted for approximately 6% of adults hospitalized with COVID-19.[4]

Other studies have shown an increase in HCC absenteeism correlating with the first weeks of the pandemic.[5] In a study in England, physician absences more than doubled during a COVID-19 surge with greater than 50% of those absences

related to COVID-19.[6] There is a notable paucity of literature describing the effect that the initial phases of a pandemic have on emergency department (ED) HCC absences or the possible interventions that could curb the number of absences.[7] This lack of data places frontline EDs at undue risk for inadequate HCC staffing at a time when patient care needs are greatest.[8]

The purpose of this study was to quantify HCC absenteeism in the ED during the outbreak of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus and to highlight the timing and factors associated with absenteeism. We conducted the study at an institution that experienced a substantial COVID-19 surge. Our goal was to provide insights for frontline departments where COVID-19 disease burden may yet occur and for potential future epidemics and pandemics.[9-11]

METHODS

Study Design and Setting

This was a retrospective, descriptive record review with a waiver of consent approved by the hospital institutional review board.

Selection of Participants and Data

We conducted the study in an urban ED that receives over 100,000 annual patient visits. The ED is staffed by 127 HCCs including resident physicians, advanced practice providers, and attending physicians. Healthcare clinicians who worked more than three clinical shifts during March 2020 were included in this study. The department created an external database that tracked HCC absences secondary to COVID-19 exposures or symptoms during the COVID-19 pandemic to assist with ED staffing. The database was blinded and then analyzed by the research team.

Definitions

Exposure was defined as a HCC without full personal protective equipment (PPE) having contact with a confirmed COVID-19 positive patient in the ED. Full PPE was defined as gloves, gown, eye protection, and mask. Surgical mask was acceptable except during any aerosolizing procedure, which then required a respirator mask. Symptomatic HCC screening varied over the study period, but primarily included fever, constitutional symptoms, respiratory symptoms, or gastrointestinal symptoms. Laboratory testing of nasopharyngeal swabs evaluated for the SARS-CoV-2 virus using polymerase chain reaction assay. Travel history was defined as any travel 30 days prior to exposure or symptom development.

Timeline of Events

Our first case of COVID-19 was confirmed on March 10, 2020. All institutional international and non-essential domestic travel was cancelled on March 11. On March 12, testing criteria were changed from a more targeted approach (Figure S1) to a much broader approach (Figure S2). Triage changes were implemented on March 13 to begin screening patients for COVID-19 symptoms and risk factors prior to entering the ED. A dedicated testing area for stable patients was created on March 17. On March 18, full PPE became required for all patient encounters. Employee health allowed asymptomatic, exposed HCCs to return to work while wearing a mask on March 20, whereas previously HCCs had been placed on home quarantine for 14 days. All exposures were still required to be reported. Nasal swabbing by providers in full PPE in a dedicated testing area was implemented on March 21.

Analysis

Descriptive statistics and graphical representations superimposed with explicit event dates were created using Microsoft Excel (Microsoft Corporation, Redmond, WA).

RESULTS

Study Subjects

During March 2020, there were 82 HCCs who worked more than three clinical shifts in the ED, and 28 (34%) who required an absence secondary to a COVID-19 exposure or symptoms for a total of 152 calendar absentee days. Of the 28 absences, 13 (46%) were women and 15 (54%) were men. The median age was 32 years (interquartile range [IQR] 28-39) and the median number of days absent was 4 (IQR 3-7).

Main Results

Of the total 28 HCC absences, 16 (57%) (N = 11 initially asymptomatic [69%], N = 5 initially symptomatic [31%]; N = 5 initially asymptomatic and went on to develop symptoms [31%]) were secondary to a known COVID-19 patient exposure and 12 (43%) were symptomatic without a known exposure (Figure 1). While 25 (89%) of those absent received COVID-19 testing, only five (20%) had positive results. Of those five who tested positive for COVID-19, four (80%) were symptomatic with no known exposure and one (20%) was symptomatic with a known exposure. A total of 11 (39%) HCCs with absences had traveled domestically or internationally, all were symptomatic, and four (36%) tested positive for COVID-19 (Figure1).

There were 24 (86%) new HCC absences from March 10–21 compared to seven (16%) after March 21 until March 31. Of the HCCs with exposure-related absences, 80% occurred on March 13 and 14. Twelve HCCs who were initially symptomatic had a negative test result. The time their tests took to result ranged from 1-10 days. The eight HCCs with results in less than five days were absent for an average of 3.3 days. The four HCCs with results in five or more days were absent for an average of 6.5 days.

DISCUSSION

After the first institutional case of COVID-19 was diagnosed, there was a large burden of HCC absenteeism (Figure 2). Data has shown that this can be a burden for patient care, as well as financially for institutions.[12] There

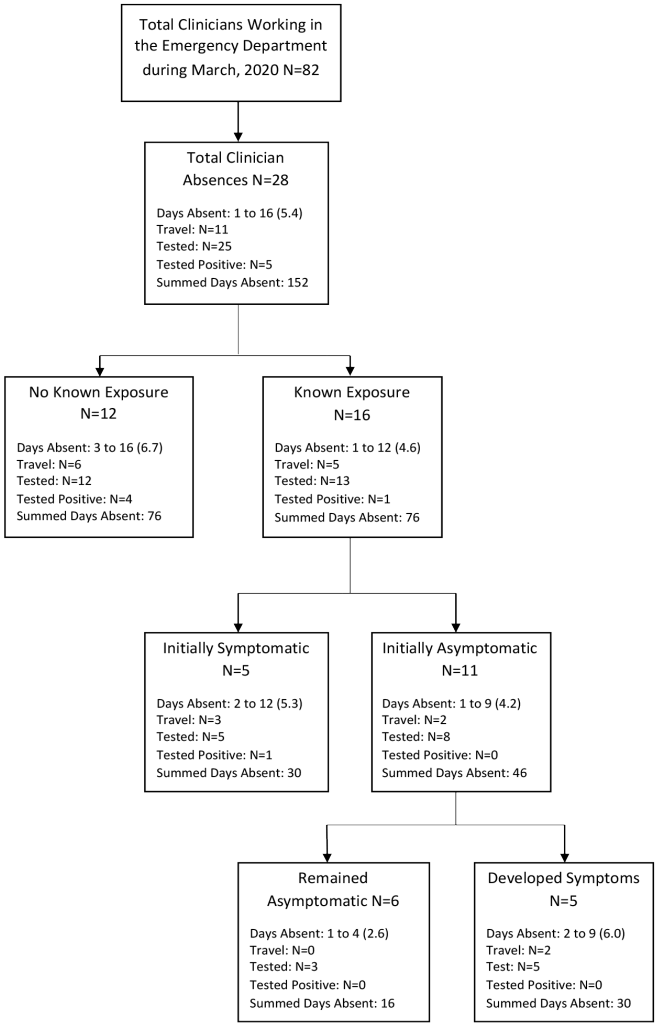


Figure 1. Breakdown of healthcare clinician absences* in the emergency department.
ED, emergency department.

are several areas of intervention that potentially could have decreased the number of absences, despite the large increase in new COVID-19 patients. These include patient isolation and PPE strategies, patient and HCC testing protocols, institutional policies on HCC exposures, and travel restrictions.

Figure 2 depicts HCC absenteeism during March 2020 with a superimposed timeline of significant events during this month. Total HCCs absent are represented in gray. New patients diagnosed with COVID-19 in the ED are represented in black per the day in which the patient was tested in the ED, which was not always the day in which their test resulted. The blue scatterplot trend line represents the date that HCCs who were not wearing full PPE were exposed to patients with COVID-19. There was typically a discrepancy between date of exposure and date of absence given the delay in patient test results. The yellow scatterplot trend line represents new symptom development concerning for COVID-19 in HCCs. Some of those HCCs were initially asymptomatic after an exposure and then went on to develop symptoms. The green scatterplot trend line represents new HCC absences per day secondary to either not wearing full PPE with exposure to a patient with COVID-19 or symptom development concerning for COVID-19.

During the early phases of the pandemic, the presumption was that there was not substantial community transmission. It was believed that suspected patients could be screened and appropriately grouped based upon symptoms, travel, and exposure history. What resulted was a cohort-based PPE approach where HCCs used full PPE only when treating higher risk patients. As COVID-19 cases increased, it became difficult to adequately screen patients based on what was an evolving symptom profile alone, especially critically ill patients who were initially triaged to resuscitation rooms. Concurrently and as the increased disease prevalence became evident, a more targeted testing strategy (Figure S1) rapidly expanded to encompass a broader group of patients (Figure S2), which led to variability in testing. Patients who were not identified and tested during an initial HCC encounter, and thus were not initially evaluated in full PPE, were sometimes tested by a subsequent HCC and found to be positive.

Due to the initial cohort-based PPE strategy and the variability resulting from the evolving testing strategy, 80% of HCCs with exposure-related absences were exposed on March 13 and 14, two days following the broadening of testing criteria on March 12. After implementing a robust, triage testing protocol where full PPE was required for every patient encounter and testing was performed preceding patient rooming in the main ED, there were no more exposure-related HCC absences despite continued increases in COVID-19 diagnoses (Figure 2). The substantial initial number of HCC absences may have been prevented with broad and consistent use of full PPE during the early stages of the pandemic, with transition to a more targeted approach after the disease presentation and local community prevalence was better quantified.[13-19]

Many of the early absences described were in asymptomatic HCCs who had an exposure. Initially, our institutional policy dictated all exposures without full PPE required a 14-day home quarantine. This accounted for 39% of the total absences (Figure 1). The policy was revised on March 20 allowing for asymptomatic HCCs to return to work with a mask. This resulted in a brisk decrease in total HCC absenteeism (Figure 2). Anticipating and planning for extra HCC coverage at institutions that have implemented more conservative return-to-work policies may ensure adequate HCC staffing.

The institutional policy regarding testing HCCs was quite variable over time given testing shortages. Initially, only those HCCs who were symptomatic were tested, but the implementation of this policy remained somewhat variable. Most COVID-19 tests for HCCs took days to result. The protocol for HCC testing initially categorized tests for HCCs as outpatient tests, and often did not prioritize them over inpatient tests. Waiting for a negative test result caused delays in return to work for many HCCs. Implementing rapid testing that prioritizes

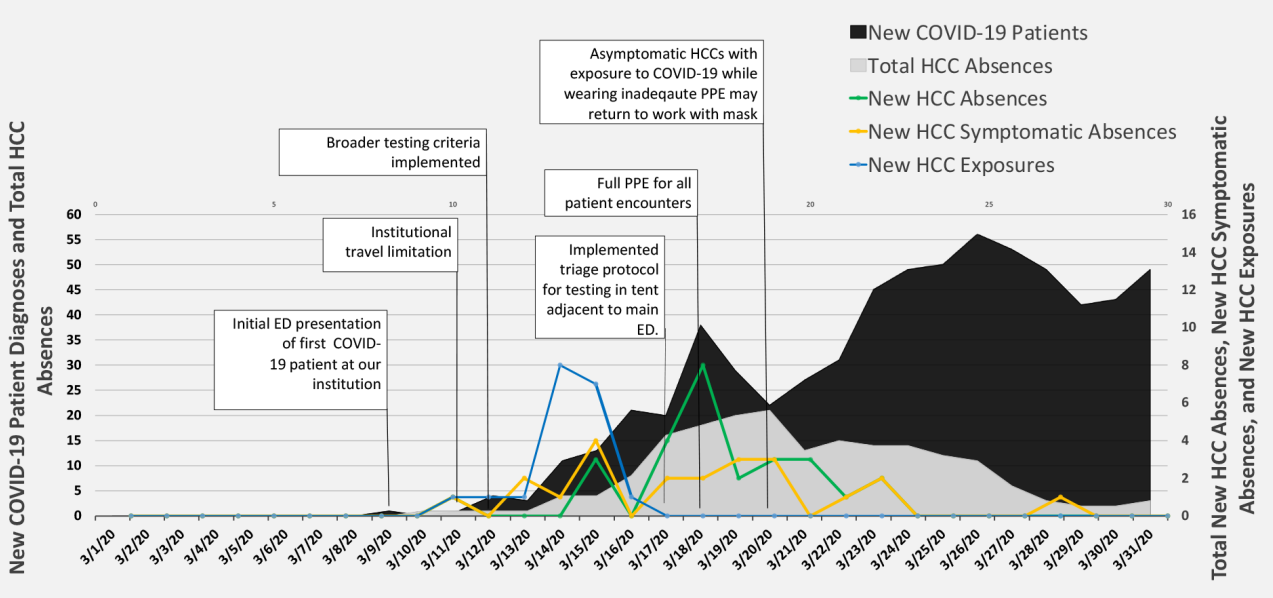


Figure 2. Healthcare clinician absenteeism and new patient diagnoses of COVID-19 in the emergency department.
HCC, healthcare clinician; *COVID-19,* coronavirus disease 2019; *PPE,* personal protective equipment; *ED,* emergency department.

HCCs may decrease days absent overall.[20] Others have suggested implementing more frequent temperature checks for employees, as well as creating teams of clinicians who always work the same shift to minimize interactions between teams.[21]

Of those who required an absence, 39% had engaged in domestic or international travel, and all were symptomatic. Interestingly, 80% of the HCCs who tested positive for COVID-19 had a travel history (Figure 1). Early HCC travel restrictions could lessen the number of HCC absences due to travel-associated transmission during pandemics.

LIMITATIONS

As a descriptive, retrospective study constructed from a database created for administrative purposes, the study is prone to selection bias and confounding variables. This limitation restricts the ability to determine causation. Additionally, the level of PPE compliance varied and, therefore, effectiveness cannot definitively be commented on. Community exposures were not tracked and may have contributed. Finally, the study was performed at a single center and may lack generalizability.

CONCLUSION

This study describes a large number of healthcare clinician absences that occurred during a COVID-19 surge. It identifies several possible interventions that could help decrease the number and duration of these absences. Broad and consistent use of full PPE and appropriate return-to-work guidelines for asymptomatic, exposed HCCs may reduce virus exposures, new absences, and total days absent. Prioritizing HCC testing and implementing HCC travel restrictions should be further explored as possible associated factors. These techniques may be used by other frontline departments to anticipate and limit HCC absenteeism during this pandemic and in future similar events.

Address for Correspondence: Taher Vohra, MD, Henry Ford Hospital, Department of Emergency Medicine, 2799 W Grand Blvd, Detroit, MI 48202. Email: TVohra1@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. Bernstein SL, Aronsky D, Duseja R, et al. The effect of emergency department crowding on clinically oriented outcomes. *Acad Emerg Med*. 2009;16(1):1-10.
2. Hoe Gan W, Wah Lim J, Koh D. Preventing intra-hospital infection and transmission of COVID-19 in healthcare workers. *Saf Health Work*. 2020;11(2):241-3.
3. Gupta N, Balcom SA, Gulliver A, et al. Health workforce surge capacity during the COVID-19 pandemic and other global respiratory disease outbreaks: a systematic review of health system requirements and responses. *Int J Health Plann Manage*.

2021;36:26-41.

4. Kambhampati AK, O'Halloran AC, Whitaker M, et al. COVID-19-associated hospitalizations among health care personnel - COVID-NET, 13 states, March 1-May 31, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69(43):1576-83.
5. Khonyongwa K, Taori SK, Soares A, et al. Incidence and outcomes of healthcare-associated COVID-19 infections: significance of delayed diagnosis and correlation with staff absence. Article. *J Hosp Infect*. 2020;106(4):663-72.
6. Appleby J. NHS sickness absence during the Covid-19 pandemic. *BMJ*. 2021;372:n471.
7. Garcia-Castrillo L, Petrino R, Leach R, et al. European Society For Emergency Medicine position paper on emergency medical systems response to COVID-19. *Eur J Emerg Med*. 2020;27(3):174-7.
8. Schwartz J, King CC, Yen MY. Protecting health care workers during the COVID-19 coronavirus outbreak: lessons from Taiwan's SARS response. *Clin Infect Dis*. 28;71(15):858-60.
9. Columbia University, Mailman School of Public Health E, Columbia Population Research Center, Built Environment and Health (BEH) Research Group. Severe COVID-19 risk mapping. 2020. Available at: https://columbia.maps.arcgis.com/apps/webappviewer/index.html?id=ade6ba85450c4325a12a5b9c09ba796c. Accessed May 8, 2020.
10. Institute for Health Metrics and Evaluation UoW. COVID-19 Projections. 2020. Available at: https://covid19.healthdata.org/united-states-of-america. Accessed April 14, 2020.
11. Parshley L. The coronavirus may hit rural America later — and harder. 2020. Available at: https://www.vox.com/2020/3/28/21197421/usa-coronavirus-covid-19-rural-america. Accessed April 14, 2020.
12. Maltezou HC, Giannouchos TV, Pavli A, et al. Costs associated with COVID-19 in healthcare personnel in Greece: a cost-of-illness analysis. *J Hosp Infect*. 2021;114:126-33.
13. Cheng VC, Tai JW, Wong LM, et al. Prevention of nosocomial transmission of swine-origin pandemic influenza virus A/H1N1 by infection control bundle. *J Hosp Infect*. 2010;74(3):271-7.
14. Cook TM. Personal protective equipment during the COVID-19 pandemic - a narrative review. *Anaesthesia*. 2020;7597):920-7.
15. Tan LF. Preventing the transmission of COVID-19 amongst healthcare workers. *J Hosp Infect*. 2020;105(2):364-5.
16. Ferioli M, Cisternino C, Leo V, et al. Protecting healthcare workers from SARS-CoV-2 infection: practical indications. *Eur Respir Rev*. 2020;29(155):200068.
17. Kamerow D. Covid-19: the crisis of personal protective equipment in the US. *BMJ*. 2020;369:m1367.
18. Ng K, Poon BH, Kiat Puar TH, et al. COVID-19 and the risk to health care workers: a case report. *Ann Intern Med*. 2020;172(11):766-7.
19. Seto WH, Tsang D, Yung RW, et al. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). *Lancet*. 2003;361(9368):1519-20.
20. Black JRM, Bailey C, Przewrocka J, et al. COVID-19: the case for health-care worker screening to prevent hospital transmission. *Lancet*. 2020;395(10234):1418-20.

Community Hospital Response to COVID-19 Outbreak

Nishad Abdul Rahman, MD
Kayla Guidry, MD
Elizabeth Danielle Brining, MD
David Liu, MD
Ngunyi Sandra Leke-Tambo, MD
Adrian Antonio Cotarelo, MD
Miriam Kulkarni, MD
Norman Mok, MD
Raffaele Milizia, MD

St. John's Riverside Hospital, Department of Emergency Medicine, Yonkers, New York

Section Editor: Elissa Perkins, MD, MPH
Submission history: Submitted February 27, 2021; Revision received September 11, 2021; Accepted September 10, 2021
Electronically published January 17, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.9.52294

Since early 2020, the world has been living through coronavirus disease 2019 (COVID-19). Westchester County, New York, was one of the hardest and earliest hit places in the United States. Working within a community emergency department amid the rise of a highly infectious disease such as COVID-19 presented many challenges, including appropriate isolation, adequate testing, personnel shortages, supply shortfalls, facility changes, and resource allocation. Here we discuss our process in navigating these complexities, including the practice changes implemented within our institution to counter these unprecedented issues. These adjustments included establishing three outdoor tents to serve as triage areas; creating overflow intensive care units through conversion of areas that had previously served as the ambulatory surgery unit, post-anesthesia care unit, and endoscopy suite; increasing critical care staff to meet unprecedented need; anticipating and adapting to medical supply shortages; and adjusting resident physician roles to meet workflow requirements. By analyzing and improving upon the processes delineated below, our healthcare system should be better prepared for future pandemics. [West J Emerg Med. 2022;23(2)129–133.]

BACKGROUND

Not since the 1918 "Spanish" influenza has a pandemic been comparable in clinical severity or transmissibility to coronavirus disease 2019 (COVID-19).[1,2,3] There has not been an opportunity in modern literature to record the intricacies of hospital surge planning required to withstand a pandemic of this nature. Early reports from China[4] and Italy[5] addressed pandemic surge changes made due to lack of critical care resources. A more recent, American-based model specific to community hospitals, the most common practice setting in the United States,[6] has not yet been reported.

Westchester County, New York, was the US epicenter of the initial viral surge, with the second greatest rate of COVID-19 cases per capita of any county within the state.[7] Our hospital, in the county's largest city Yonkers,[8] was severely impacted by the pandemic. Our institution is comprised of two acute care hospitals, St. John's Riverside Hospital – Andrus Pavilion (SJRH-AP) and St. John's Riverside Hospital – Dobbs Ferry (SJRH-DB) with a total of 150 inpatient beds in a community setting, outside the resources of the larger New York City tertiary care centers. Considering that community hospitals – defined as non-federal, short-term, general hospitals – comprise 85% (5198/6146) of all hospitals in the US,[6] our experience may provide translatable insights.

We present the challenges that SJRH faced and the key facility changes that were implemented during pandemic surge planning in our Westchester County community hospital as we progressed through our initial COVID-19 pandemic surge from March–July 2020.

Current Literature

Specific changes made at individual Chinese and Italian hospitals to counteract COVID-19 have been documented.[9,10]

However, there has been limited literature published concerning how individual hospitals responded to COVID-19 within the US. Information gleaned from this experience could prove to have utility in the ongoing worldwide battle against COVID-19, as well as potential future infectious disease outbreaks.

Westchester County COVID-19 Pandemic Impact and St. John's Riverside Hospital

As of July 1, 2020, the global cumulative confirmed COVID-19 cases totaled 10.6 million with 526,208 deaths. In the United States, >2.6 million cases were confirmed and >127,000 deaths were attributed to COVID-19, with cases continuing to increase at the time of writing.[7] Within New York State, Rockland County had the highest per capita case rate (4165 cases/100,000 persons), Westchester County had the second highest at 3604/100,000 persons, and New York City had the sixth highest with 2607 cases/100,000 persons.[7]

Our emergency department (ED) has approximately 46,000 annual visits. We are an academic site functioning as a teaching hospital, with two residency programs - emergency medicine and internal medicine. Yonkers is the largest city in Westchester County with 200,000 residents.[8]

DATA

Testing

From March 9-July 1, 2020, there were 7791 total ED patients under investigation (PUI) for COVID-19 at SJRH. Of these 7791 PUIs, 829 had positive COVID-19 swabs (10.6%). Notably, due to lack of testing availability, not all PUIs were swabbed for COVID-19, with some cases deemed to be suspicious for COVID-19 clinically by findings such as hypoxia, or by using radiographic signs such as ground-glass opacities on chest radiograph or chest computed tomography.

Admissions

Of the total 7791 PUIs, 2038 patients were admitted to the hospital (26.2%), 5467 were discharged home from the ED (70.2%) and 2038 were admitted to the hospital. Among the latter, 1178 patients were ultimately discharged from their inpatient hospitalization (1178/2038, 68.2%).

Mortality

Of the 2,038 PUIs who were admitted to the hospital, 153 died (overall inpatient PUI mortality of 7.5%). Of the total 7,791 PUIs, including those who did not test positive for COVID-19, there were 179 deaths (179/7,791, mortality rate among all PUIs of 2.2%). There were 26 PUIs who died before being admitted to the hospital (26/7,791, 0.3%). Of the 829 PUIs who were found to be COVID-19 positive, 168 patients died (168/829, mortality rate among COVID-19 positive PUIs of 20.2%).

Transfers

Our mortality data does not include the 222 patients (222/7,791, 2.8%) who were transferred to other facilities. Of those 222 patients, 128 were transferred during their ED visit (57.7%). An additional 94 admitted patients were transferred (94/222, 42.3%).

Surge Bed Capacity

Over the course of the pandemic, we improved our intensive care unit (ICU) capacity from an initial 12 beds to 55 ICU beds, an increase of over 450% from our usual critical care capacity (55/12, 458.3%). These beds were created using areas that had previously served as the ambulatory surgery unit (ASU), post-anesthesia care unit (PACU), and endoscopy suite (ENDO). Furthermore, we had more ventilated patients than ever, with as many as 65 ventilated patients within our hospital at peak including the ED, PACU, ASU, ENDO, and main ICU.

A total of 130 employees tested positive for COVID-19.

KEY LESSONS LEARNED

1. Establish a screening zone

The Tents: In anticipation of a surge in potential COVID-19 patients with unknown acuity, three screening tents were erected outside the ED ambulance bay (Figure). The first two tents were approximately 100 square feet each and were acquired by the hospital. A third, 800 square-foot tent was provided by the Westchester Department of Emergency Management. The large tent became the primary location for intake, medical screening, and discharging stable COVID patients. The original, smaller tents were used predominantly for diagnostic testing - one for radiographs and another for electrocardiograms, parenteral medications, and nebulizer treatments. Combined, these tents established approximately 25 evaluation spaces. Considering the rapid turnaround for most of these patients, this proved sufficient for even large volumes.

In accordance with the federal Emergency Medical Treatment and Labor Act and New York State regulations, our hospital bylaws identify nurse practitioners (NP) and physician assistants (PA) as qualified medical personnel capable of performing a medical screening exam; thus, all patients were screened and triaged to the appropriate treatment area based on illness severity by a NP or PA. To enhance rapid documentation, existing rapid medical evaluation notes were used. Discharge instructions were created and templated to expedite discharge, referrals, and return criteria.

Notably, the exponential surge of COVID-19 within New York and the limited availability of testing kits necessitated that our COVID-19 tests were reserved almost exclusively for patients with high illness severity requiring hospital admission. Per Department of Health testing guidelines at that time, many mildly symptomatic patients without hypoxia or other vital sign changes were evaluated in screening tents and discharged with public health referrals and without COVID-19 testing.

The Main ED: Patients with hypoxia, abnormal vital signs, or clinical distress were evaluated in the main ED. Patients who were triaged into the main ED provided their cell phone

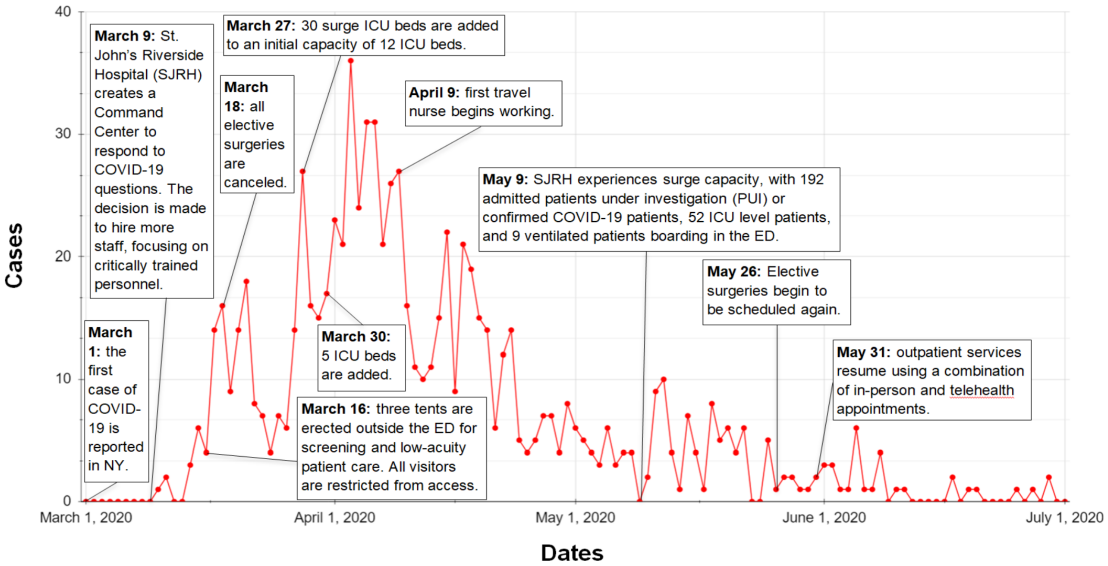


Figure. Timeline of key pandemic events compared with Saint John's Riverside Hospital confirmed COVID-19 cases (March 1, 2020-July 1, 2020).
ICU, intensive care unit; *COVID-19,* coronavirus disease 2019; *NY,* New York; *ED,* emergency department.

numbers to staff to be used for registration and history taking, thereby minimizing staff exposures. Emergency medical services (EMS) transporting patients via ambulance called an ED notification for suspected COVID-19 patients prior to arrival and were directed to either the screening tents or into the main ED based on illness severity. All healthcare workers wore personal protective equipment (PPE) within the screening tent and main ED for the entire duration of their clinical shifts.

2. Create overflow critical care units. (The ICU is not a place; it is a state of mind.)

Exponentially increasing ICU bed requirements necessitated expanded critical care capacity. All elective surgeries were canceled on March 16, 2020, allowing us to convert areas that had previously served as the ASU, PACU, and ENDO suite into makeshift ICUs staffed by clinicians with critical care training. This included 17 ASU beds, 12 PACU beds, and 12 ENDO beds at SJRH-AP, as well as 12 ASU beds, eight PACU beds, and one ENDO bed at SJRH-DF. Known COVID-19 positive patients often remained within the ED for extended periods, with a significant increase in our average length of stay (LOS) compared to the prior year (11 hours and 20 minutes during the study period compared to 8 hours and 58 minutes in 2019, representing a 26.4% increase in LOS). Thus, the ED came to serve as an adjunct fifth ICU with critical care teams rounding at the bedside.

Upon evaluation of our heating, ventilation and air conditioning (HVAC) systems, we discovered that the ASU and PACU units were part of a non-ducted system, which does not permit isolated air transport to individual rooms as a ducted system would. Individual, non-ducted units were fitted with portable, high-efficiency particulate air filters. Limited space led to admitted COVID-19 positive patients requiring ventilation being grouped into shared rooms, with as many as four patients to a room. Moving forward, our institution will be converting a non-telemetry floor to a ducted HVAC system with increased electricity supplies for ventilator use. This will serve as the ICU overflow unit for future surges that may similarly require extended ICU-level admissions.

We recommend that hospital systems prioritize and install ducted systems to facilitate rapid conversion into isolation rooms in the event of a pandemic surge.

3. Increase critical care staffing corresponding with patient volume.

The starkest personnel shortage we faced was the unprecedented need for critical care-trained nursing staff. We trained non-critical care, in-house nurses and hired a total of 41 travel nurses to meet the needs of the ED and ICUs, supplementing the previous 47 ED nurses and 29 ICU nurses. The nursing department provided courses on critical care medication and ventilator management to nurses with minimal prior ICU experience. Nursing supervisors reassigned nurses with ICU experience from other departments to staff the surge ICUs, forming teams composed of non-critical care nurses working under the supervision of a nurse with formal ICU training and experience.

New York's rigorous standards for medical clearances, licensing, credentialing, and hiring protocols challenged our institution's ability to quickly transition travel nurses onto the floors. Unfortunately, our first travel nurse was unable to work clinically until April 9, 2020. By comparison, the

highest daily confirmed positive COVID-19 cases we had at SJRH occurred on April 4. This limited the capacity of travel nurses to intervene during the steepest phase of COVID-19 case growth. Furthermore, we experienced the paradoxical issue of ED understaffing during the pandemic surge and overstaffing after ED volume had drastically decreased. Effective allocation of surge staffing requires a protean mindset and a culture of adaptability.

We suggest the early inception of credentialing for short-term critical care-trained staff. Anticipate increased nursing and physician need in the ED and the ICUs early in the surge, with decreased ED staffing needs later. Allow flexible allocation of critical care staff, as ED volume may increase exponentially and then rapidly plummet, while inpatient ICUs remain full for weeks beyond the peak of the surge.

4. Implement the Use of Reusable Personal Protective Equipment Gowns.

St. John's Riverside Hospital used up its entire supply of disposable gowns within the first week of the pandemic surge. This issue was compounded by a national shortage of disposable gowns in late April 2020, leading to prices for disposable gowns increasing by 300%. To address gown shortages, our hospital transitioned to purchasing washable PPE to meet standard PPE requirements. The shortage of disposable gowns continued through the peak of the surge, and coveralls or "bunny suits" were the most prominent form of PPE used during the majority of the surge.

To control and prevent further spread of the COVID-19, we advise changing to reusable PPE and investing in coveralls or "bunny suits" early on. Alternatively, any system to ensure adequate disposable PPE must be ready to counter massive surges in need and potential nationwide shortages.

5. Expect Medical Supply Shortages.

Supply challenges were an inextricable complication of the pandemic. Conversations by leadership through the Greater New York hospital network helped facilitate movement of patients and equipment between hospital systems, and daily calls within the SJRH network were critical in combatting shortages. On the upslope of the pandemic surge curve, there was a national shortage of disposable gowns, D5W intravenous (IV) fluids, and small N-95 masks. Other specific shortages included the following:

a. Central line kits
b. Ventilators and ventilator circuits
c. Arterial blood gas (ABG) kits
d. Rigid stylets
e. Endotracheal tube holders
f. Feeding tubes
g. Yankauer suction tubes
h. Fentanyl
i. Bougies
j. Sedation medication such as propofol and midazolam
k. Vasopressors such as norepinephrine, vasopressin, and epinephrine
l. Gloves
m. Disinfectant wipes
n. Ultrasound probe covers.

Additionally, we recommend flexibility and innovation to counteract temporary shortages. For example, pseudo-ABG kits were created and used by drawing heparin into 5-cc syringes. For short periods, long 14G IVs were placed in lieu of traditional triple lumen central lines to facilitate centrally acting medications such as pressors. This temporizing measure allowed the bridging of patients until resupply.

We recommend that hospitals stockpile critical medical supplies and work aggressively to establish adequate supply chains in partnership with neighboring healthcare organizations.

6. Resident Physician Roles

Resident physicians played a critical role in our hospital's response to this pandemic. With many hospitals hosting one or more residency programs, it is important to discuss the optimal utilization of these staff members. Specifically, it is essential to assign resident physicians to roles that are consistent with their training and with hospital staffing needs.

All electives were canceled during the surge, and residents worked exclusively within either the ED or one of the COVID ICUs. Cancelled electives for emergency medicine residents included ultrasound, neonatal ICU, neurosurgical ICU, EMS, and anesthesia. Cancelled rotations for internal medicine residents included gastroenterology, geriatrics, nephrology, and outpatient medicine. Eight of 30 emergency medicine residents and seven of 30 internal medicine residents were pulled from their electives. Senior residents were responsible for rounding on all ventilated patients within the ED, ensuring continuity of care and adjustment of medications and ventilator settings as needed. Residents were of particular utility within COVID ICUs, especially overnight, with critical care attendings available by phone. To ensure wellness, shifts were restricted to 12 hours, with a dedicated day team and night team for ICU care.

We advocate that resident physicians be integrated into ED and ICU care in a manner that optimizes patient care, educational opportunity, and resident wellness.

CONCLUSION

The last pandemic surge of this severity and clinical acuity was over 100 years ago, long before the development of modern medicine, including intensive care units and ventilators. To our knowledge, there are no current reports that address the changes necessary for a US community hospital experiencing a pandemic surge. Our institution's experience through the pandemic as a community site at a major national epicenter provides a vital perspective on the future of pandemic response, as well as the present COVID-19 crisis.

We advise community institutions to increase critical care staffing in accordance with patient volume, create overflow

critical care units, evaluate their HVAC systems, establish screening zones, use available resident physicians in the ED and ICUs, and secure supply chain for PPE and critical care supplies.

Address for Correspondence: Nishad AAbdul Rahman, MD, St. John's Riverside Hospital, Department of Emergency Medicine, 967 N Broadway, Yonkers, NY 10701. Email: nishadrahman13@gmail.com.

Conflicts of Interest: By the WestJEM 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. Faust JS, Lin Z, del Rio C. Comparison of estimated excess deaths in New York City during the COVID-19 and 1918 influenza pandemics. *JAMA Netw Open*. 2020;3(8):e2017527.
2. Reed C, Biggerstaff M, Finelli L, et al. Novel framework for assessing epidemiologic effects of influenza epidemics and pandemics. *Emerg Infect Dis*. 2013;19(1):85-91.
3. Reed C, Angulo FJ, Swerdlow DL, et al. Estimates of the prevalence of pandemic (H1N1) 2009, United States, April–July 2009. *Emerg Infect Dis*. 2020;15(12):2004-7.
4. Huang C, Wang Y, Xingwang L, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395(10223):497-506.
5. Grasselli G, Pesenti A, Cecconi M. Critical care utilization for the COVID-19 outbreak in Lombardy, Italy: early experience and forecast during an emergency response. *JAMA*. 2020;323(16):1545–6.
6. American Hospital Association. Fast Facts on U.S. Hospitals, 2020. 2020. Available at: https://www.aha.org/statistics/fast-facts-us-hospitals. Accessed September 24, 2020.
7. *The New York Times*. Tracking coronavirus in New York: latest map and case count. 2021. Available at: https://www.nytimes.com/interactive/2020/us/new-york-coronavirus-cases.html. Accessed September 24, 2020.
8. Yonkers. Demographics. 2021. Available at: https://www.yonkersny.gov/work/demographics. Accessed September 24, 2020.
9. Rolani S, Villa G, D'Aloia P, et al. COVID-19: An Italian hospital response from the nursing perspective. *Nurs Adm Q*. 2021;45(2):94-101.
10. Zhang Y, Sun Z, Latour JM, et al. Hospital response to the COVID-19 outbreak: the experience in Shanghai, China. *J Adv Nurs*. 2020;76(7):1483-5.

Untapped Potential for Emergency Department Observation Unit Use: A National Hospital Ambulatory Medical Care Survey (NHAMCS) Study

Angelo Navas, BS*
Billy Guzman, MD*
Almujtaba Hassan, MD†
Joseph B. Borawski, MD, MPH, FACEP*
Dean Harrison, MPAS, PA-C*
Pratik Manandhar, MS‡
Alaatin Erkanli, PhD§
Alexander T. Limkakeng Jr., MD, MHD*

*Duke University School of Medicine, Department of Emergency Medicine, Durham, North Carolina
†King Fahad Armed Forces Hospital, Department of Critical Care Medicine, Jeddah, Kingdom of Saudi Arabia
‡Duke University Medical Center, Duke Clinical Research Institute, Durham, North Carolina
§Duke University School of Medicine, Department of Biostatistics and Bioinformatics, Durham, North Carolina

Section Editor: William Fernandez, MD, MPH
Submission history: Submitted February 22, 2021; Revision received July 17, 2021; Accepted August 10, 2021
Electronically published January 18, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.8.52231

Introduction: Millions of people present to the emergency department (ED) with chest pain annually. Accurate and timely risk stratification is important to identify potentially life-threatening conditions such as acute coronary syndrome (ACS). An ED-based observation unit can be used to rapidly evaluate patients and reduce ED crowding, but the practice is not universal. We estimated the number of current hospital admissions in the United States (US) eligible for ED-based observation services for patients with symptoms of ACS.

Methods: In this cross-sectional analysis we used data from the 2011-2015 National Hospital Ambulatory Medical Care Survey (NHAMCS). Visits were included if patients presented with symptoms of ACS (eg, chest pain, dyspnea), had an electrocardiogram (ECG) and cardiac markers, and were admitted to the hospital. We excluded patients with any of the following: discharge diagnosis of myocardial infarction; cardiac arrest; congestive heart failure, or unstable angina; admission to an intensive care unit; hospital length of stay > 2 days; alteplase administration, central venous catheter insertion, cardiopulmonary resuscitation or endotracheal intubation; or admission after an initial ED observation stay. We extracted data on sociodemographics, hospital characteristics, triage level, disposition from the ED, and year of ED extracted from the NHAMCS. Descriptive statistics were performed using sampling weights to produce national estimates of ED visits. We provide medians with interquartile ranges for continuous variables and percentages with 95% confidence intervals for categorical variables.

Results: During 2011-2015 there were an estimated 675,883,000 ED visits in the US. Of these, 14,353,000 patients with symptoms of ACS and an ED order for an ECG or cardiac markers were admitted to the hospital. We identified 1,883,000 visits that were amenable to ED observation services, where 987,000 (52.4%) were male patients, and 1,318,000 (70%) were White. Further-more, 739,000 (39.2%) and 234,000 (12.4%) were paid for by Medicare and Medicaid, respectively. The majority (45.1%) of observation-amenable hospitalizations were in the Southern US.

Conclusion: Emergency department-based observation unit services for suspected ACS appear to be underused. Over half of potentially observation-amenable admissions were paid for by Medicare and Medicaid. Implementation of ED-based observation units would especially benefit hospitals and patients in the American South. [West J Emerg Med. 2022;23(2)134–140.]

INTRODUCTION

Over six million adults present to the emergency department (ED) with chest pain in the United States annually.[1,2] While there are multiple etiologies of chest pain, including non-cardiac and benign disorders, accurate and timely risk stratification is important to identify potentially life-threatening conditions such as acute coronary syndrome (ACS). Several objective measures (ie, electrocardiography [ECG], cardiac biomarkers, noninvasive imaging of the myocardium)[3] and decision-support tools[4] have been developed for ACS risk stratification. Yet 2-4% of patients with ACS are inadvertently discharged from the ED.[5,6,7] Of those patients with chest pain admitted for further evaluation, less than half will be diagnosed with ACS.[8] One factor contributing to these discrepancies in the ED is that ACS symptoms are often non-specific.[9] Additionally, multiple non-ACS conditions are associated with elevated troponin levels.[10] Emerging evidence suggests that ED-based observation units (EDOU) for chest pain may overcome these limitations by enabling implement-ation of a rapid risk-stratification protocol (eg, cardiac biomarker testing, telemetry monitoring, stress testing, echocardiogram) over a short period of time.[1,11]

The use of EDOUs has been described since the 1980s. In 2006 an Institute of Medicine report, *The Future of Emergency Care in the United States Health System*, supported the use of EDOUs as a tool to reduce ED crowding, improve patient care, and reduce cost.[12] Although these units are diverse, a defining feature is the use of protocolized care with the goal of rapidly discharging the patient back home within 24 hours. Despite documented financial and patient benefits, their adoption has not been universal.[13] Recent estimates suggest that 39% of EDs have a separate observation or clinical decision unit.[2] While the utility of EDOUs for chest pain has been reported,[4,14] it is not fully known to what degree ED-based observation services could expand in the United States.

In this study we used a publicly available, de-identified, and unlinked survey database of nationwide ED visits to determine the number of patients admitted to the hospital from the ED for symptoms of ACS who could potentially have been evaluated in an EDOU. We also sought to determine which patient factors were most associated with patients being admitted despite meeting our derived observation-eligible criteria. Our goal was to corroborate the potential for more EDOUs nationwide as a means to significantly reduce unnecessary hospital admissions and related expenses.

Population Health Research Capsule

What do we already know about this issue?
Delay in rapid identification of potentially life-threatening conditions such as acute coronary syndrome (ACS) can be secondary to ED crowding.

What was the research question?
What would be the benefit of ED-based observation units (EDOU) for suspected ACS?

What was the major finding of the study?
Implementaion of EDOUs would benefit patients with suspected ACS, especially in the Southern US .

How does this improve population health?
An EDOU could minimize ED crowding and rapidly identify potentially life-threatening conditions such as ACS, and could have economic impact nationwide.

METHODS

Study Design and Data Source

We conducted a cross-sectional analysis using data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) from 2011–2015. Visits were included if patients presented with symptoms of ACS (eg, chest pain, dyspnea), had an electrocardiogram (ECG) and cardiac markers, and were admitted to the hospital. We obtained data for this analysis from the publicly available NHAMCS dataset published on the US Centers for Disease Control and Prevention (CDC) website. The database includes information that is de-identified and unlinked to the patient encounter and aggregated solely for informative and research purposes.

The NHAMCS is an annual, nationally representative probability sample survey administered by the CDC's National Center for Health Statistics. Data is collected on visits to outpatient clinics and EDs of non-institutional, short-stay. and general hospitals in 50 states and the District of Columbia, excluding federal, military, and Veterans Affairs hospitals. The NHAMCS uses a four-stage probability sampling design including selection of primary sampling units (PSU), hospitals within PSUs, clinics within hospitals, and patient visits within clinics. The exact methods of the NHAMCS survey have been described in detail elsewhere.[15]

Hospitals are selected based on geographic PSUs. For the years included, on average 411 hospitals were eligible annually, and 369 participated, giving an unweighted average hospital sampling response rate of 89.8%. Sixteen data collection groups randomly rotate across these hospitals through 13 four-week reporting periods throughout the year. Contractors for the NHAMCS (SRA International, Inc., Durham, NC) collect data from ED visit medical records while being monitored by NHAMCS field representatives. The NHAMCS staff members independently check 10% of the

data for accuracy. Error rates are 0.3-0.9% for various items on the survey; the survey includes patient-level data, patient disposition, and hospital-level data.

Study Population

For this analysis we focused on visits to hospital EDs for symptoms of ACS (Figure 1). Visits were included if a cardiac troponin and ECG were ordered in the ED, the patient was admitted to inpatient status into the hospital and was discharged with a length of stay shorter than two days. We excluded patients with any of the following: discharge diagnosis of myocardial infarction, cardiac arrest, congestive heart failure, or unstable angina; admission to an intensive care unit; hospital length of stay > 2 days; alteplase administration, central venous catheter insertion, cardiopulmonary resuscitation or endotracheal intubation; or admission after an initial ED observation stay. We further excluded any patient with a non-cardiovascular primary diagnosis upon hospital discharge.

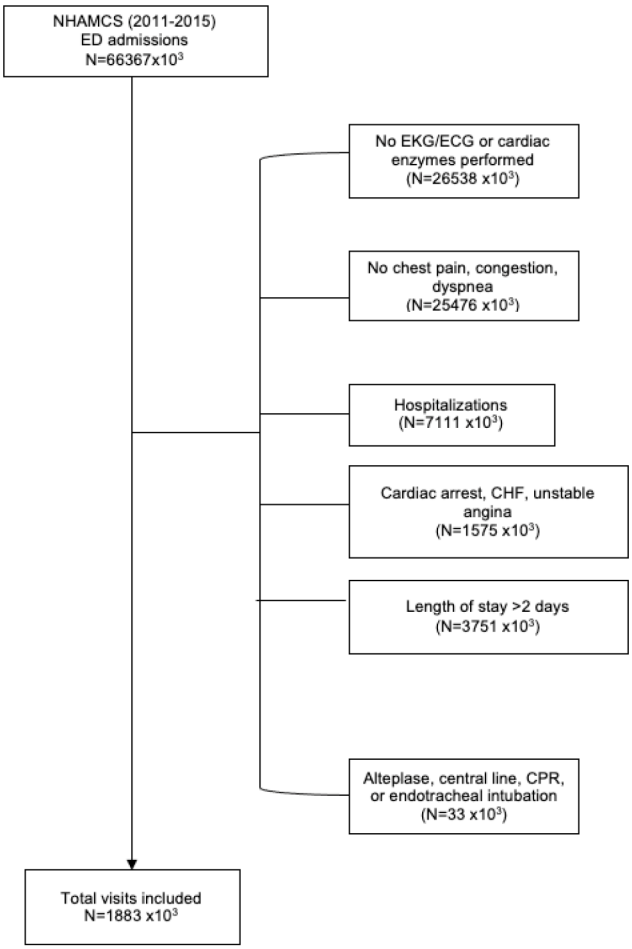


Figure 1. Flow diagram of inclusion and exclusion criteria for patient visits associated with acute coronary syndrome care. *NHAMCS*, National Hospital Ambulatory Medical Care Survey; *ED*, emergency department; *EKG/ECG*, electrocardiogram; *CHF*, congestive heart failure; *CPR*, cardiopulmonary resuscitation.

Variables

The NHAMCS survey records demographic data, payment source, clinician types, procedures, prescriptions, laboratory and radiographic tests ordered for each visit, up to three reasons for visit (chief complaints), the ED diagnosis (*International Classification of Diseases, 9th Revision* codes), and the final hospital discharge diagnosis for those patients who were admitted to the hospital. In addition, we extracted the following variables from the NHAMCS database: age; race/ethnicity; gender; insurance status; clinician type; hospital characteristics (geographic location at the level of state, academic status, metropolitan area, and ownership); and disposition from the ED (admission, discharge, and transfer). We used data from the NHAMCS files for 2011–2015.

Ethics

This study was exempted from full review by our institutional review board.

Data Analysis

We performed data analyses using SAS version 9.4 (SAS Institute Inc., Cary, NC). Sociodemographics, hospital characteristics, and dispositions from the ED were summarized using the median with interquartile range for continuous variables and percentage with 95% confidence intervals for categorical variables. We calculated unweighted percentages for "reasons for visits" and final diagnoses. Estimates of average annual national visits were derived using survey procedures with the weights, strata, and PSU design variables provided by the NHAMCS.

RESULTS

During 2011–2015, there were an estimated 675,883,000 ED visits nationwide in the US. Of these, 14,353,000 patients with symptoms of ACS who had an ECG in the ED and cardiac markers were admitted to the hospital. This number was calculated using raw percentages of selective cohorts and population ratio adjustment. We identified 1,883,000 visits that may have been amenable to observation services. Of these visits, 987,000 (52.4 %) were by males and 1,318,000 (70.0 %) identified as White (Table 1). Furthermore, 739,000 (39.2 %) and 234,000 (12.4 %) were paid for by Medicare and Medicaid, respectively (Figure 2). The majority of these observation-amenable hospitalizations were in the Southern US (Figure 3).

When comparing ED visits leading to observation-amenable admissions to overall proportions of ED visits, they occurred proportionally slightly more in females, Medicare patients, and in the Midwest and South. These types of admissions occurred less often in Medicaid patients and in the US Northeast and West.

DISCUSSION

Chest pain is the second most common reason for ED visits

Table 1. Characteristics of emergency department visits amenable to observation services.

Characteristic	Weighted number ($x10^3$)	Weighted proportion of admissions potentially amenable to observation, % (95% CI)	Weighted number in all ED visits ($x10^3$)	Weighted proportion in all ED visits (%)
Age				
Median	1883	56.4 (53.9, 58.8)	675,883	100%
25th		47.0 (43.9, 50.2)		
75th		68.5 (64.1, 72.9)		
Race/ethnicity				
Non-Hispanic White	1318	70.0 (63.6, 76.3)	396,617	58.7%
Non-Hispanic Black	369	19.6 (13.9, 25.3)	153,018	22.6%
Hispanic	149	7.9 (4.8, 11.0)	105,988	15.7%
Non-Hispanic Other	47	2.5 (0.1, 5.0)	20,260	3.0%
Gender				
Female	896	47.6 (41.3, 53.9)	373,717	55.3%
Male	987	52.4 (46.1, 58.7)	302,165	44.7%
Unknown	90	4.8 (1.7, 7.8)		
Primary source of payment				
Private insurance	620	32.9 (26.9, 39.0)	190,986	28.3%
Medicare	739	39.2 (32.8, 45.7)	123,652	18.3%
Medicaid or CHIP	234	12.4 (8.4, 16.5)	192,110	28.4%
Workers' compensation	10	0.6 (0.0, 1.6)	55,35	0.8%
Self-pay	125	6.6 (3.7, 9.5)	85,766	12.7%
No charge/Charity	8	0.4 (0.0, 0.9)	5,721	0.8%
Other	57	3.0 (0.4, 5.6)	18,907	2.8%
Seen in this ED within last 72 hours				
Unknown	137	7.2 (2.9, 11.6)	70,984	10.5%
Yes	33	1.8 (0.5, 3.0)	28,233	4.2%
No	1714	91.0 (86.5, 95.5)	567,103	83.9%
Geographic region				
Northeast	188	10.0 (6.8, 13.1)	116,551	17.2%
Midwest	560	29.7 (22.2, 37.3)	159,356	23.6%
South	849	45.1 (36.7, 53.5)	257,543	38.1%
West	286	15.2 (10.9, 19.5)	142,432	21.1%

ED, emergency department; *CI*, confidence interval; *CHIP*, Children's Health Insurance Program.

in the US. An EDOU can be particularly useful to risk-stratify patients with symptoms of ACS. These units provide a period of therapeutic intervention and diagnostics (usually 24 hours) as an alternative to hospitalization where the appropriateness of inpatient services is unclear. The EDOU protocols can reduce healthcare costs and help vulnerable patients with common cardiac complaints avoid unnecessary hospitalizations.[9,12,16] However, there is no clear estimate of annual ED visits in the US for ACS symptoms that would be amenable to evaluation in the EDOU or the characteristics of such visits. The current analysis provides an estimate of the need for systematic national efforts to encourage the implementation of EDOUs to evaluate patients with ACS symptoms.

In this study we determined the proportion of patients who were hospitalized for symptoms of potential ACS who could have been observed in an EDOU. Emergency department-based observation unit services for ACS appear to be underused. We identified that over half of observation-amenable admissions were paid for by Medicare and Medicaid. These findings appear to vary geographically within the US.

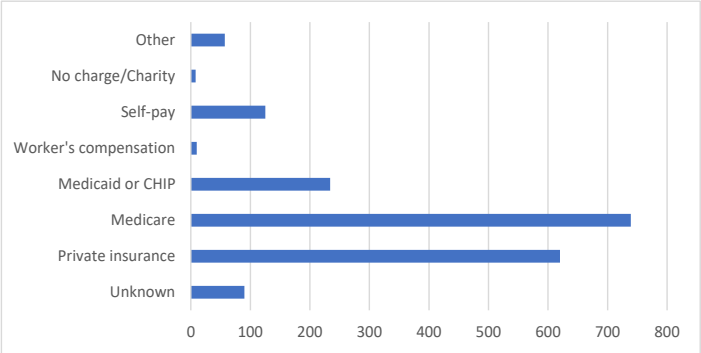


Figure 2. Source of payment for emergency department visits amenable to observation services.

This is the first study based on a nationally representative sample to evaluate the rate of use of EDOUs for chest pain. Previous work has shown that national EDOUs are growing in number, from 19% in 2003 to 39% in 2017, and that chest pain is the most common EDOU symptom requiring diagnosis.[2,14,16] Although the number of EDOUs is growing, there remains room for further expansion. Studies have shown that patients at low risk or intermediate risk of ACS are more common than patients with unstable angina or ST-elevation myocardial infarction.[17] Indeed, we identified nearly two million patients within this risk category who were not evaluated in an EDOU. Importantly, EDOUs have been shown to reduce admission rates from the ED for chest pain.[18] Another benefit of the EDOU is reduction in costs, with an estimated savings of $124 per patient for ED visits with chest pain.[19]

The majority of patients in our analysis who missed an opportunity for EDOU evaluation were Medicare beneficiaries. Older patients (age >65 years) have a higher rate of EDOU use for chest pain.[20] Previous work has specifically determined how much Medicaid and Medicare have paid for observation services.[21] These studies show that patients treated in observation units for chest pain are less likely to have an adverse event within 30 days and Medicare payments for these services are nearly half what they are for inpatient services.[22] On the other hand, these services may cost patients more because they fall under Medicare Part B (outpatient-related services), which requires them to pay a $183 deductible and 20% cost-sharing for services.[22] We also note that observation-amenable admissions occur proportionally more frequently in Medicare patients and less frequently in Medicaid patients, suggesting that financial incentives may play a role. Thus, it is possible that although EDOUs reduce a hospital's health-related expenditures, one reason for their underutilization is patient finances. It is important to note, however, that for commercially insured patients, observation units reduce total out-of-pocket expenses.[23] Increasing the use of observation services may require further expanding the number of EDOUs in the US and evaluating payment options for Medicare beneficiaries.

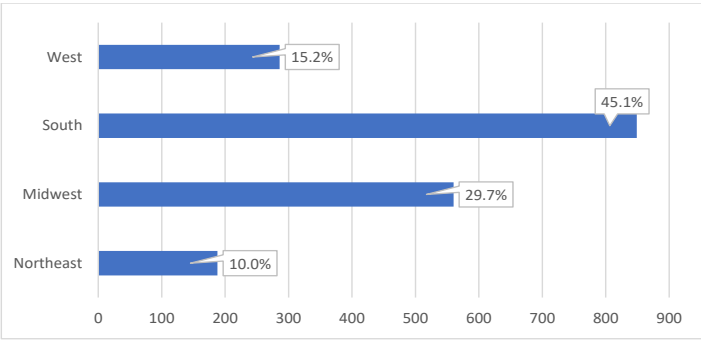


Figure 3. Geographic region of emergency department visits amenable to observation services.

Despite the growing use of EDOUs, no previous work has specifically commented on geographic variation of observation for ACS.[24] However, studies have shown over half of EDOUs generally are in an urban setting and 30% are in the South.[25] Our analysis revealed that 45% of the visits for ACS that could have been seen in an EDOU were in hospitals in the Southeast US, while just 10% were in the Northeast US. One explanation for these differences may be that there are a greater number of EDOUs or a shorter distance to a hospital with an ED in the Northeast – an important factor when a patient is experiencing symptoms of ACS. It is also possible that many of the EDs in the Northeast and West are in high-density population areas and have already adapted EDOUs as a means of dealing with hospital crowding. An investigation of ED-managed observation units also found that EDs in an area with a median income of <$32,000 were less likely to have an observation unit.[26] This is particularly important given research showing that patients with a lower socioeconomic status may report to EDs less frequently for chest pain or delay seeking treatment for chest pain.[26,27]

LIMITATIONS

Our study has several limitations. First, this was a cross-sectional analysis using retrospective data of ED visits across five years (2011–2015). However, the NHAMCS is a nationally representative database that includes data on patient visits to the ED, demographic characteristics, symptoms, chief complaint, diagnoses, laboratory services, and medications. We recognize that we present a hypothetical construct of what an observation-amenable admission is, but we believe it is a reasonable estimate. This database estimate cannot account for numerous factors that may have impacted needs for hospitalization and were not in the existing NHAMCS variables, including social determinants of health. Furthermore, it represents a conservative estimate of the number of hospitalizations potentially amenable to observation services.

We did not include patients hospitalized for other, atypical anginal symptoms, and it may have been clinically appropriate and reasonable for a certain proportion of the hospitalizations that we excluded to have started out

as observation status. Next, the unweighted ED response rate of the NHAMCS was <80%, which could have biased results and limited generalizability. Nevertheless, the NHAMCS is the largest dataset to date with population-based estimates of ED visits in the US. Finally, while our inclusion criteria may be subject to misclassification bias, we used a comprehensive algorithm to determine participants with ACS symptoms who were not evaluated in an EDOU. It is also important to note that not all hospitals can build and staff observation units easily.

CONCLUSION

We identified 1,883,000 visits for ACS symptoms that were amenable to EDOU services. We also found that over half of observation-amenable admissions were paid for by Medicare and Medicaid, and were more likely to occur in the Southern US. These data support the need to further expand the use of EDOU for patients with symptoms of ACS. Although the benefits of ED-based observation service have been previously modeled theoretically and demonstrated in local settings, ultimately, further research should determine the economic and patient-oriented impacts of expansion of ED-based observation services as it actually occurs nationwide.

ACKNOWLEDGMENTS

We would like to thank the Research on Research group (www.researchonresearch.org), Duke University, Durham, NC, for manuscript writing templates.

Address for Correspondence: Angelo Navas, BS, Duke University School of Medicine, Department of Emergency Medicine, 2424 Erwin Road, Durham, North Carolina 27705. Email: angelo_navas@med.unc.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. Shah J, Shah A, Pietrobon R. Scientific writing of novice researchers: what difficulties and encouragements do they encounter? *Acad Med*. 2009;84(4):511-6.
2. Rui P and Kang K. National Hospital Ambulatory Medical Care Survey: 2017 emergency department summary tables. 2017. Available at: https://www.cdc.gov/nchs/data/nhamcs/web_tables/2017_ed_web_tables-508.pdf. Accessed December 15, 2020.
3. Mokhtari A, Dryver E, Soderholm M, et al. Diagnostic values of chest pain history, ECG, troponin and clinical gestalt in patient with chest pain and potential acute coronary syndrome assesses in the emergency department. *Springerplus*, 2015;4:219.
4. Gesell SB, Golden SL, Limkaken AT, et al. Implementation of the HEART Pathway: using the consolidated framework for implementation research. *Crit Pathw Cardiol*. 2018;17(4):191-200.
5. Pope JH, Aufderheide TP, Ruthazer R, et al. Missed diagnoses of acute cardiac ischemia in the emergency department. *N Engl J Med*. 2000;342(16):1163-70.
6. Schull MJ, Vermeulen MJ, Stukel TA. The risk of missed diagnosis of acute myocardial infarction associated with Emergency Department volume. *Ann Emerg Med.* 2006;48(6):647-55.
7. Lee TH, Rouan GW, Weisberg MC, et al. Clinical characteristics and natural history of patients with acute myocardial infarction sent home from the emergency room. *Am J Cardiol*. 1987;60(4):219-24.
8. Hansen LH and Mikkelsen S. Ischemic heart disease: accuracy of the prehospital diagnosis – a retrospective study. *Emerg Med Int*. 2013;2013:754269.
9. Borawski JB, Graff L, Limkaken AT, et al. Care of the patient with chest pain in the observation unit. *Emerg Med Clin North Am.* 2017;35(3):535-47.
10. Januzzi JL. Causes of non ACS related troponin elevations. 2010. Available at: https://www.acc.org/latest-in-cardiology/articles/2014/07/18/13/16/causes-of-non-acs-related-troponin-elevations. Accessed December 15, 2020.
11. Amsterdam EA, Wenger NK, Brindis RG, et al. 2014 AHA/ACC Guideline for the management of patients with non-ST-elevation acute coronary syndromes: Executive summary. *Circulation*. 2014;130(25):2354-94.
12. Berwanger O, Polanczyk CA, Rosito G. Chest pain observation units for patients with symptoms suggestive of acute cardiac ischemia. *Cochrane Database Sys Rev*. 2017;11:CD004820.
13. Institute of Medicine. The future of emergency care in the United States health system. *Ann Emerg Med.* 2006;48(2):115-20.
14. Ross MA, Aurora T, Graff L, et al. State of the art: emergency department observation units. *Crit Pathw Cardiol*. 2012;11(3):128-38.
15. Madsen T, Mallin M, Bledsoe J, et al. Utility of the emergency department observation unit in ensuring stress testing in low-risk chest pain patients. *Crit Pathw Cardiol.* 2009;8(3):122-4.
16. McNaughton CD and Self WH. Observational health services studies using nationwide administrative datasets: understanding strengths and limitations of the National Hospital Ambulatory Medical Care Survey (NHAMCS). *Ann Emerg Med*. 2013;61(5):593-4.
17. Kirk JD, Diercks DB, Turnipseed SD, et al. Evaluation of chest pain suspicious for acute coronary syndrome: use of an accelerated diagnostic protocol in a chest pain evaluation unit. *Am J Cardiol*. 2000;85(5A):40B-8B.

18. Goodacre S, Nicholl J, Dixon S, et al. Randomised controlled trial and economic evaluation of a chest pain observation unit compared with routine care. *BMJ*. 2004;328(7434):254.
19. Graff L, Delara J, Ross M, et al. Chest Pain Evaluation Registry (CHEPER) Study: impact on the care of the emergency department chest pain patient. *Am J Cardiol*. 199;80(5):563-8.
20. Ross MA, Compton S, Richardson D, et al. The use and effectiveness of an emergency department observation unit for elderly patients. *Ann Emerg Med*. 2003;41(5):668-77.
21. Cafardi SG, Pines JM, Deb P, et al. Increased observation services in Medicare beneficiaries with chest pain. *Am J Emerg Med*. 2016;34(10):16-9.
22. Centers for Medicare and Medicaid Services. Are you a hospital inpatient or outpatient? 2014. Available at: https://www.medicare.gov/Pubs/pdf/11435-are-you-an-inpatient-or-outpatient.pdf. Accessed December 7, 2020.
23. Adrion ER, Kocher KE, Nallamothu BK, et al. Rising use of observation care among the commercially insured may lead to total and out-of-pocket cost savings. *Health Affairs*. 2017;36(120):2102-9.
24. Napolitano, J.D., Saini, I. Observation Units: Definition, History, Data, Financial Considerations, and Metrics. *Curr Emerg Hosp Med Rep 2*. 2014;1–8.
25. Wiler JL, Ross MA, Ginde AA. National study of emergency department observation services. *Acad Emerg Med*. 2011;18:959-65.
26. Richards HM, Reid ME, Murray Watt GC. Socioeconomic variations in responses to chest pain: qualitative study. *BMJ*. 2002;324(7349):1308.
27. Wechkunanukul K, Grantham H, Damarell R, et al. The association between ethnicity and delay in seeking medical care for chest pain: a systematic review. *JBI Database System Rev Implement Rep*. 2016;14(7):208-35.

Association of Emergency Department Payer Mix with ED Receipt of Telehealth Services: An Observational Analysis

Kori S. Zachrison, MD, MSc*†
Margaret E. Samuels-Kalow, MD, MSHP*†
Krislyn M. Boggs, MPH*
Sijia Li, MS*
Emily M. Hayden, MD, MHPE*†
Carlos A. Camargo, Jr., MD, DrPH*†

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

Section Editor: William Fernandez, MD, MPH
Submission history: Submitted May 3, 2021; Revision received August 27, 2021; Accepted September 15, 2021
Electronically published January 31, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.9.53014

Introduction: Telehealth is commonly used to connect emergency department (ED) patients with specialists or resources required for their care. Its infrastructure requires substantial upfront and ongoing investment from an ED or hospital and may be more difficult to implement in lower-resourced settings. Our aim was to examine for an association between ED payer mix and receipt of telehealth services.

Methods: Using data from the National Emergency Department Inventory (NEDI)-USA 2016 survey, we categorized EDs based on receipt of telehealth services (yes/no). The NEDI-USA data for EDs in New York state was linked with data from state ED datasets (SEDD) and state inpatient data (SID) to determine EDs' payer mix (percent self-pay or Medicaid). Other ED characteristics of interest were rural location, academic status, and annual ED visit volume. We compared EDs with and without telehealth receipt, and used a logistic regression model to examine the relationship between ED payer mix and telehealth receipt after accounting for other ED characteristics.

Results: Of the 162 New York EDs in the SEDD-SID dataset, 160 (99%) were linked to the NEDI-USA dataset and 133 of those responded (83%) to the survey. Telehealth receipt was reported by 48 EDs (36%, 95% confidence interval [CI], 28-44%). Emergency departments with and without telehealth receipt were similar (all P >0.40) with respect to rurality (6% vs 9%, respectively), academic status (13% vs 8%), and annual volume (median 36,728 vs 43,000). By contrast, median percent of Medicaid or self-pay patients was lower in telehealth EDs (36%) vs non-telehealth EDs (45%, P = 0.02). In adjusted analysis, increasing proportion of Medicaid and self-pay patients was associated with decreased odds of telehealth receipt (odds ratio 0.87 per 5% increase; 95% CI, 0.77-0.99). Rural location, academic status, and ED volume were not significantly associated with odds of ED telehealth receipt in the adjusted model.

Conclusion: Among EDs in the state of New York, increasing proportion of self-pay and Medicaid patients was associated with decreased odds of ED telehealth receipt, even after accounting for rural location, academic status, and ED volume. The findings support the need for additional infrastructural investment in EDs serving a greater proportion of disadvantaged patients to ensure equitable access. [West J Emerg Med. 2022;23(2)141–144.]

INTRODUCTION

As telehealth transforms the delivery of healthcare, emergency departments (ED) in particular stand to benefit. Emergency departments have varying level of resources, with some rural EDs lacking consultant availability and even physician staffing.[1,2] Patients presenting to less resourced or rural EDs are often transferred to urban referral centers to access resources or specialty care. Yet where some care is becoming increasingly regionalized and concentrated in fewer centers (eg, definitive pediatric hospital care),[3] telehealth provides an opportunity to counter this trend. By virtually bringing a consulting specialist to a patient in a rural ED, telehealth can mitigate this gap in resource availability for those sites. Rather than bringing patients to the resources, telemedicine enables a strategy of bringing the resources to the patient. Potential benefits include enabling patients to receive medical care closer to their home and, simultaneously, enabling hospitals to provide a level of resource to patients that would not have otherwise been possible. In doing so, smaller hospitals may be able to retain more patients and maintain a higher census and more favorable financial status as well.

Yet telehealth infrastructure requires substantial upfront and ongoing investment from an ED or hospital, and this may be more difficult to implement in lower-resourced settings. We have previously found that smaller, rural EDs are the least likely to receive telehealth services.[4] These findings are concerning as the expansion of telehealth has potential to exacerbate inequities in care access when the hospitals that could most benefit from telehealth are least likely to have the resources to receive telehealth services. The objective of this study was to further explore the potential connection between level of resources and ED receipt of telehealth services, specifically to examine for an association between ED payer mix and receipt of telehealth services. We hypothesized that EDs with higher proportion of self-pay or Medicaid patients would have lower odds of receiving telehealth services, after accounting for other ED characteristics.

METHODS

Using data from a survey of all US EDs open in 2016, as part of the National ED Inventory (NEDI-USA), we identified EDs' receipt of telehealth services. This one-page survey was administered in 2017 to characterize EDs open in 2016. The methods, including those of telehealth status ascertainment, have been previously reported.[4,5] We included all EDs that were open 24/7 and available for use by the general public, including hospital-based and freestanding EDs. There was no incentive to participate. Surveys were completed on paper, online, or by telephone. For respondents completing the survey by telephone, a standard script was used to define telehealth as needed. We categorized EDs based on receipt of telehealth services (yes/no) based on response to the survey item "Does your ED *receive* telemedicine services for patient evaluation?" The study was approved by the Massachusetts General Hospital Institutional Review Board.

The NEDI-USA data for EDs in New York State was linked with data from state ED datasets (SEDD) and state inpatient data (SID)[6] to determine EDs' payer mix (percent self-pay or Medicaid). Other ED character-istics of interest were rural location (based on location outside of a core-based statistical area), academic status (based on presence of an emergency medicine residency), and annual ED visit volume. We used t-tests and chi-square test to compare EDs with and without telehealth receipt. A multivariable logistic regression model examined the relationship between ED payer mix and telehealth receipt after accounting for other ED characteristics. We tested for an interaction between ED volume and proportion of payer mix to determine whether the relationship between payer mix and likelihood of telehealth use varied by volume. Because the interaction was not significant it was dropped from the model for ease of interpretation.

RESULTS

Of the 162 New York State EDs in the SEDD-SID linked dataset, 160 (99%) were linked with the NEDI-USA dataset and 133 (83%) responded to the NEDI-USA survey (Figure).

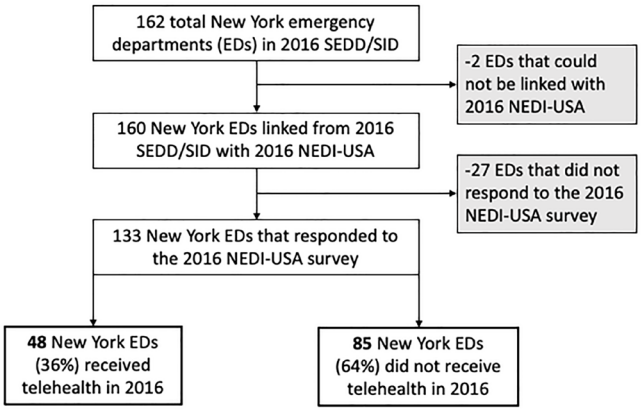


Figure. Flowchart of emergency departments included in the study. *SEDD/SID,* State Emergency Department Database/State Inpatient Database; *NEDI-USA,* National Emergency Department Inventory-USA.

Telehealth receipt was reported by 48 EDs (36%, 95% confidence interval [CI] 28-44%). In bivariate comparisons, EDs with and without telehealth receipt were similar (all $P > 0.40$) with respect to rurality (6% vs 9%, respectively), academic status (13% vs 8%), and annual ED visit volume (median 36,728 vs 43,000). By contrast, median percent of Medicaid or self-pay patients was lower in telehealth EDs vs non-telehealth EDs (36% vs 45%, respectively; $P = 0.02$).

In adjusted analysis, the results were similar. Rural location, academic status, and annual ED visit volume were not significantly associated with odds of ED telehealth receipt in the adjusted model (Table). By contrast, increasing

Table. Unadjusted and adjusted odds of telehealth receipt in New York State, by emergency department characteristics.

	Unadjusted odds ratio	95% CI	Adjusted odds ratio	95% CI
Rural location	0.64	(0.16-2.54)	0.54	(0.13-2.29)
Academic ED	1.59	(0.50-5.04)	1.63	(0.39-6.89)
Annual ED volume (per 5,000 increase)	1.00	(0.97-1.03)	1.00	(0.96-1.05)
Percent Medicaid or self-pay (per 5% increase)	0.89	(0.80-0.99)	0.87	(0.77-0.99)

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

proportion of Medicaid and self-pay patients was associated with decreased odds of telehealth receipt (odds ratio 0.87 per 5% increase, 95% CI, 0.77-0.99).

DISCUSSION

In summary, among EDs in New York State, increasing proportion of self-pay and Medicaid patients was associated with decreased odds of ED telehealth receipt, even after accounting for rural location, academic status, and annual ED visit volume. While we are not aware of prior research specifically examining the relationship between ED payer mix and telehealth receipt, this finding is consistent with other literature demonstrating patient-level disparities in access by insurance status.[7] Prior research has also demonstrated increased likelihood of ED closure among safety-net EDs and EDs serving a higher share of population with public insurance.[8,9] It may follow that EDs serving a greater proportion of disadvantaged patients may have less telehealth access. Particularly in 2016, technological equipment and internet connectivity infrastructure were expensive, and the cost may have been prohibitive for EDs in hospitals operating with thin or even negative financial margins.[10]

Payment policy may play a role. In the context of these pre-COVID-19 pandemic data, reimbursement for telemedicine was extremely limited and mostly only available for patients in rural areas (with the exception of coverage for telestroke introduced with the FAST Act in 2017).[11] Yet even for rural hospitals the payment structure has been a barrier. In both the commercial and academic hub-and-spoke model, EDs with telehealth typically pay subscription fees directly to the telehealth provider. There are theoretically two ways in which these sites could then recoup those costs: 1) the ED could credential all telehealth consultants at their site in order to bill professional fees on their behalf; or 2) the ED would need to successfully avoid transfer and locally admit a large proportion of patients so that the increase in locally admitted bed-days would offset the expense.[12] However, this may not be worthwhile in the context of low volumes and high administrative burden. In addition, if those bed-days are for patients with Medicaid or self-pay, the potential financial gains of avoiding transfer may be further limited. Finally, there may be alternative reimbursement strategies that may be suitable, such as expanded allowance for physicians to be remote from patients; this strategy has been well established in diagnostic radiology.

From a clinical perspective, telehealth may be considered a worthwhile – and moreover, an important – investment, enabling higher quality care delivery for patients by providing access to resources and consultants that would not have otherwise been available. There is a successful model for telehealth implementation among rural critical access hospital EDs in the Midwest with Avera Health.[13] However, in some of these EDs, the business case may involve the substitution of nonphysician providers or non-emergency physicians for EM-trained physicians, with availability of backup tele-emergency physicians.[14] This transition from emergency physicians to non-physician clinicians may have alternative implications for quality of care delivery if patients no longer have access to emergency care from emergency physicians.

LIMITATIONS

This study has limitations. Telehealth receipt was identified based on survey responses, which were not validated and were dependent on respondents' knowledge of programs, although we aimed to mitigate this by surveying ED directors and others in leadership who are knowledgeable about ED operations. Survey responses may also be subject to social desirability bias. Our data is from a single state and may not be generalizable to other settings. Furthermore, much has changed and may be expected to continue changing in the telehealth landscape since 2016, including lower costs of technology and changes in payment policy during the coronavirus 2019 public health emergency. For example, the Centers for Medicare and Medicaid Services 1135 waiver enabled broad expansions in telehealth reimbursement improving access to virtual care.[15,16]

While these changes are temporary under the public health emergency declaration and the future of telehealth reimbursement policy remains unclear,[17] it is likely that the post-pandemic reimbursement landscape will be distinct from the 2016 results presented here. Further research is warranted to confirm these findings in other settings and with more recent data. Finally, while the benefits of telemedicine on morbidity and mortality are well established in some conditions (eg, telestroke),[18] the relative costs and benefits in other domains of care may be debated.

CONCLUSION

These novel findings support additional infrastructural investment in EDs serving a greater proportion of disadvantaged

patients to ensure equitable access, and further development of strategies to reduce costs and improve reimbursement payment models to address this disparity in access.

Address for Correspondence: Kori S. Zachrison, MD, MSc, Massachusetts General Hospital, Department of Emergency Medicine, 55 Fruit Street, Boston, Massachusetts 02114. Email: kzachrison@mgh.harvard.edu.

Conflicts of Interest: By the WestJEM 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 work was funded by the Agency for Healthcare Research and Quality (K08 HS024561, Zachrison), the National Foundation of Emergency Medicine (Zachrison/Camargo), and the RBaby Foundation (Camargo). The authors have no conflicts of interest to declare.

REFERENCES

1. Sawyer BT, Ginde AA. Scope of practice and autonomy of physician assistants in rural vs urban emergency departments. *Acad Emerg Med*. 2014;21(5):520-5.
2. Groth H, House H, Overton R, et al. Board-certified emergency physicians comprise a minority of the emergency department workforce in Iowa. *West J Emerg Med*. 2013;14(2):186-90.
3. França UL, McManus ML. Trends in regionalization of hospital care for common pediatric conditions. *Pediatrics*. 2018;141(1):e20171940.
4. Zachrison KS, Boggs KM, Hayden ME, et al. A national survey of telemedicine use by US emergency departments. *J Telemed Telecare*. 2020;26(5):278-84.
5. Sullivan AF, Richman IB, Ahn CJ, et al. A profile of US emergency departments in 2001. *Ann Emerg Med*. 2006;48(6):694-701.
6. Boggs KM, Teferi MM, Espinola JA, et al. Consolidating emergency department-specific data to enable linkage with large administrative datasets. *West J Emerg Med*. 2020;21(6):141-5.
7. Iobst C, King W, Baitner A, et al. Access to care for children with fractures. *J Pediatr Orthop*. 2010;30(3):244-7.
8. Hsia RY, Kellermann AL, Shen Y-C. Factors associated with closures of emergency departments in the United States. *JAMA*. 2011;305(19):1978-85.
9. Hsia RY, Srebothnjak T, Kanzaria HK. System-level health disparities in California emergency departments: minorities and Medicaid patients are at higher risk of losing their emergency departments. *Ann Emerg Med*. 2012:59(5):358-65.
10. Zachrison KS, Boggs KM, Hayden EM, et al. Understanding barriers to telemedicine implementation in rural emergency departments. *Ann Emerg Med*. 2019;75(3):392-399.
11. Furthering Access to Stroke Telemedicine Act of 2017. HR1148, 115th Congress (2017).
12. Zachrison KS, Richard JV, Mehrotra A. Paying for telemedicine in smaller rural hospitals. *JAMA Heal Forum*. 2021. In Press.
13. Ward MM, Ullrich F, MacKinney AC, et al. Tele-emergency utilization: In what clinical situations is tele-emergency activated? *J Telemed Telecare*. 2016;22(1):25-31.
14. MacKinney AC, Ward MM, Ullrich F, et al. The business case for tele-emergency. *Telemed J E Health*. 2015;21(12):1005-11.
15. Telehealth Provisions in the Consolidated Appropriations Act, 2021 (HR 133): CCHP Fact Sheet January 2021. Available at: https://www.fcc.gov/covid-19-telehealth-program. Accessed August 19, 2021.
16. Centers for Medicare and Medicaid Services. Medicare Telemedicine Health Care Provider Fact Sheet. Available at: https://www.cms.gov/newsroom/fact-sheets/medicare-telemedicine-health-care-provider-fact-sheet. Accessed August 19, 2021.
17. Association of American Medical Colleges. House subcommittee holds hearing on the path forward for telehealth. Available at: https://www.aamc.org/advocacy-policy/washington-highlights/house-subcommittee-holds-hearing-path-forward-telehealth. Accessed August 19, 2021.
18. Wilcock AD, Schwamm LH, Zubizarreta JR, et al. Reperfusion treatment and stroke outcomes in hospitals with telestroke capacity. *JAMA Neurol*. 2021;28(5):527-35.

Early Rooming Triage: Accuracy and Demographic Factors Associated with Clinical Acuity

David Y. Zhang, MD, PhD*†
Bradley Shy, MD*‡§
Nicholas Genes, MD, PhD*¶‖

*The Mount Sinai Hospital, Department of Emergency Medicine, New York, New York
†New York-Presbyterian Hospital, Columbia University Irving Medical Center, Department of Biomedical Informatics, New York, New York
‡Denver Health and Hospital Authority, Department of Emergency Medicine, Denver, Colorado
§University of Colorado School of Medicine, Aurora, Colorado
¶Ronald O. Perelman Department of Emergency Medicine, NYU Langone Health, New York, New York
‖NYU Grossman School of Medicine, Department of Emergency Medicine, New York, New York

Section Editor: Brian Yun, MD, MBA, MPH
Submission history: Submitted June 27, 2021; Revision received December 10, 2021; Accepted December 19, 2021
Electronically published February 28, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.12.53873

Introduction: Early rooming triage increases patient throughput and satisfaction by rapidly assigning patients to a definitive care area, without using vital signs or detailed chart review. Despite these operational benefits, the clinical accuracy of early rooming triage is not well known. We sought to measure the accuracy of early rooming triage and uncover additional patient characteristics that can assist triage.

Methods: We conducted a single-center, retrospective population study of walk-in emergency department (ED) patients presenting to the ED via an early rooming triage system, examining triage accuracy and demographic factor correlation with higher acuity ED outcomes.

Results: Among all patients included from the three-year study period (N = 238,457), early rooming triage was highly sensitive (0.89) and less specific (0.61) for predicting which patients would have a severe outcome in the ED. Patients triaged to the lowest acuity area of the ED experienced severe outcomes in 4.39% of cases, while patients triaged to the highest acuity area of the ED experienced severe outcomes in 65.9% of cases. An age of greater than 43 years (odds ratio [OR] 3.48, 95% confidence interval: 3.40, 3.57) or patient's home address farther from the ED ([OR] 2.23 to 3.08) were highly correlated with severe outcomes. Multivariable models incorporating triage team judgment were robust for predicting severe outcomes at triage, with an area under the receiver operating characteristic of 0.82.

Conclusion: Early rooming workflows are appropriately sensitive for ED triage. Consideration of demographic factors, automated or otherwise, can augment ED processes to provide optimal triage. [West J Emerg Med. 2022;23(2)145–151.]

INTRODUCTION

Background

Emergency department (ED) triage is a continually evolving process, changing in response to both emerging patient characteristics and improved understanding of fundamental pathophysiological processes. Prior to the development of scales such as the Emergency Severity Index (ESI), triage decisions were heterogeneous and variable.

Significant inter-rater variation was observed when nurses and emergency medical technicians were tested with standardized clinical scenarios,[1] and nurses and physicians were not able to accurately predict the need for admission at triage.[2] In response, the five-point ESI scale was developed and validated. The ESI score has good inter-rater reliability and is predictive of hospital admission,[3] especially at the extremes of triage scores.[4] Additionally, the ESI score is validated in a range of specialized populations, such as pediatric patients,[5] leading to its widespread use in ED triage.

Since the validation of these triage risk assessment tools almost 20 years ago, ED triage processes have changed to progressively improve ED throughput and patient satisfaction. In addition, disease-specific triage pathways have emerged for acute clinical presentations, such as stroke, sepsis, and acute coronary syndrome. Although these changes have improved care for critically ill patients and improved ED metrics, they concurrently demand more of triage teams, requiring greater accuracy with less initial information. Given these changes, it is essential to both validate the performance of these systems and discover patient characteristics that improve risk stratification.

Population Health Research Capsule

What do we already know about this issue?
Emergency department patients are diverse, with a wide range of clinical presentations. Several different triage methods exist to manage these presentations.

What was the research question?
We determined the accuracy of early rooming triage, and whether use of demographic factors could improve it.

What was the major finding of the study?
Early rooming triage is effective and can be further improved by considering the patient's age and ZIP code.

How does this improve population health?
Emergency department outcomes vary across demographic strata. Consideration of these factors will optimize resource allocation and improve patient care.

Importance

Triage workflow has since expanded beyond ESI. To improve ED front-end operations, two complementary and successful approaches have emerged: practitioner-in-triage systems, and early rooming systems (direct to bed or split flow systems).[6] Practitioner-in-triage systems, where a physician or midlevel practitioner works in triage to expedite patient care, have demonstrated improved wait times,[7] fewer patients waiting to be seen,[8] and decreased length of stay.[9] These improvements are tempered by increased physician or midlevel resources dedicated to triage. Similar benefits have been noted for early rooming strategies—patients are rapidly placed in a care area after a cursory registration process, allowing for concurrent triage, nursing, and physician assessment. Early rooming strategies have improved patient waiting times, decreased lengths of stay, and decreased rates of patients leaving without being seen.[10,11] These improvements also improve patient care, as patients initially leaving without being seen nevertheless have significant rates of critical illness and need for hospitalization.[11] Despite this progress, it is unclear whether abbreviated registration in early rooming retains the accuracy and sensitivity for critical illness, compared to traditional triage workflows.

Goals of This Investigation

Patient demographics are continually evolving, with increasing numbers of non-urgent patients with different care requirements.[12,13] The number of geriatric patients also continues to grow, with a different set of unique characteristics.[14,15] A plethora of risk-stratification tools have emerged; however, they are typically either fast with poor accuracy,[16] or require additional clinical data such as vital signs[17,18] and laboratory testing.[19–21] These tools are not appropriate for early rooming triage, where vital signs and testing cannot delay initial triage decisions. In response to these challenges, we now present data from a large population of walk-in patients at an urban academic ED. We assess the sensitivity and specificity of early rooming for detecting emergent outcomes and explore demographic factors available at triage that further improve triage accuracy.

MATERIALS AND METHODS

Early Rooming Triage

In our ED, early rooming triage is performed by a registration clerk and experienced nurse for all walk-in patients. After a brief discussion with the patient and registration in the electronic health record (EHR), patients are rapidly assigned to one of three care areas, specialized for treating low-, medium-, and high-acuity patients. When beds are not available in these areas, patients are moved to an available chair, hallway area, or other proximal location in the ED. This ensures the patient is rapidly available to all members of the care team, who work in parallel to manage the patient clinically. If a patient is found to need a different level of care at any time during the ED evaluation, patients are moved to higher or lower acuity areas as appropriate.

Study Design and Setting

We conducted a retrospective population study of all walk-in ED visits at a large, academic, urban ED between January 1, 2017–December 31, 2019, examining both the accuracy of early rooming triage and demographic factors predictive of severe ED outcomes. This work was reviewed and approved by our institutional review board under protocol 16-00180.

Selection of Participants

We included every walk-in patient triaged based on acuity. Major groups not included in the study were pediatric patients triaged based on age, and patients directly triaged to the psychiatric ED. A pilot geriatric emergency area was active during part of the study period, and patients triaged there based on age criteria were also excluded in the study. Visits with missing demographic or location data were not included in subsequent analysis.

Methods of Measurement

We directly extracted patient demographic factors, patient behavioral factors, and disposition (including admission and death) directly from the EHR. Six outcome measures were used as surrogates for severe outcome based on their ease of extraction from the health record and their perceived correlation with patients requiring higher level of care in the ED. Since these measures have not been individually validated for this purpose, we considered them in aggregate to represent sick patients more comprehensively. Patients were considered to necessitate an operative intervention if an operative note was signed at any time during the current visit, including after admission. Sepsis alerts were triggered within the EHR based on vital sign criteria, and only counted as positive for this study if the clinician confirmed the sepsis status in a structured clinical note and order set. Targeted temperature management and intravenous (IV) epinephrine use were inferred by the presence of those signed orders during the current visit. Patients transferred to another institution or placed in the observation unit were not considered admitted in this study.

Outcome Measures

We used a composite outcome consisting of six electronically accessible outcomes or treatments in the ED, each representing an aspect of patient care that was highly suggestive of the need for higher level of triage. Patients were considered to require higher levels of triage if they experienced any one of the following: admission to the hospital, operative intervention during the current visit, confirmed sepsis, death, IV epinephrine, or targeted temperature management. For assessing triage accuracy, patients were considered correctly triaged if they were either triaged to the medium- or high-acuity areas of the ED and subsequently developed a severe outcome, or if they were triaged to the low-acuity area of the ED and subsequently did not develop any severe outcome.

Analysis

After EHR extraction, we performed all data processing and data analysis in SAS Studio 3.8 (SAS Institute Inc, Cary, NC). We inferred residence from ZIP code. Event frequencies, coincidence, univariate logistic, and multivariable logistic analysis were performed using their corresponding packages in SAS Studio. We performed multivariable regression by including all factors with univariate significance, assuming no interaction between individual factors.

RESULTS

There were 327,876 patient visits to the walk-in triage area of the ED during the study period, and of these visits, triage data was available for 323,486 (98.66%). Of all visits, a subset (25.93%) was triaged to specialized pediatric, psychiatric, or geriatric areas using criteria that were not based on acuity and were not included in the study. The remaining 238,457 patients (72.73%) underwent triage based on perceived acuity to low-, medium-, and high-acuity areas of the ED **(Figure 1A)**.

The distribution of all walk-in patients was trimodal, representing pediatric, young adult, and older adult populations **(Figure 1B)**. Since pediatric patients were excluded from the study population, the patients who were included in the study formed a bimodal distribution with a central nadir at age 43 **(Figure 1C)**. Based on the shape of the distribution, we separated patients into two age groups to correlate with outcomes: one with patients aged 42 or younger, and one with patients three or older. Patients arrived during the day more than twice as often as at night **(Figure 1D).** Additionally, there was a small increase in volume on Mondays, decreasing as the week went on **(Figure 1E)**. Patients walking into the ED were slightly more likely to be female, and most had previously visited the same ED. Although our ED is in Manhattan, less than 60% of walk-in patients resided in Manhattan; most of the remainder resided in one of the other boroughs of New York City. Seven percent of patients either resided in ZIP codes outside the above-mentioned areas, or they had no ZIP code information, leading to an additional demographic group **(Table 1).**

We defined six "severe outcomes" that were suggestive of a patient needing higher levels of care in the ED. These outcomes were chosen to be easily accessible in the EHR, allowing for the analysis of many patient visits. The outcomes – admission to the hospital; operative intervention; confirmed sepsis; death; IV epinephrine; and targeted temperature management—occurred with varying frequency and overlap, with the most frequent being admission, operative intervention, and sepsis. Rarer outcomes had the most overlap, including death, IV epinephrine, and targeted temperature management, consistent with the care of critically ill patients **(Figure 2A)**. Approximately one-fifth of walk-in patients experienced at least one of these outcomes, with both older patients and patients triaged to higher acuity areas of the ED predictably experiencing more severe outcomes. Of all

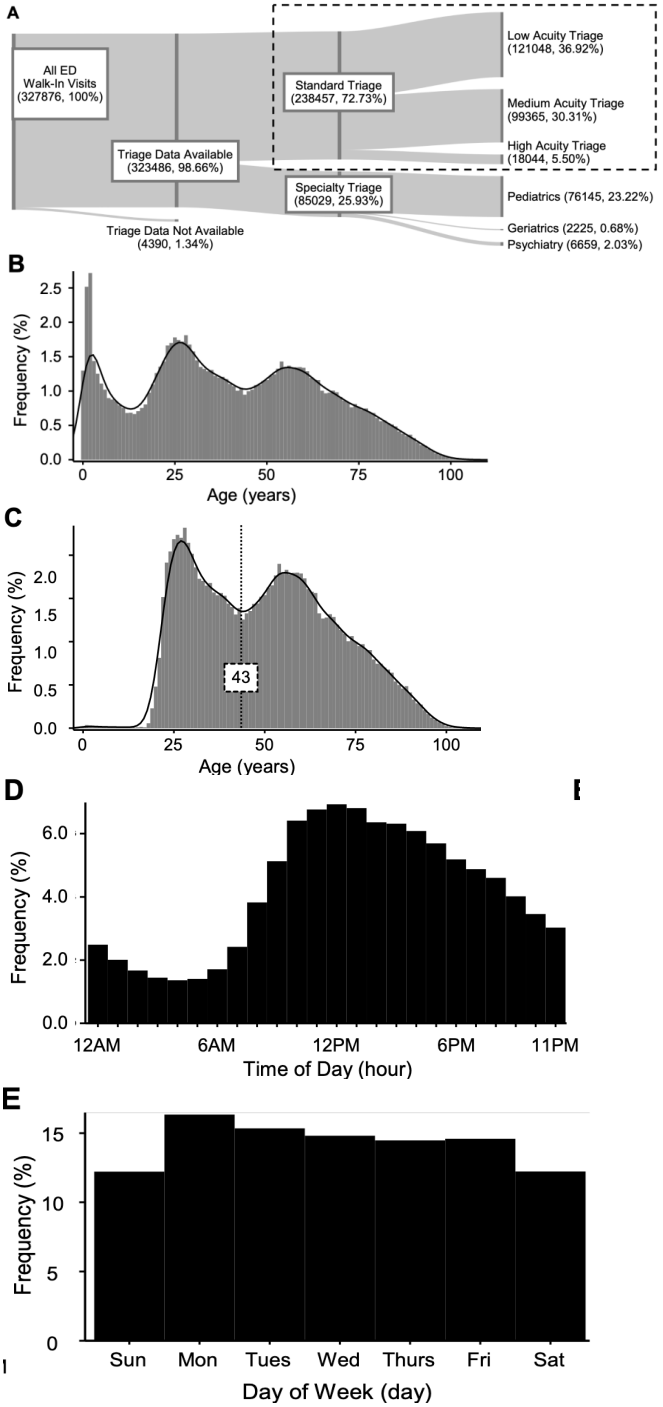


Figure 1. Patient inclusion and baseline demographic figures. (A) Distribution of all walk-in emergency department (ED) patients arriving during the study period, with aggregate triage processes and triage destinations. Vertical bars are proportional to the number of patients in each group. The dashed line surrounds the patients included in subsequent analysis. All percentages are expressed as a fraction of all walk-in patients.
(B) Age distribution of all walk-in ED patients with local trendline.
(C) Age distribution of patients included in subsequent analysis, after specialty triage has been excluded. The vertical dashed line splits the patients < 43 years of age from the patients ≥ 43 years of age.
(D-E) Distribution of arrival times and arrival day for patients undergoing standard triage.

Table 1. Selected demographic characteristics of study population.

Demographic	N	%
Gender		
Male	101,718	42.7
Female	136,739	57.3
Age		
< 43 years	93,968	39.4
≥ 43 years	144,489	60.6
Residence*		
Manhattan	147,968	62.1
Bronx	38,100	16.0
Queens	16,747	7.0
Brooklyn	16,334	6.9
Staten Island	1,815	0.8
Other/unknown	17,493	7.3
Previous ED visit		
No	70,866	29.7
Yes	167,591	70.3

*inferred from ZIP code of address.
ED, emergency department.

patients triaged to the low-acuity area of the ED, only 4.40% (5322 of 121,048) experienced a severe outcome. In contrast, 65.9% (6144 of 18,044) patients triaged to the high-acuity area of the ED experienced severe outcomes. Patients triaged to the medium-acuity area of the ED were predictably between these values, with 32.3% (32,095 of 99,365) patients experiencing severe outcomes **(Figures 2B-C).**

All demographic factors were significantly correlated with outcomes, likely due to the large number of patients in the study. Of those, the strongest correlations were in age and area of residence: older patients and patients traveling from most outside boroughs were two to four times more likely to have severe outcomes. Patients with prior ED visits were slightly more likely to have severe outcomes, and female patients had fewer severe outcomes compared to male patients. While not a demographic factor, triage to the medium- and high- acuity areas predicted a 10-fold and 44-fold increased chance of severe outcome, respectively, compared to low-acuity triage **(Table 2)**. The correlation between day of the week and severe outcomes was not clinically significant. Correlation between hour of arrival and severe outcomes was remarkable only for a small drop in acuity immediately before the start of the workday **(Figures S1 and S2).**

When used as a multivariable predictive model, demographic factors alone **(Figure 3A)** had reasonable predictive ability for patients with at least one severe outcome, which was greatly enhanced by adding triage team decision to the model. The measured performance of the triage team alone was similar to a single point on the combined multivariable model **(Figure 3B and S3).**

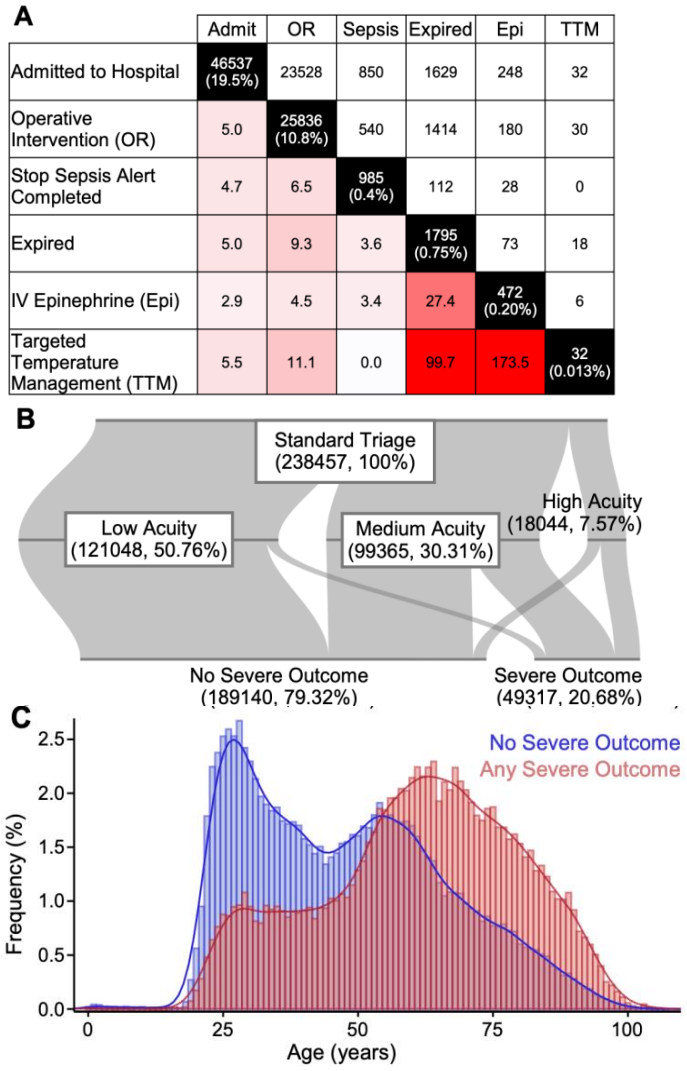


Figure 2. Frequency and coincidence of severe outcomes.
(A) Frequencies and coincidence of the six outcomes assessed. For each outcome, the total number of patients and percentage as a fraction of all study patients are listed along the black diagonal. Above the diagonal, the number of visits with both intersecting outcomes is listed. Below the diagonal, the fold enrichment above what would be expected based on the product of their individual frequencies, the fold enrichment would be 5. Increasing red color indicates higher levels of co-incidence.
(B) Proportions of patients experiencing any severe outcome, divided by initial triage area. Horizontal bars are proportional to the number of patients in each subgroup. Percentages are expressed as fraction of the study population.
(C) Age distribution of patients, separated into patients experiencing any severe outcome, vs patients experiencing no severe outcomes.

DISCUSSION

In this study, we show that early rooming triage retains a high degree of sensitivity for severe outcomes, at the expense of lower specificity. This is entirely appropriate for a triage system, where inappropriate triage to a lower acuity area has the potential to cause more harm than inappropriate triage to a high-acuity area. We also demonstrate that age and patient's location of residence are highly correlated with severe outcomes, with other demographic factors reaching statistical (but not clinical) significance. Direct extraction of these demographic and clinical fields from the EHR virtually eliminates selection and recall bias from our retrospective study design, additionally allowing for the inclusion of many patients.

This work challenges several ED stereotypes. The high-frequent visitor or "ED super-user" (a patient with recent or numerous ED visits) has been shown to have lower acuity and lower likelihood of admission compared to patients presenting to the ED for the first time.[22] In our multivariable regression, we observed no clinically significant difference between patients with a previous visit and patients without a previous visit. We did, however, observe considerable variation in the time since last ED visit **(Figure S4)**, raising the possibility that various binning and subgroup analyses may reveal alternate trends. Challenging another stereotype – that patients who wait until Monday to present to the ED have lower acuity compared to patients presenting over the weekend[23] – we observed no differences between severity and day of presentation, which suggests that either sick and critically ill patients also wait until Monday to present to the ED or the rise in ED census on Mondays is due to other factors.

It is reassuring that the performance of our triage team, at a single level of sensitivity and specificity, was not significantly worse than a multivariable model including additional demographic factors. This suggests that the triage team is already considering the same or other redundant factors in the triage process. One situation where demographic factors could further enhance triage would be if we wanted to shift the sensitivity and specificity of triage to an alternate point. A higher sensitivity (but lower specificity) approach could be used when high-acuity areas of the ED were less busy. Conversely, a higher specificity (but lower sensitivity) approach could be used at times when high-acuity areas of the ED were busier. We present both human- and computer-directed triage approaches in **(Figure S5)**.

LIMITATIONS

This study is limited by its single-center design. It is likely that there are demographic factors specific to other EDs that are uniquely correlated with acuity. We recommend site-specific investigation of prognostic demographic factors before their use in triage. Additionally, this study included only walk-in patients in our ED, as ambulance arrivals underwent a different triage process. The risk stratification and demographic variation of ambulance arrivals is a related and interesting topic that we hope will be addressed in future work.

The breadth of outcome measures included in this study was limited by the accessible data within the EHR. While this approach allowed for the streamlined analysis of a very large number of visits, certain emergent interventions such as blood

Table 2. Correlation between demographic factors and severe outcomes.

	Univariate regression		Multivariable regression	
Demographic (comparison group)	OR	95% CI	OR	95% CI
Gender (vs male)				
Female	0.74	(0.72 - 0.75)	0.81	(0.8 - 0.83)
Age (vs <43 years)				
≥ 43 years	3.48	(3.40 - 3.57)	3.44	(3.36 - 3.53)
Residence (vs Manhattan)				
Bronx	0.85	(0.82 - 0.88)	0.94	(0.91 - 0.97)
Queens	2.23	(2.15 - 2.31)	2.19	(2.11 - 2.27)
Brooklyn	2.32	(2.24 - 2.41)	2.38	(2.29 - 2.47)
Staten Island	3.08	(2.80 - 3.39)	2.93	(2.65 - 3.23)
Other/unknown	2.34	(2.26 - 2.42)	2.42	(2.33 - 2.51)
Previous ED visit (vs no prior)				
Yes	0.90	(0.88 - 0.92)	1.03	(1.01 - 1.05)
ED triage location (vs low acuity)*				
Medium acuity	10.37	(10.06 - 10.70)		
High acuity	42.11	(40.41 - 43.89)		

*Not included in multivariable regression
OR, odds ratio; *CI*, confidence interval; *ED*, emergency department.

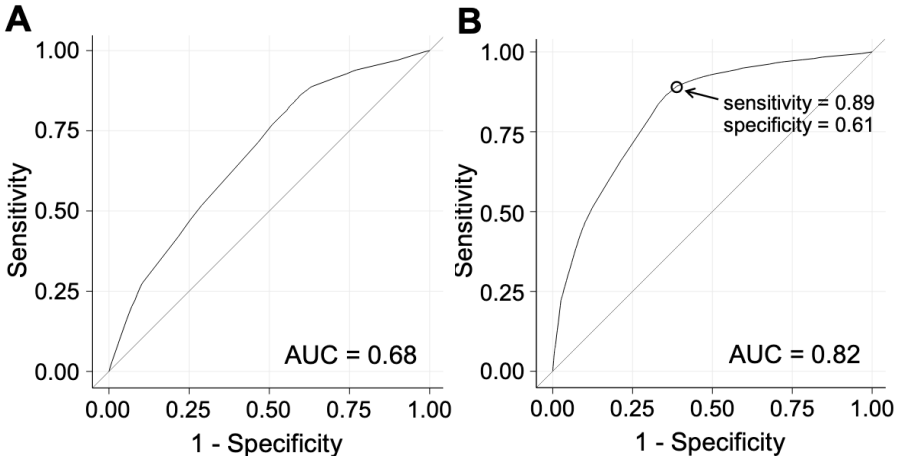


Figure 3. Predictive ability of multivariate models.
ROC analysis for two multivariate logistic regression models to predict severe emergency department (ED) outcomes: (A) a model from Table 2 containing demographic factors alone, and (B) a model with the same demographic factors, but also including the initial triage decision made by the ED team. The circle marks the performance of the triage team alone, in a location with high sensitivity and lower specificity.
AUC, area under the curve; *ROC*, receiver operating characteristic; *ED*, emergency department.

transfusion or naloxone administration were not included. We look forward to more detailed and nuanced data as our chart extraction techniques improve.

Lastly, we found a surprisingly low number of patients with confirmed sepsis in our study population. This is likely due to clinical workflow changes within the health record, or limitations in our data extraction. We have included these limited patients in our aggregate outcome measure; however, we have likely underestimated the true prevalence of confirmed sepsis in our patient population.

CONCLUSION

Early rooming triage has previously established benefits for patient throughput and satisfaction. In this study, we demonstrate that early rooming triage nevertheless retains high sensitivity for detecting critically ill patients, despite

the lack of vital signs or chart review in triage. Based on our data, we hope that ED teams will be more confident when using early rooming triage to improve ED workflow. Future studies should focus on implementation of combined clinical and computational triage processes, with the opportunity to dynamically alter triage criteria to match ED patient load.

ACKNOWLEDGEMENTS

We are grateful for the assistance of David Gutteridge for facilitating interactions with our institutional review board, and additionally grateful for the assistance of Karen Trommer, Anurag Gautam, and Paul Francaviglia for extraction of data from the electronic health record.

Address for Correspondence: Nicholas Genes, MD, PhD, Ronald O. Perelman Department of Emergency Medicine, NYU Langone Health, 570 1st Ave, New York NY 10016. Email: nicholas.genes@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. Wuerz R, Fernandes CM, Alarcon J. Inconsistency of emergency department triage. Emergency Department Operations Research Working Group. *Ann Emerg Med*. 1998;32(4):431-5.
2. Brillman JC, Doezema D, Tandberg D, et al. Triage: limitations in predicting need for emergent care and hospital admission. *Ann Emerg Med*. 1996;27(4):493-500.
3. Tanabe P, Gimbel R, Yarnold PR, et al. Reliability and validity of scores on the Emergency Severity Index version 3. *Acad Emerg Med*. 2004;11(1):59-65.
4. Wuerz RC, Milne LW, Eitel DR, et al. Reliability and validity of a new five-level triage instrument. *Acad Emerg Med*. 2000;7(3):236-42.
5. Baumann MR, Strout TD. Evaluation of the Emergency Severity Index (version 3) triage algorithm in pediatric patients. *Acad Emerg Med*. 2005;12(3):219-24.
6. Wiler JL, Gentle C, Halfpenny JM, et al. Optimizing emergency department front-end operations. *Ann Emerg Med*. 2010;55(2):142-60.e1.
7. Travers JP, Lee FC. Avoiding prolonged waiting time during busy periods in the emergency department: Is there a role for the senior emergency physician in triage? *Eur J Emerg Med*. 2006;13(6):342-8.
8. Terris J, Leman P, O'Connor N, et al. Making an IMPACT on emergency department flow: improving patient processing assisted by consultant at triage. *Emerg Med J*. 2004;21(5):537-41.
9. Holroyd BR, Bullard MJ, Latoszek K, et al. Impact of a triage liaison physician on emergency department overcrowding and throughput: a randomized controlled trial. *Acad Emerg Med*. 2007;14(8):702-8.
10. Spaite DW, Bartholomeaux F, Guisto J, et al. Rapid process redesign in a university-based emergency department: decreasing waiting time intervals and improving patient satisfaction. *Ann Emerg Med*. 2002;39(2):168-77.
11. Chan TC, Killeen JP, Kelly D, Guss DA. Impact of rapid entry and accelerated care at triage on reducing emergency department patient wait times, lengths of stay, and rate of left without being seen. *Ann Emerg Med*. 2005;46(6):491-7.
12. Uscher-Pines L, Pines J, Kellermann A, et al. Emergency department visits for nonurgent conditions: systematic literature review. *Am J Manag Care*. 2013;19(1):47-59.
13. Afilalo J, Marinovich A, Afilalo M, et al. Nonurgent emergency department patient characteristics and barriers to primary care. *Acad Emerg Med*. 2004;11(12):1302-10.
14. Hwang U, Morrison RS. The geriatric emergency department. *J Am Geriatr Soc*. 2007;55(11):1873-6.
15. Salvi F, Morichi V, Grilli A, et al. The elderly in the emergency department: a critical review of problems and solutions. *Intern Emerg Med*. 2007;2(4):292-301.
16. Askim Å, Moser F, Gustad LT, et al. Poor performance of quick-SOFA (qSOFA) score in predicting severe sepsis and mortality: a prospective study of patients admitted with infection to the emergency department. *Scand J Trauma Resusc Emerg Med*. 2017;25(1):56.
17. Brown JB, Gestring ML, Forsythe RM, et al. Systolic blood pressure criteria in the National Trauma Triage Protocol for geriatric trauma: 110 is the new 90. *J Trauma Acute Care Surg*. 2015;78(2):352-9.
18. Rady MY, Smithline HA, Blake H, Nowak R, Rivers E. A comparison of the shock index and conventional vital signs to identify acute, critical illness in the emergency department. *Ann Emerg Med*. 1994;24(4):685-90.
19. Kruse O, Grunnet N, Barfod C. Blood lactate as a predictor for in-hospital mortality in patients admitted acutely to hospital: a systematic review. *Scand J Trauma Resusc Emerg Med*. 2011;19:74.
20. Lee DS, Stitt A, Austin PC, et al. Prediction of heart failure mortality in emergent care: a cohort study. *Ann Intern Med*. 2012;156(11):767-75.
21. Shapiro NI, Wolfe RE, Moore RB, et al. Mortality in Emergency Department Sepsis (MEDS) score: a prospectively derived and validated clinical prediction rule. *Crit Care Med*. 2003;31(3):670-5.
22. Ruger JP, Richter CJ, Spitznagel EL, et al. Analysis of costs, length of stay, and utilization of emergency department services by frequent users: implications for health policy. *Acad Emerg Med*. 2004;11(12):1311-7.
23. Meacock R, Anselmi L, Kristensen SR, et al. Higher mortality rates amongst emergency patients admitted to hospital at weekends reflect a lower probability of admission. *J Health Serv Res Policy*. 2017;22(1):12-9.

Association of Suicide Attempt with Stimulant Abuse in California Emergency Departments in 2011: A Study of 10 Million ED Visits

Shahram Lotfipour, MD[*†]
Nikhil Shah, BS[‡]
Hina Patel, BS[§]
Soheil Saadat, MD, PhD, MPH[*]
Tim Bruckner, PhD, MPH[¶]
Parvati Singh, PhD[‖]
Bharath Chakravarthy, MD[*]

[*]UC Irvine School of Medicine, Department of Emergency Medicine, Irvine, California
[†]Eisenhower Health, Department of Emergency Medicine, Rancho Mirage, California
[‡]Feinberg School of Medicine-Northwestern University, Chicago, Illinois
[§]UC Irvine School of Biological Sciences, Irvine, California
[¶]UC Irvine Program in Public Health, Irvine, California
[‖]UC Irvine School of Medicine, Department of Public Health, Irvine, California

Section Editor: Mark I. Langdorf, MD, MHPE
Submission history: Submitted December 2, 2020; Revision received July 25, 2021; Accepted August 2, 2021
Electronically published February 23, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.8.51022

Introduction: Our goal in this study was to identify stimulant abuser patients who are at specifically high risk of suicide attempt (SAT), in order to prioritize them in preventive and risk mitigation programs.

Methods: We used the California State Emergency Department Database (SEDD) to obtain discharge information for 2011. The SEDD contains discharge information on all outpatient ED encounters, including uninsured patients and those covered by Medicare, Medicaid, and private insurance. We identified SAT and stimulant abuse by using the relevant International Classification of Diseases, Ninth Revision, codes.

Results: The study included 10,124,598 outpatient ED visits. Stimulant abuse was observed in 0.97% of ED visits. Stimulant abuse was more common among young and middle-aged males and people with low median household income. Moreover, it was more common among Native American (1.8%) and Black (1.8%), followed by non-Hispanic White (1.1%) patients. The prevalence of SAT was 2.0% (N = 2000) for ED visits by patients with a history of stimulant abuse, and 0.3% (N = 28,606) for ED visits without a history of stimulant abuse (odds ratio 7.29, 95% confidence interval, 6.97-7.64). The SATs were directly associated with stimulant abuse, younger age (age groups >10), and non-Hispanic White and Native American race. Association of SAT with stimulant abuse was stronger in female patients.

Conclusion: Stimulant abuse was the only modifiable risk factor for suicide attempt in our study. Reaching out to populations with higher prevalence of stimulant abuse (young and middle-aged individuals who are Native American or Black, with lower household income) to control the stimulant abuse problem, may reduce the risk of SAT. In this regard, people who are at higher risk of SAT due to non-modifiable risk factors (younger age, and Native American or White race) should be prioritized. Moreover, controlling stimulant abuse among women may be specifically effective in SAT prevention. [West J Emerg Med. 2022;23(2)152–157.]

INTRODUCTION

The use and abuse of stimulants has been increasing across the United States.[1] This includes rates of recreational cocaine use along with medical and nonmedical amphetamine consumption. The risk, severity, and type of stimulant abuse have been shown to vary across different populations.[1]

Various trends have been established in regard to different population demographics. For example, it has been shown that methampheta-mine is more prevalent in the western US, although this has been trending eastward.[2]

Cocaine and amphetamines have different mechanisms of action but similarly affect monoamine transporters. Cocaine blocks the reuptake of neurotransmitters, while amphetamine releases more into the synapse.[2] Therefore, when comparing the two drugs, methamphetamine affects dopamine balance in the brain for a longer period of time. This is one of the many factors that have led to the differential effects of these stimulants.[3]

In recent years, there has been an increase in overall prescriptions to college students, especially to those in academically stressful situations.[4] Misuse of stimulants has been shown to cause multiple issues including tissue ischemia and long-term neurological changes. An apparent correlation has been observed between the increase in overall stimulant prescription to patients of varying ages and demographics and misuse of these stimulants, resulting in both physiological and neurological changes that could be prevented.[5] Particularly, the neurological changes that result from stimulant abuse may increase their risk of suicide. Globally, suicide is the third leading cause of death in the 15-44 age group.[6] Although a strong correlation between stimulant abuse-induced neurological changes and suicide exists, various other factors contribute to the onset of suicidal thoughts. The rising concern with regard to impulsive suicidal thoughts, and their potential to claim lives, has spurred public health intervention efforts to provide support to these most vulnerable and at-risk populations. Public health interventions in populations suffering from stimulant abuse can facilitate a reduction of suicide attempts (SAT) in this demographic.[5] Specific, targeted preventive efforts may reduce SAT in at-risk populations and help maintain mental and physiological health.

An association between stimulant abuse and SAT has already been reported.[7] We expanded on this work, accessing the 2011 State Emergency Department Database (SEDD) to determine which subgroups, if any, of stimulant-abuse populations are at increased risk of SAT. This subgroup analysis may inform targeted public health efforts focused on the most at-risk individuals.

Population Health Research Capsule

What do we already know about this issue?
Different populations in the US are increasingly susceptible to the use of stimulants. A strong correlation exists between stimulant abuse and suicide attempt (SAT).

What was the research question?
We investigated which subgroups of stimulant abuse patients in California emergency departments had higher risk of SAT.

What was the major finding of the study?
A SAT was associated with stimulant abuse, younger age, and being non-Hispanic White or Native American. The association was stronger in females.

How does this improve population health?
Suicide prevention interventions in healthcare settings should actively target patients (especially females) who have stimulant abuse issues.

METHODS

We used data from the California State Emergency Department Database (SEDD) 2011 for analysis. We considered emergency department (ED) visits identified by E95* *International Classification of Diseases, Ninth Revision* (ICD-9), code as a SAT case. The visit was classified as stimulant abuse-related, if at least one of the following ICD-9 codes was associated with the visit: 304.2* (Cocaine dependence); 304.3* (Cannabis dependence); 304.4* (Amphetamine type and other psychostimulants dependence); 305.2* (Nondependent abuse of drugs: cannabis); 305.6* (Nondependent abuse of drugs: cocaine type); 305.7* (Nondependent abuse of drugs: amphetamine type); 969.7* (Poisoning by psychostimulants); 970.0 (Poisoning by analeptics); 970.8* (Poisoning by other central nervous system stimulants); 970.9 Poisoning by unspecified central nervous system stimulants); E854.2 (Accidental poisoning by other psychotropic agents: psychostimulants); E854.3 (Accidental poisoning by other psychotropic agents: central nervous system stimulants); E939.7 (Drugs, medicaments, and biological substances causing adverse effects in therapeutic use: psychotropic agents, psychostimulants) ; E940.0 (Drugs, medicaments, and biological substances causing adverse effects in therapeutic use: central nervous system stimulants, analeptics); E940.8 (Other specified central nervous system stimulants causing adverse effects in therapeutic use); and E940.9 (Unspecified central nervous system stimulant causing adverse effects in therapeutic use).

We used Stata 14.2 SE statistical software (StataCorp LLC, College Station, TX) for data analysis. Prevalence proportions are reported as percentage and 95% confidence intervals (CI). Logistic regression analysis was used to examine the association of SAT with age groups, gender, stimulant abuse, and race. Some patients had been referred more than once to the ED; therefore, the dataset was considered as clustered at the level of the patient, and the standard errors were estimated by clustered robust method.

RESULTS

The study included 10,124,598 ED visits in California in 2011. Stimulant abuse was associated with 97,834 (0.97%; 0.96% - 0.97%) ED visits. Table 1 shows the prevalence of stimulant abuse in different patient groups. Stimulant abuse was more common among patients of young and middle age, male (1.40%), Black (1.8%), and Native American (1.8%), followed by non-Hispanic White (1.1%) patients. Stimulant abuse was more common in patients with lower household income. The prevalence of SAT was 2.0% (N = 2000) for ED visits with a history of stimulant abuse, and 0.3% (N = 28,606) for ED visits without a history of stimulant abuse (odds ratio [OR] 7.29, 95% CI, 6.97-7.64). In the state of California, 30,606 (0.30%) ED visits were associated with SAT.

Table 1. Prevalence of stimulant abuse per emergency department visits, according to patients' characteristics.

	Stimulants Abuse			
	No		Yes	
Demographics	Count	Row %	Count	Row %
Age group				
0-10	1,768,307	100.0%	237	0.0%
10-20	1,112,735	98.7%	14,267	1.3%
20-30	1,637,599	98.2%	29,655	1.8%
30-40	1,300,234	98.5%	19,899	1.5%
40-50	1,289,198	98.6%	18469	1.4%
50-60	1,141,177	99.0%	11,613	1.0%
60-70	712,538	99.6%	2,925	0.4%
70-80	491,645	99.9%	403	0.1%
80-90	515,341	100.0%	90	0.0%
Gender				
Male	4,465,778	98.6%	61,998	1.4%
Female	5,426,236	99.4%	35,214	0.6%
Race				
White	4,119,855	98.9%	44,413	1.1%
Black	1,079,244	98.2%	19,593	1.8%
Hispanic	3,515,411	99.3%	25,526	0.7%
Asian/Pacific	453,282	99.6%	1,799	0.4%
Native American	18,253	98.2%	335	1.8%
Other	321,250	99.1%	2,782	0.9%
Median household income state quartile for patient ZIP Code				
1	3,087,808	98.8%	38,239	1.2%
2	2,684,738	99.1%	24,087	0.9%
3	2,289,600	99.2%	18,698	0.8%
4	1,702,577	99.3%	11,243	0.7%

Univariable Analysis

The association of SAT with stimulant abuse was stronger in women (OR 9.18, 95% CI, 8.60-9.80) compared to men (OR 6.45, 95% CI, 6.04-6.88). This pattern was seen in all age groups >10. The association of SAT with stimulant abuse was stronger in ages above 60 (OR 12.55, 95% CI, 8.68-18.16) compared to younger age groups (OR 6.43, 95% CI, 6.14-6.74). The pattern was similar in both genders (Figure 1). The association of SAT with stimulant abuse in Asian/Pacific (OR 12.01, 8.88 - 16.26) and Hispanic patients (OR 9.41, 8.59 - 10.32) was stronger than White (OR 6.66, 6.26 - 7.09) and Black (OR 5.61, 4.93 - 6.39) patients (Figure 2).

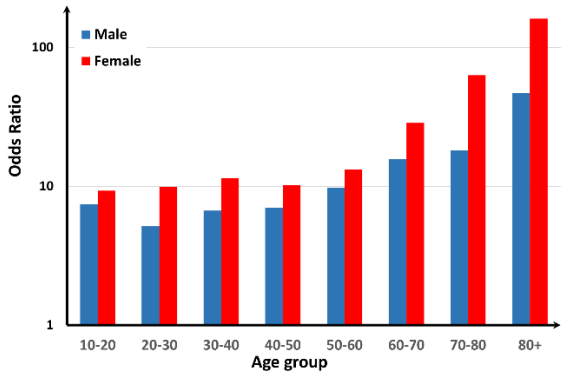


Figure 1. Association of suicide attempt with stimulant abuse in age-gender groups.

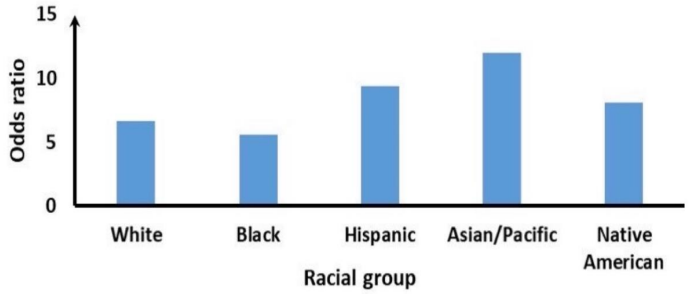


Figure 2. Association of suicide attempt with stimulant abuse in racial groups.

Multivariable Analysis

In a multivariable analysis (Table 2), SAT was directly associated with stimulant abuse (OR 4.18), young age (>10), and female gender. Suicide attempts were more frequent among White and Native American patients, compared to Black. The association of SAT with stimulant abuse was stronger in female patients in multivariable analysis.

DISCUSSION

Analysis of over 10 million ED visits in California gave us insight into the relation between SAT and stimulant abuse in different patient populations. Our findings cohere with

Table 2. Association of suicide attempt with stimulant abuse and different demographic characteristics.

Variable	Odds ratio	Standard error	Z	P	95% Confidence interval
Stimulant abuse					
Yes (vs No)	4.18	.159	37.67	<0.001	3.88 – 4.51
Gender					
Female (vs male)	1.07	.017	4.59	<0.001	1.04 – 1.11
Age groups					
10-20 (vs 0-10)	92.30	14.160	29.50	<0.001	68.33 – 124.68
20-30 (vs 0-10)	59.45	9.11	26.67	<0.001	44.04 – 80.27
30-40 (vs 0-10)	46.36	7.12	24.99	<0.001	34.31 – 62.64
40-50 (vs 0-10)	41.46	6.37	24.25	<0.001	30.68 – 56.02
50-60 (vs 0-10)	29.70	4.57	22.02	<0.001	21.96 – 40.16
60+ (vs 0-10)	7.89	1.23	13.25	<0.001	5.82 – 10.72
Race					
White (vs Black)	1.89	.049	24.77	<0.001	1.80 – 1.99
Hispanic (vs Black)	1.07	.030	2.43	0.015	1.01 – 1.13
Asian/Pacific (vs Black)	1.18	.054	3.55	<0.001	1.08 – 1.29
Native American (vs Black)	1.61	.228	3.35	0.001	1.22 – 2.12
Others (vs Black)	1.58	.068	10.60	<0.001	1.45 – 1.72
Interactions					
Stimulant by Female	1.49	.080	7.36	<0.001	1.34 – 1.65
Model Constant	.0001	0.00001	-63.79		

Pseudo R_2 = 0.05 (Standard error adjusted for 4,528,235 clusters).

previous findings and indicate that depressed or suicidal individuals are more likely to abuse stimulants and are increasingly susceptible to SAT. As the only modifiable risk factor in our study, stimulant abuse was more common in young and middle-aged, male, Native American, and Black patients with lower household income. We also found that stimulant abuse puts females at higher risk of SAT.

The risk of SAT is prevalent across patient populations and increases with factors such as stimulant abuse.[5] Not only does a SAT endanger the life of a vulnerable individual, it also psychologically affects the individual, families, communities, and society as a whole. The substantial impact that suicide has on the community necessitates public health intervention efforts to target high-risk populations. Young populations have been deemed increasingly at risk of suicide due to a variety of psychosocial stressors.[5] Research stipulates that within these diverse, young populations, females have proven to be the most vulnerable group.[5] Suicide remains the second leading cause of death in individuals between the ages of 10-34.[6] Stimulant abuse contributes to the numerous stressors that young populations face.[8] Public health prevention efforts within this demographic group may reduce the economic and human cost of suicide.

The rising national trend in nonmedical prescription stimulant abuse has allowed experts to discern the psychological factors that contribute to the start of recreational substance consumption.[9] This work indicates that the initiation of abuse often follows discrete traumatic events.[10] Therefore, the inefficiency of prescription medication as a coping mechanism may be attributed to these higher suicidal rates. A prominent correlation between lower median household income state quartile (MHIQ) and increased stimulant abuse (MHIQ = 1.2%) exists (Table 1). Poor access to healthcare and high rates of depression in individuals of lower socioeconomic status contribute to psychological effects prompting nonmedical stimulant abuse.[8] Non-medical stimulant use has also been associated with other harmful habits including tobacco, alcohol, and other illicit drug use.[4] Each of these habits has also been correlated to increased suicide risk, all of which may be contributing factors.[11]

Multivariable analysis showed SAT is associated with stimulant abuse and younger age. One potential reason for this result may involve the absence of impulse control correlated with drug abuse.[12] Meanwhile, the proportion of ED visits with associated stimulant abuse was higher in younger age groups. This pattern corroborates past research indicating increased non-medical stimulant use among college populations.[4] Association of SAT with stimulant abuse (besides younger age), and higher prevalence of stimulant abuse in those who are younger in age indicates that

young people should be targeted for active stimulant-abuse prevention and treatment interventions.

We found a stronger association between SAT and stimulant abuse in females, in all age groups. Previous literature coheres with this finding. Gender differences in stimulants have been established both behaviorally and pharmacologically. Women have been known to undergo the telescoping effect, which stipulates that in the long term, females escalate from low-dose use to addiction faster than men.[13] The quicker increase in consumption rates has been attributed to hormonal fluctuations inherent with the menstrual cycle. This hormonal fluctuation has been shown to subject women to differential drug effects dependent on their menstrual phase.[14] Women have been shown to be significantly more susceptible to physiological dependence, which is the most extreme classification of drug use in the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*. This is associated with an increase in extreme lifestyle changes attributable to drug administration and consumption.[3]

Suicide attempts are associated with Native American and White race. At the same time, stimulant abuse was more common in Native American, and to a lesser extent, White patients. This pattern indicates active stimulant-abuse prevention and treatment interventions could specifically reduce SAT in those racial groups. It has been well established in the literature that race plays a significant role in the type of substance being abused.[15] The increased rate of cocaine abuse in Black populations has been attributed to distribution networks and the historic, structurally driven prevalence of cocaine in Black communities.[15] White and Hispanic populations, on the other hand, have more commonly used amphetamines or are considered dual users of both stimulants.[3] Interestingly, Asian/Pacific Islanders have also experienced a sharp increase in non-cocaine stimulant admissions to treatment centers.[16] We were not able to differentiate the exact type of the stimulant in this study.

LIMITATIONS

It should be noted that this study does have its limitations. First, a substantial number of patients diagnosed in the ED could have had suicidal thoughts without SAT. Additionally, patients who have intended self-harm without SAT could have been mischaracterized as SAT. This categorizes individuals who had suicidal intentions but no SAT in the same category as those who were suicidal with SAT.

CONCLUSION

Suicide attempts were associated with stimulant abuse, younger age, and White or Native American race. Stimulant abuse was the only modifiable risk factor for SAT in our study. Therefore, we recommend that groups with higher prevalence of stimulant abuse (young and middle aged, Native American and Black race, with lower household income) be targeted for stimulant-abuse prevention and treatment to reduce SAT. In this regard, people who are at higher risk of SAT due to non-modifiable risk factors (younger age, Native American or White race) should be prioritized. Moreover, controlling stimulant abuse among women would be specifically effective in SAT prevention. The findings presented could be of value when developing screening tools to implement in a patient care setting that stratifies patients into risk categories for SAT.

Address for Correspondence: Bharath Chakravarthy, MD, MPH, University of California, Irvine, Department of Emergency Medicine, 101 The City Drive South, Route 128-01, Orange, California 92868. Email: bchakrav@uci.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. Sanchez K, Chartier KG, Greer TL, et al. Comorbidities and race/ethnicity among adults with stimulant use disorders in residential treatment. *J Ethn Subst Abuse.* 2015;14(1):79–95.
2. Ciccarone D. Stimulant abuse: pharmacology, cocaine, methamphetamine, treatment, attempts at pharmacotherapy. *Prim Care.* 2011;38(1):41-58.
3. Wu LT, Blazer DG, Patkar AA, et al. Heterogeneity of stimulant dependence: a national drug abuse treatment clinical trials network study. *Am J Addict.* 2009;18(3):206-18.
4. McCabe SE, Knight JR, Teter CJ, et al. Non-medical use of prescription stimulants among US college students: prevalence and correlates from a national survey. *Addiction.* 2005;100(1):96-106.
5. Pompili M, Serafini G, Innamorati M, et al. Suicidal behavior and alcohol abuse. *Int J Environ Res Public Health.* 2010;7(4):1392-431.
6. Bachmann S. Epidemiology of Suicide and the psychiatric perspective. *Int J Environ Res Public Health.* 2018;15(7):1425.
7. Artenie AA, Bruneau J, Zang G, et al. Associations of substance use patterns with attempted suicide among persons who inject drugs: Can distinct use patterns play a role? *Drug Alcohol Depend.* 2015;147:208-14.
8. Stewart TD, Reed MB. Nonmedical use of prescription medications among young adults in the United States. In: US National Library of Medicine National Institutes of Health; 2017. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5501653/. Accessed July 7, 2017.

9. Arria AM, Wish ED. Nonmedical use of prescription stimulants among students. *Pediatr Ann.* 2006;35(8):565-71.
10. Rougemont-Bücking A, Grazioli VS, Marmet S, et al. Non-medical use of prescription drugs by young men: impact of potentially traumatic events and of social-environmental stressors. *Eur J Psychotraumatol.* 2018;9(1):1468706.
11. Jung M. The relationship between alcohol abuse and suicide risk according to smoking status: a cross-sectional study. *J Affect Disord.* 2019;244:164-70.
12. de Wit H. Impulsivity as a determinant and consequence of drug use: a review of underlying processes. *Addict Biol.* 2009;14(1):22-31.
13. Becker JB, Hu M. Sex differences in drug abuse. *Front Neuroendocrinol.* 2008;29(1):36-47.
14. Greenfield SF, Back SE, Lawson K, Brady KT. Substance abuse in women. *Psychiatr Clin North Am.* 2010;33(2):339-355.
15. Sexton RL, Carlson RG, Siegal HA, Falck RS, Leukefeld C, Booth B. Barriers and pathways to diffusion of methamphetamine use among African Americans in the rural South: preliminary ethnographic findings. *J Ethn Subst Abuse.* 2005;4(1):77-103.
16. Wong W, Barnett PG. Characteristics of Asian and Pacific Islanders admitted to U.S. drug treatment programs in 2005. *Public Health Rep.* 2010;125(2):250-7.

Association of Blood Alcohol and Alcohol Use Disorders with Emergency Department Disposition of Trauma Patients

Wirachin Hoonpongsimanont, MD, MS*†
Ghadi Ghanem, BS*
Preet Sahota, MS*
Abdullah Arif, BA*
Cristobal Barrios, MD‡
Soheil Saadat, MD, MPH, PhD*
Shahram Lotfipour, MD, MPH*†

*University of California, Irvine School of Medicine, Department of Emergency Medicine, Orange, California
†Eisenhower Medical Center, Department of Emergency Medicine, Rancho Mirage, California
‡University of California, Irvine School of Medicine, Department of Surgery, Division of Trauma, Burns, and Critical Care & Acute Care Surgery, Orange, California

Section Editor: Eric Snoey, MD
Submission history: Submitted December 29, 2020; Revision received July 23, 2021; Accepted September 9, 2021
Electronically published February 28, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.9.51376

Introduction: Trauma patients who present to the emergency department (ED) intoxicated or with an alcohol use disorder (AUD) undergo more procedures and have an increased risk of developing complications. However, how AUD and blood alcohol concentration (BAC) impact a trauma patient's disposition from the ED remains inconclusive. In this study we aimed to identify the associations between positive BAC or an AUD with admission to the hospital, including the intensive care unit (ICU).

Methods: This was a retrospective study analyzing data from 2010–2018 at a university-based, Level I trauma ED. Included in the study were 4,699 adult trauma patients who completed the Alcohol Use Disorders Identification Test (AUDIT) and had blood alcohol content test results.

Results: Positive BAC was associated with hospital admission and ICU admission after adjusting for injury severity score (ISS) (odds ratio 1.5 and 1.3, respectively). The AUDIT was only correlated with hospital and ICU admission in patients with ISS of 1 to 15. By increasing risk of AUD (low, moderate, high, and likely alcohol dependent) the proportion of ICU admissions rose from 29.3% to 37.3%, 40.0% and 42.0% (P <0.01). The results did not change significantly by adjustment for the age of patients.

Conclusion: BAC is associated with increasing ED disposition to the hospital or ICU. Furthermore, self-reported alcohol use was associated with an increased risk of hospital or ICU admission in patients with minor or moderate injuries. Further studies to determine viable options to decrease admission rates in these patients are warranted. [West J Emerg Med. 2022;23(2)158–165.]

INTRODUCTION

Alcohol consumption can play a significant role in trauma patients' visits to the emergency department (ED). Previous studies have found that between 33.5% and 47% of trauma patients presenting to the ED have a positive blood alcohol concentration (BAC).[1,2] Furthermore, a systematic review of trauma centers across the United States found that 26.2–62.5% of visits to trauma centers were alcohol related.[3]

Alcohol consumption prior to injury has been shown to lead to higher rates of infection-related complications and more diagnostic tests, which ultimately results in longer lengths of stay, extra procedures, higher hospitalization costs, and a higher probability of hospital admission.[4-6] Patients with positive BACs are most likely to present to the ED between midnight and 2 AM, have a higher injury severity score (ISS), and have an increased risk of head trauma.[6-8] While BAC is the most commonly used tool for assessing patients' acute alcohol consumption levels, it cannot capture and often misses habitual consumption levels.[9,10] Blood alcohol concentration has also been shown to miss more than one third of trauma

patients with a current alcohol use disorder (AUD).[11] For that reason, many EDs have incorporated increased screening for AUDs in their patient populations.

Alcohol use disorder has become increasingly prevalent in trauma patients. A study conducted across four major trauma centers in Los Angeles found that 24.0% of patients were characterized with AUD.[12] Furthermore, on a national level, 34.3% of adult ED patients have either risky drinking, problem drinking, or alcohol-dependence behaviors.[13] Researchers have also found upward trends in alcohol-related ED visits over a nine-year period, indicating an increase in problematic drinking in this population over time.[14] In the trauma population, AUD and substance use disorders in general are associated with increased mortality.[15] Other studies beyond emergency medicine have found that in patients who undergo surgery, having an AUD was strongly correlated with hospital readmission. The readmitted patients with an AUD also had increased length of stay, hospitalization costs, and risk of death.[16]

Due to the increasing prevalence of AUD in trauma patients, the American College of Surgeons Committee on Trauma has mandated that Level I trauma centers provide alcohol screening to all trauma patients and interventions for those with high risk of AUD. The current standard alcohol screening tool is the Alcohol Use Disorders Identification Test (AUDIT). The AUDIT is a self-reported, 10-item questionnaire developed by the World Health Organization; it is designed to assess patients' alcohol consumption habits over the prior year.[17] Upon completion of the questionnaire, a score is generated, which ranges from 0-40 and categorizes the patient as either low risk for alcohol dependence (0-7) or high risk for alcohol dependence (8-19), or likely alcohol dependent (20-40). Patients with AUDIT scores of 8-19 are offered a personalized brief intervention aimed at reducing their alcohol consumption, which has proven effective.[18-20] Despite the self-report bias present in AUDIT, the survey has been shown to be a reliable and well-validated measure to assess habitual alcohol intake in patients.[21-25] Delivering the AUDIT test through a self-administered, computerized system has also been shown to be feasible and may reduce biases associated with alcohol reporting.[22,26]

While many studies have found correlations between alcohol consumption and a myriad of other variables, the evidence for associations between AUDIT and disposition in trauma patients is limited. In this study, we aimed to identify the correlation between acute and chronic alcohol consumption, as defined by BAC and AUDIT, respectively, with disposition of trauma patients from the ED.

Population Health Research Capsule

What do we already know about this issue?
Alcohol consumption has a significant impact on trauma patients' care in the emergency department.

What was the research question?
What is the association between alcohol consumption and disposition of trauma patients from the ED?

What was the major finding of the study?
Positive blood alcohol concentration and self-reported alcohol use were associated with hospital and intensive care unit admission in trauma patients.

How does this improve population health?
Effective alcohol screening and intervention could help reduce the admission rate in trauma patients.

METHODS

Study Setting and Design

We conducted a retrospective, chart review study on databases that were obtained at a Level I trauma center, university-based ED between 2010–2018. Patients were included if they were over 18 years of age and met trauma activation criteria (Supplemental Document). All these patients completed the AUDIT in either Spanish or English. The study was reviewed and approved by the university's institutional review board as an exempt category. Patient informed consent was not applicable to this study.

Study Protocol

We obtained our data from two databases: the hospital Trauma Registry and the Computerized Alcohol Screening and Intervention (CASI) program database. The Trauma Registry database compiles patient information from all trauma patients as part of quality assurance. Data analysts obtained patient demographics; nurse abstractors obtained information on patient injuries, treatments, BAC, and diagnoses/outcomes. We obtained ED disposition (death, intensive care unit [ICU] admission, hospital admission, and discharge from the ED), BAC, and ISS[27] from this database. When patients were first admitted to the ED, and trauma surgeons deemed it appropriate, the patients received venous blood draws to measure BAC as part of evaluation protocols. We included only patients who had BAC measurement results.

The CASI database was compiled by trained research associates (RA) who administered the AUDIT to trauma patients. Implementation of AUDIT screening was standard of care for trauma patients from 8 AM to midnight in the ED, and 8 AM to noon in the inpatient units. All trauma patients were approached to complete the AUDIT when they were clinically stable during their stay in the ED or inpatient units. Patients completed the AUDIT on a CASI tablet privately, unless a patient specifically

requested assistance from an RA. Responses to individual questions were kept confidential. The AUDIT score is shared with the patient, and a printout of the score is attached to the patient's medical record. We excluded patients who were on a psychiatric hold, incarcerated, or pregnant. For those with cognitive impairments such as acute intoxication, altered mental status, and critical illness, the RAs approached the patients once their conditions were resolved. The AUDIT results and demographic information were electronically recorded and automatically stored in a secure hospital database. We extracted patient demographic data and AUDIT scores from this database.

The two databases were linked by a unique identifier for each patient using Python Language Reference version 2.7 (Python Software Foundation, Wilmington, DE).

Statistical Analysis

Frequencies are reported as N (%). We studied the distribution of categorical variables using the chi-square, or chi-square for trend, statistical test. Associations of BAC and AUDIT with ICU admission and hospital admission were studied by calculating odds ratios (OR) in each level of ISS. We examined the homogeneity of estimated OR among levels of ISS using the Breslow-Day statistical test, and if the homogeneity was not rejected we reported a Mantel-Haenszel common OR. Statistical analyses were performed using SPSS Statistics 25 for Windows (IBM Corporation, Armonk, NY).

RESULTS

We identified a total of 4,699 adult trauma patients with known BAC who had completed the AUDIT questionnaire. Of these patients 3116 were male and 1583 were female (Table 1). The mean age of female patients was 51.4 years (±30.20) compared to 42.2 years (±19.86) in male patients (P <0.001). While male patients were younger, a higher percentage of them presented with an ISS score greater than 15 (P = 0.001). A total of 3551 (75.6%) patients had a BAC of zero upon arrival to the ED; 243 (5.2%) patients presented with a BAC greater than 250 milligrams per deciliter (mg/dL). A greater percentage of male patients presented with positive BAC (Table 1) as compared to female patients (P < 0.001). A similar pattern was observed with AUDIT scores.

Associated Factors with Hospital and ICU Admission: All Patients

Our results showed an association between positive blood alcohol with both hospital admission and ICU admission (among

Table 1. Demographics of adult trauma patients included in the study.

	Gender		Total
	Male	Female	
Age (Mean ± SD)	42.2 ± 19.86	51.4 ± 30.20	45.3 ± 24.24
ISS			
1-15	2,394 (76.8%)	1,292 (81.6%)	3,686 (78.4%)
16-24	460 (17.8%)	177 (11.2%)	637 (13.6%)
=>25	262 (8.4%)	114 (7.2%)	376 (8.0%)
Blood Alcohol Concentration (mg/dL)			
0.0	2,205 (70.8%)	1,346 (85.0%)	3,551 (75.6%)
0.1 - 100.0	318 (10.2%)	78 (4.9%)	396 (8.4%)
100.1 - 250.0	398 (12.8%)	111 (7.0%)	509 (10.8%)
>250.0	195 (6.3%)	48 (3.0%)	243 (5.2%)
AUDIT score			
0-7	2,582 (82.9%)	1,494 (94.4%)	4,076 (86.7%)
8-15	347 (11.1%)	63 (4.0%)	410 (8.7%)
16-19	79 (2.5%)	10 (0.6%)	89 (1.9%)
=>20	108 (3.5%)	16 (1.0%)	124 (2.6%)
ED disposition			
Discharged	470 (15.1%)	291 (18.4%)	761 (16.2%)
In Hospital (non-ICU)	1,482 (47.7%)	816 (51.6%)	2,298 (49.0%)
ICU	1,157 (37.2%)	474 (30.0%)	1,631 (34.8%)
Dead	1 (0.0%)	1 (0.1%)	2 (0.0%)

SD, standard deviation; *ISS*, Injury Severity Score; *mg,* milligram; *dL,* deciliter; *AUDIT*, Alcohol Use Disorders Identification Test; *ED*, emergency department; *ICU*, intensive care unit.

those who had been admitted to the hospital) after adjusting for ISS (Mantel-Haenszel OR: 1.5 [1.2 - 1.9] and 1.3 [1.1 - 1.5], respectively) (Table 2). The association was still significant after adjusting for age groups (18-30, 31-50, 51+) and ISS (Mantel-Haenszel OR: 1.7 [1.4-2.1] and 1.4 [1.2-1.7], respectively (Appendices 1 and 2). However, we did not find a statistically significant association between AUDIT score when considered as a score of zero (ie, self-reported abstainer) vs "1 or more" scores, and hospital ($P = 0.763$) or ICU admission ($P = 0.494$) after adjustment for ISS.

Associated Factors with Hospital Admission in Patients with Injury Severity Score 1-15

There was a statistically significant association between hospital admission and BAC among patients with ISS of 1-15 (Figure 1). By increasing BAC (from 0 mg/dL to 0.1-100 mg/dL, 100.1-250 mg/dL, and >250 mg/dL) the proportion of hospital admission rose from 78.1% to 84.5%, 86.8% and 80.1%, respectively ($P = 0.001$). The association remains statistically significant ($P < 0.001$) after adjustment for age (Appendix 3).

A similar association was observed between hospital admission and AUDIT scores in patients with an ISS of 1-15 (Figure 2). By increasing AUDIT levels (from 0-7 to 8-15, 16-19, and ≥20) the proportion of hospital admissions rose from 79.1% to 82.2%, 79.4% and 88.9%, respectively (P = 0.016). The association remained statistically significant ($P < 0.001$) after adjustment for age (Appendix 4).

Associated Factors with ICU Admission in Patients with ISS 1-15 Who Were Amitted to the Hospital

Among the patients who had been admitted into the hospital, we found a statistically significant association between ICU admission and BAC in patients with ISS of 1-15 (Figure 3). The proportion of ICU admissions in patients with BAC up

Table 2. Association of blood alcohol with hospital admission and intensive care unit admission adjusted for Injury Severity Score.

ISS levels				Hospital admission				ICU admission			
				No	Yes*	Total	Odds ratio (95% CI)	No	Yes	Total	Odds ratio (95% CI)
1-15	BA	Negative	Count	614	2,194	2,808	1.53 (1.2 – 1.9)	1,547	641	2,188	1.3 (1.1 - 1.5)
			row %	21.9%	78.1%	100.0%		70.7%	29.3%	100.0%	
		Positive	Count	134	734	868		480	254	734	
			row %	15.4%	84.6%	100.0%		65.4%	34.6%	100.0%	
		Total	Count	748	2,928	3,676		2,027	895	2,922	
			row %	20.3%	79.7%	100.0%		69.4%	30.6%	100.0%	
16-24	BA	Negative	Count	7	479	486	0.7 (0.2 - 2.8)	169	309	478	1.4 (0.9 - 2.1)
			row %	1.4%	98.6%	100.0%		35.4%	64.6%	100.0%	
		Positive	Count	3	146	149		41	105	146	
			row %	2.0%	98.0%	100.0%		28.1%	71.9%	100.0%	
		Total	Count	10	625	635		210	414	624	
			row %	1.6%	98.4%	100.0%		33.7%	66.3%	100.0%	
=>25	BA	Negative	Count	2	255	257	1.0(1.0 - 1.0)	37	217	254	1.0 (0.6 – 2.0)
			row %	0.8%	99.2%	100.0%		14.6%	85.4%	100.0%	
		Positive	Count	0	115	115		16	98	114	
			row %	0.0%	100.0%	100.0%		14.0%	86.0%	100.0%	
		Total	Count	2	370	372		53	315	368	
			row %	0.5%	99.5%	100.0%		14.4%	85.6%	100.0%	
Total	BA	Negative	Count	623	2,928	3,551	Mantel-Haenszel common odds ratio:	1,753	1,167	2,920	Mantel-Haenszel common odds ratio:
			row %	17.5%	82.5%	100.0%		60.0%	40.0%	100.0%	
		Positive	Count	137	995	1,132		537	457	994	
			row %	12.1%	87.9%	100.0%	1.5 (1.2 - 1.9)	54.0%	46.0%	100.0%	1.3 (1.1 - 1.5)
		Total	Count	760	3,923	4,683	P <0.001	2,290	1,624	3,914	$P = 0.002$
			row %	16.2%	83.8%	100.0%		58.5%	41.5%	100.0%	

* Including 2 dead.

ISS, Injury Severity Score; *CI*, confidence interval; *ICU*, intensive care unit; *BA*, blood alcohol.

to 100 mg/dL was 29.3%. The proportion of ICU admissions rose to 35.9% and 39.6% by increasing BAC to 100.1-250 mg/dL and >250 mg/dL, respectively ($P = 0.001$). The association remained statistically significant ($P < 0.001$) after adjustment for age (Appendix 5). We observed a similar association between ICU admission and AUDIT scores in the same group of patients (Figure 4). By increasing AUDIT levels (from 0-7 to 8-15, 16-19, and ≥ 20) the proportion of ICU admissions rose from 29.3% to 37.3%, 40.0% and 42.0%, respectively. ($P < 0.001$). The association remained statistically significant ($P < 0.001$) after adjustment for age (Appendix 6).

DISCUSSION

When we considered BAC as a dichotomous variable (BAC 0 mg/dL and BAC >0 mg/dL), we found that positive blood alcohol is associated with increased risk of hospital and ICU admission. Having a positive BAC may complicate the initial patient presentation and subsequent tests, especially in patients with lower ISS, whereas the effects of chronic alcohol use may not have yet manifested. Management and differentials of patients are also complicated by alcohol use, as intoxication may mask the effects of a stroke or head injury.[28] Physicians may, therefore, opt to admit these patients until they are stable

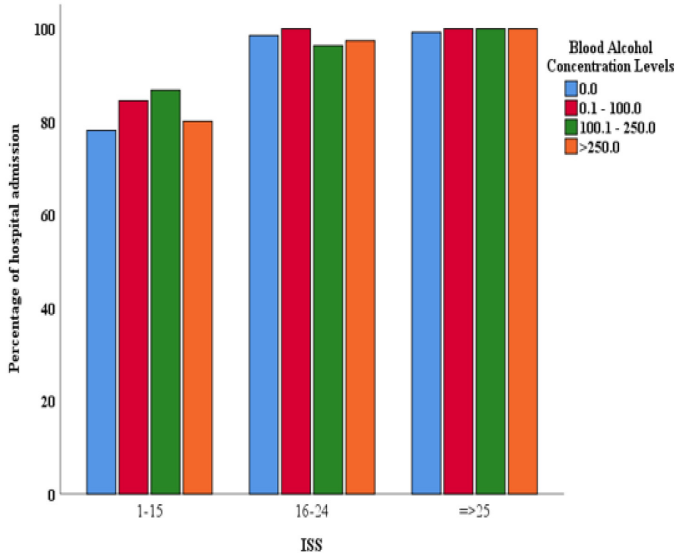


Figure 1. Association of hospital admission with blood alcohol concentration, per Injury Severity Score category.
ISS, Injury Severity Score.

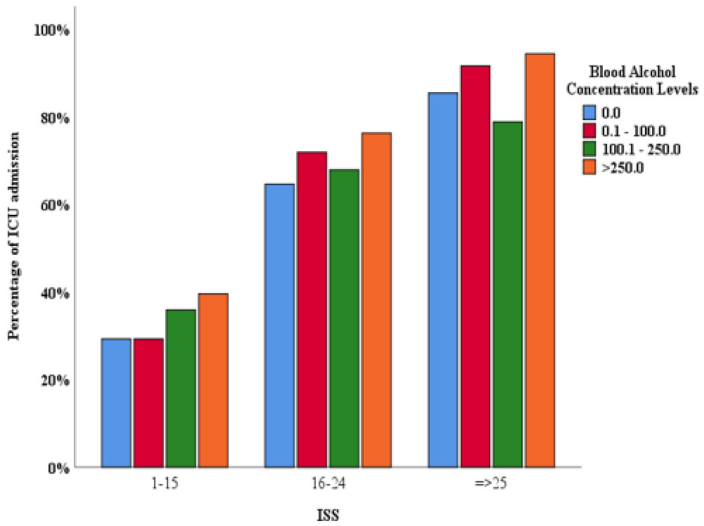


Figure 3. Association of ICU admission with blood alcohol concentration, per Injury Severity Score category.
ISS, Injury Severity Score.

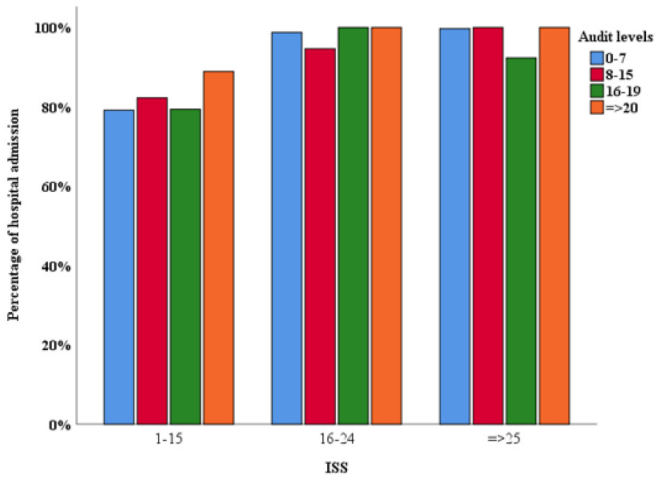


Figure 2. Association of hospital admission with AUDIT* scores, per Injury Severity Score category.
**AUDIT*, Alcohol Use Disorders Identification Test; *ISS*, Injury Severity Score.

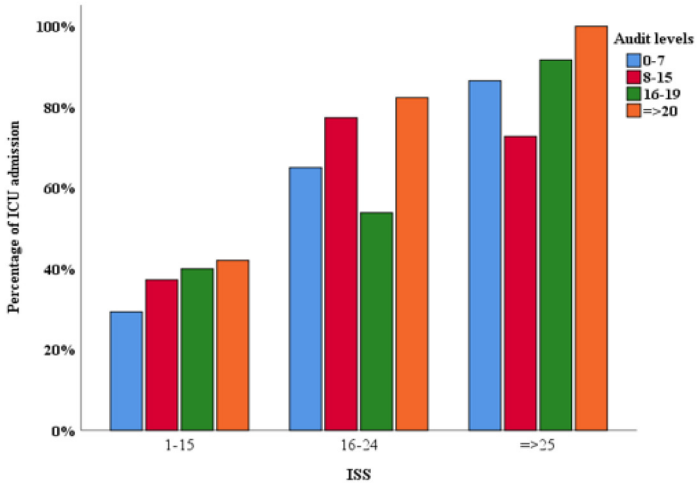


Figure 4. Association of intensive care unit admission with AUDIT* scores, per Injury Severity Score category.
**AUDIT*, Alcohol Use Disorder Identification test; *ISS*, Injury Severity Score.

and can be properly assessed. Furthermore, patients who are undomiciled are more than twice as likely to present with positive BAC after a trauma than a comparative sample of domiciled patients.[29] This may complicate the discharge process for lower ISS patients who do not have reliable transportation, a shelter to return to, or a follow-up plan. This population also has a higher rate of psychiatric-related admissions.[29]

Intoxicated trauma patients are less likely to sustain severe injuries.[30,31] However, they are more likely to present with a depressed Glasgow Coma Scale score,[32] which is usually associated with intracranial trauma, hypoxia, or shock from associated injuries. This may prompt physicians to admit these patients for further investigation and work-up. Furthermore, these patients may be cognitively impaired, even as their blood alcohol levels approach zero or may go on to develop complications from alcohol withdrawal syndrome that will eventually require hospital admission.[33]

Trauma patients who are BAC positive are more likely to have a pre-existing condition of chronic alcohol use, cirrhosis, coagulopathy, chronic pulmonary condition, chronic obstructive pulmonary disease, or chronic drug use.[34] Another study found that 66% of frequent binge drinkers and 10% of infrequent binge drinkers were found to be BAC positive upon admission.[35] Binge drinking is known to dysregulate adipocyte and liver function, thereby contributing to metabolic derangement and alcoholic liver disease.[36] A single binge-alcohol session can also modulate immune system functioning.[37] The combination of pre-existing conditions and impaired immune function may, therefore, contribute to the increased risk of infections observed in patients with positive BAC.[38] Other studies have indicated that patients with positive BAC also have a higher risk of developing pneumonia.[39] These complications may encourage a physician to admit patients with positive BAC either due to incidental findings (not related to the trauma) or fear of patient deterioration.

When we categorized AUDIT into four levels (0-7, 8-15, 16-19, ≥20) we observed statistically significant associations between AUDIT levels and both ICU and hospital admission only in patients with ISS of 1-15. The AUDIT is a reflection of the patient's perceived long-term alcohol consumption habits. Chronic alcohol use has been found to contribute to a plethora of diseases and immune dysfunctions, as well as comorbidities with other psychological disorders.[40,41] In severely injured patients (ISS greater than 15), the health consequences of chronic alcohol use was likely to have been masked or superseded by the traumatic injury. But when the injuries were minor (ISS 1-15), the effects of chronic alcohol use on the patient's health became more prominent and possibly contributed to hospital admission. Previous studies have identified that orthopedic trauma patients with a history of AUD are more likely to be admitted and have an increased length of stay.[42,43] However, many of these studies were unable to discern a cause behind these statistics. Our results would indicate that the skew in data may have been primarily due to patients with minor injuries but higher risk of AUD. We therefore recommend that future studies designed to discern the effects of AUD on patient outcomes should further stratify this population by ISS.

LIMITATIONS

Patients with prolonged altered mental status due to various reasons, including intoxication and being intubated, completed the AUDIT at a later stage of their hospital stay or were excluded from our study. Although most patients completed the study within 48 hours while they were still in the ED, the accuracy of AUDIT responses might diminish if the patients completed the survey near the time of their discharge. Trauma patients with the inability to personally complete the survey due to their injuries completed the AUDIT with assistance from research personnel, which may have introduced social desirability response biases in these patients. Furthermore, ethanol tolerance may skew the symptoms of intoxication for patients with a history of AUD, thereby complicating the scale of BAC intoxication and clinical intoxication.[44] Systemic biases have also been found in determining which patients are tested for BAC, which may have caused us to miss some patients on initial presentation.[45]

Other patient care outcomes besides hospital admission, such as alcohol withdrawal symptoms and poor surgical outcomes, may impact patient management but were not available in our databases.

CONCLUSION

Blood alcohol concentration is a reflection of acute alcohol use, often correlated with binge drinking and adverse effects on human health. The presence of BAC was found to be associated with hospital and ICU admissions after adjustment for Injury Severity Score; therefore, screening BAC might expedite disposition of trauma patients in the ED. The Alcohol Use Disorder Identification Test is a self-reported reflection of perceived alcohol consumption habits and possible chronic alcohol use. Our study found that AUDIT is associated with an increased risk of hospital or ICU admission in minor or moderately injured trauma patients only.

Address for Correspondence: Wirachin Hoonpongsimanont, MD, MS, Eisenhower Medical Center, Department of Emergency Medicine, 39000 Bob Hope Dr., Rancho Mirage, CA 92270. Email: wirachin@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. Soderstrom CA, Trifillis AL, Shankar BS, et al. Marijuana and alcohol use among 1023 trauma patients. *Arch Surg.* 1988;123(6):733-7.
2. Rivara FP, Jurkovich GJ, Gurney JG, et al. The magnitude of acute and chronic alcohol abuse in trauma patients. *Arch Surg*. 1993;128(8):907-12.
3. MacLeod JBA, Hungerford DW. Alcohol-related injury visits: Do we know the true prevalence in U.S. trauma centres? *Injury.* 2011;42(9):922-6.
4. Cowperthwaite MC, Burnett MG. Treatment course and outcomes following drug and alcohol-related traumatic injuries. *J Trauma Manag Outcomes*. 2011;5:3.
5. O'Keeffe T, Rhee P, Shafi S, et al. Alcohol use increases diagnostic testing, procedures, charges, and the risk of hospital admission: a population-based study of injured patients in the emergency department. *Am J Surg*. 2013;206(1):16-22.
6. Cittadini F, De Giovanni N, Caradonna L, et al. Prevalence of alcohol and other drugs in injured drivers and their association with clinical outcomes. *Eur Rev Med Pharmacol Sci*. 2017;21(9):2008-14.
7. Comelli I, Lippi G, Sanchis-Gomar F, et al. Visits for alcohol-related problems in a large urban emergency department. Results of a 15-year survey. *Acta Biomed*. 2018;88(4):514–8.
8. Savola O, Niemelä O, Hillbom M. Alcohol intake and the pattern of trauma in young adults and working aged people admitted after trauma. *Alcohol Alcohol*. 2005;40(4):269-73.
9. Paton A. Alcohol in the body. *BMJ*. 2005;330(7842):85–7.
10. Ewing T, Barrios C, Lau C, et al. Predictors of hazardous drinking behavior in 1,340 adult trauma patients: a computerized alcohol screening and intervention study. *J Am Coll Surg*. 2012;215(4):489-95.
11. Soderstrom CA, Smith GS, Dischinger PC, et al. Psychoactive substance use disorders among seriously injured trauma center patients. *JAMA*. 1997;277(22):1769-74.
12. Ramchand R, Marshall GN, Schell TL, et al. Alcohol abuse and illegal drug use among Los Angeles County trauma patients: prevalence and evaluation of single item screener. *J Trauma*. 2009;66(5):1461–7.
13. Cherpitel CJ, Ye Y. Drug use and problem drinking associated with primary care and emergency room utilization in the US general population: data from the 2005 National Alcohol Survey. *Drug Alcohol Depend*. 2008;97(3):226–30.
14. McDonald AJ, Wang N, Camargo CA. US emergency department visits for alcohol-related diseases and injuries between 1992 and 2000. *Arch Intern Med*. 2004;164(5):531-7.
15. Dezman ZDW, Gorelick DA, Buchanan L, et al. 20-year mortality after discharge in a cohort of 1,099 former trauma inpatients with and without substance use disorders. *Injury*. 2020;51(12):2930-7.
16. Gili-Miner M, Béjar-Prado L, Gili-Ortiz E, et al. Alcohol use disorders among surgical patients: unplanned 30-days readmissions, length of hospital stay, excessive costs and mortality. *Drug Alcohol Depend*. 2014;137:55-61.
17. Saunders JB, Aasland OG, Babor TF, et al. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO Collaborative Project on Early Detection of Persons with Harmful Alcohol Consumption--II. *Addiction.* 1993;88(6):791-804.
18. Lotfipour S, Mortazavi R, Chakravarthy B. Commentary: Alcohol and motor vehicle-related crashes--driver attitudes need further intervention. *Ann Emerg Med*. 2011;57(4):406-8.
19. Harrison C, Hoonpongsimanont W, Anderson CL, et al. Readiness to change and reasons for intended reduction of alcohol consumption in emergency department versus trauma population. *West J Emerg Med*. 2014;15(3):337–44.
20. Neumann T, Neuner B, Weiss-Gerlach E, et al. The effect of computerized tailored brief advice on at-risk drinking in subcritically injured trauma patients. *J Trauma*. 2006;61(4):805-14.
21. Imani G, Barrios C, Anderson CL, et al. Computerized alcohol screening identified more at-risk drinkers in a Level 2 than a Level 1 trauma center. *BMC Public Health*. 2017;17(1):32.
22. Lotfipour S, Howard J, Roumani S, et al. Increased detection of alcohol consumption and at-risk drinking with computerized alcohol screening. *J Emerg Med*. 2013;44(4):861–6.
23. Vaca F, Winn D, Anderson C, et al. Feasibility of emergency department bilingual computerized alcohol screening, brief intervention, and referral to treatment. S*ubst Abus.* 2010;31(4):264-9.
24. Albright JM, Kovacs EJ, Gamelli RL, et al. Implications of formal alcohol screening in burn patients. *J Burn Care Res*. 2009;30(1):62-9.
25. Sakai LM, Esposito TJ, Ton-That HH, et al. Comparison of objective screening and self-report for alcohol and drug use in traumatically injured patients. *Alcohol Treat Q*. 2012;30(4):433–42.
26. Lotfipour S, Cisneros V, Chakravarthy B, et al. Assessment of readiness to change and relationship to AUDIT score in a trauma population utilizing computerized alcohol screening and brief intervention. *Subst Abus*. 2012;33(4):378–86.
27. Baker SP, Neill B, Haddon Jr W, et al. The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma Acute Care Surg*. 1974;14(3):187-96.
28. Arokszallasi T, Balogh E, Csiba L, et al. Acute alcohol intoxication may cause delay in stroke treatment - case reports. *BMC Neurol.* 2019;19(1):14.
29. Miller JP, O' Reilly GM, Mackelprang JL, et al. Trauma in adults experiencing homelessness. *Injury.* 2020;51(4):897-905.
30. Velmahos GC, Jindal A, Chan LS, et al. "Insignificant" mechanism of injury: not to be taken lightly. *J Am Coll Surg.* 2001;192(2):147-52.
31. Sarani B, Temple-Lykens B, Kim P, et al. Factors associated with mortality and brain injury after falls from the standing position. *J Trauma*. 2009;67(5):954-8.
32. Hadjizacharia P, O'Keeffe T, Plurad DS, et al. Alcohol exposure and outcomes in trauma patients. *Eur J Trauma Emerg Surg*. 2011;37(2):169-75.
33. Heffernan T, Samuels A, Hamilton C, et al. Alcohol hangover has detrimental impact upon both executive function and prospective memory. *Front Psychiatry*. 2019;10:282.
34. Cowperthwaite MC, Burnett MG. Treatment course and outcomes following drug and alcohol-related traumatic injuries. *J Trauma Manag Outcomes.* 2011;5:3.
35. Savola O, Niemelä O, Hillbom M. Blood alcohol is the best indicator of hazardous alcohol drinking in young adults and working-age patients

with trauma. *Alcohol*. 2004;39(4):340-5.
36. Parker R, Kim S-J, Gao B. Alcohol, adipose tissue and liver disease: mechanistic links and clinical considerations. *Nat Rev Gastroenterol Hepatol*. 2018;15(1):50-9.
37. Afshar M, Richards S, Mann D, et al. Acute immunomodulatory effects of binge alcohol ingestion. *Alcohol*. 2015;49(1):57–64.
38. Cowperthwaite MC, Burnett MG. Treatment course and outcomes following drug and alcohol-related traumatic injuries. *J Trauma Manag Outcomes*. 2011;5:3.
39. Ahmed N, Greenberg P. Examining the influence of blood alcohol level on the incidence of pneumonia & sepsis complications following traumatic injury. *Alcohol.* 2019;76:111-5.
40. Cook RT. Alcohol abuse, alcoholism, and damage to the immune system--a review. *Alcohol Clin Exp Res*. 1998;22(9):1927-42.
41. Gauba D, Thomas P, Balhara YP, et al. Psychiatric comorbidity and physical correlates in alcohol-dependent patient. *Indian J Psychol Med*. 2016;38(5):414–8.
42. Gitajn IL, Reider L, Scharfstein DO, et al. Variability in discharge disposition across US trauma centers after treatment for high-energy lower extremity injuries. *J Orthop Trauma*. 2020;34(3):e78-e85.
43. Vincent HK, Vasilopoulos T, Zdziarski-Horodyski LA, et al. Preexisting psychiatric illness worsens acute care outcomes after orthopaedic trauma in obese patients. *Injury.* 2018;49(2):243-8.
44. Olson KN, Smith SW, Kloss JS, et al. Relationship between blood alcohol concentration and observable symptoms of intoxication in patients presenting to an emergency department. *Alcohol Alcohol.* 2013;48(4):386–9.
45. Cheever CS, Barbosa-Leiker C. Impact of alcohol screening for traumatic brain injury patients being admitted to neurosurgical intensive care unit. *J Neurosci Nurs.* 2018;50(2):83-7.

Substance Use-related Emergency Department Visits and Resource Utilization

Weiwei Beckerleg MD, MPH, FRCPC[*†] **Joel Hudgins, MD, MPH**[‡§]

[*]The Ottawa Hospital, Division of General Internal Medicine, Ottawa, Ontario, Canada
[†]University of Ottawa, Faculty of Medicine, Ottawa, Ontario, Canada
[‡]Boston Children's Hospital, Division of Emergency Medicine, Boston, Massachusetts
[§]Harvard Medical School, Boston, Massachusetts

Section Editor: Erin Dehon, PhD
Submission history: Submitted June 24, 2021; Revision received January 11, 2022; Accepted January 5, 2022
Electronically published February 28, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2022.1.53834

Introduction: Substance use-related visits to the emergency department (ED) have been linked to higher service delivery costs, although little is known about the specific services used. Our goal In this study was to describe the recent trends of substance use-related ED visits and assess the association between substance use and specific ED resource utilization.

Methods: We performed a retrospective, cross-sectional study using the National Hospital Ambulatory Medical Care Survey (NHAMCS) data from 2013–2018. All ED visits in the United States for patients ≥18 years of age were included. The primary exposure was having substance use included as a chief complaint or diagnosis, which we identified using the International Classification of Diseases, 9th and 10th revisions, codes. The primary outcome was the use of diagnostic services (including laboratory studies and cardiac monitoring) or imaging studies in the ED.

Results: The study sample included 95,506 visits in the US, extrapolating to over 619 million ED visits nationwide. The total number of ED visits remained stable during the study period, but substance use-related visits increased by 45%, with these visits making up 2.93% of total ED visits in 2013 and 4.25% in 2018. This increase was primarily driven by stimulant-, sedative- (opioids and benzodiazepines), and hallucinogen-related visits. Mental health-related visits rose in parallel by 66% during the same period. Compared to non-substance use-related visits, substance use-related visits were more likely to undergo any diagnostic study (adjusted odds ratio [aOR] 1.28; 95% confidence interval (CI): 1.11-1.47; P = 0.001), toxicology screening (aOR 10.15; 95% CI: 8.84-11.66), but less likely to have imaging studies (aOR 0.62; 95% CI: 0.56-0.68; P <0.0001). In stratified analyses, substance use-related visits with concurrent mental health disorders were more likely to undergo imaging studies (aOR 1.56; 95% CI: 1.09-2.22), while findings were opposite for those without concurrent mental health disorders (aOR 0.64; 95% CI: 0.51-0.71; P for interaction <0.0001).

Conclusion: Substance use- and mental health-related ED visits are rising, and they are associated with increased resource utilization. Further studies are needed to provide more guidance in the approach to acute services in this vulnerable population. [West J Emerg Med. 2022;23(2)166–173.]

INTRODUCTION

Substance use is associated with multiple adverse health outcomes, including increased rates of infectious disease, mental health disorders, and mortality.[1] These outcomes are rapidly increasing over time, with recent data showing that the age-standardized mortality rate due to substance use disorders (SUD) increased by 618.3% between 1980–2014 in the United States.[1] The most common causes of death associated with substance use were injuries and poisoning, along with other external

causes.[2] Among people ages 15-49 in the US, SUDs and intentional injuries make up close to one third of all deaths.[1] The poor outcomes associated with substance use, along with its rising prevalence and low treatment rates, create a significant public health issue.[3] From 2004–2013 the proportion of US adults receiving treatment for SUDs stayed at 1.2-1.3%, representing less than 20% of the population affected.[4]

In light of the low treatment rates, it is not surprising that emergency department (ED) visits related to substance use have risen rapidly.[5] This increase has created predictable challenges for emergency clinicians and the healthcare system overall, as substance use-related ED visits have been linked to increased length of stay, higher service delivery costs, and higher rates of hospital admissions.[6-9] In addition, increasing ED utilization has outpaced similar increases in hospital inpatient care, meaning the burden of these increased visits has fallen disproportionately on EDs and emergency clinicians.[10] While resource utilization is high in this population, it remains unclear which specific resources are used in the ED for these visits on a national scale.

Identifying the resource utilization pattern for substance use-related visits could help inform resource allocation and potentially increase standardization of care. This could in turn lead to reduction in unnecessary testing or treatment, and eventually reduce the strain on emergency physicians and the healthcare system overall. With this rationale in mind, we aimed to describe the trends of substance use-related ED visits among US adults nationwide over a five-year period, beginning in 2013, and to evaluate the relationship between substance use and ED resource utilization.

Population Health Research Capsule

What do we already know about this issue?
Substance use-related visits to the emergency department (ED) have been increasing and are linked to higher service delivery costs.

What was the research question?
We aimed to assess the association between substance use and specific ED resource utilization.

What was the major finding of the study?
Patients with substance use-related ED visits are more likely to undergo diagnostic tests, including toxicology screening.

How does this improve population health?
Results from this study support the need for future studies to provide guidance in the approach to acute services for substance use-related ED visits.

METHODS

This was a retrospective, cross-sectional study using data from the National Hospital Ambulatory Medical Care Survey (NHAMCS), which is conducted by the National Center for Health Statistics (NCHS).[11] We included data from January 1, 2013–December 31, 2018. The NHAMCS is an annual, national probability sample of ambulatory care visits throughout the US and collects data on visits to hospital-based EDs. The survey employs a four-stage probability design with samples of area primary sampling units (PSU, hospitals within PSUs, clinics within outpatient departments, and patient visits within emergency service areas (ESA). Within each ESA, patient visits were systematically selected over a randomly assigned four-week reporting period. There were approximately 2000 PSUs that covered 50 states and the District of Columbia, and approximately 600 hospitals. Data collection was overseen by the US Bureau of the Census, which provided field training on data abstraction for participating hospital staff.

Ethics approval was obtained from the research ethics board at our home institution.

Study Population

All ED visits for patients ≥18 years of age were included. We excluded visits to the ED made by patients younger than 18, visits for which the chief complaint or diagnoses were missing, and visits with missing data on use of diagnostic services, medications, procedures, disposition decision, or use of mental health consultation services.

Exposures and Covariates

The primary exposure was defined as having substance use listed as a chief complaint or diagnosis in the visit, as identified by the *International Classification of Diseases* 9th and 10th revisions (ICD) codes. The ICD codes were taken from previously published briefs by the Health Care Utilization Project.[5, 12] Substances of interest included alcohol (ethanol), opioids, cannabis, cocaine, amphetamines, hallucinogens, and other recreational substances of abuse that affect the central nervous system. Substances were further broken down into five categories as defined by previous literature: 1) alcohol; 2) opioid, sedative/hypnotic, or anxiolytic; 3) cocaine, amphetamine, psychostimulant, or sympathomimetic; 4) cannabis or hallucinogen; and 5) other/unspecified or combined.[7] The reference group consisted of ED visits without substance use as a diagnosis or chief complaint.

Covariates of interest were defined a priori and identified from literature review.[6-8] They included age, gender, ethnicity, homelessness, burden of comorbidities, presence of mental health disorder, geographical region, metropolitan statistical

area, payment source, day of visit, and arrival time. Mental health disorder was treated as a separate diagnosis from SUD to specifically examine the trend of substance use-related visits and to emulate previous studies in this area.

Outcomes

The primary outcomes of interest consisted of the use of any diagnostic services, toxicology screens or imaging studies in the ED. Diagnostic services included laboratory investigations, toxicology screens, imaging studies, electrocardiograms, and cardiac monitoring. Imaging studies included all imaging carried out in the ED, such as radiographs, ultrasounds, computed tomography (CT), and magnetic resonance imaging. Secondary outcomes consisted of number of procedures performed (eg, intravenous fluids, casts, intubation, lumbar puncture, etc), number of medications administered, disposition, and use of mental health consultation services in the ED. These variables were identified using pre-existing matching labels in the NHAMCS database.[11]

Statistical analysis

The NHAMCS used a multistage estimation procedure to produce essentially unbiased estimates. The first step included inflation by reciprocals of selection probabilities, which was the product of the probability at each sampling stage. The second step adjusted for survey nonresponse, which included inflating weights of visits to hospitals or EDs similar to nonrespondent units, depending on the pattern of missingness. During data analysis, survey procedures were used (using the svy command) and patient visit weights were applied to obtain the total estimated ED visits from sampled visits (using the PATWT variable). As per the NHCS, sampled visits with relative standard error of 30% or more and observations that were based on fewer than 30 sampling records may yield unstable estimates. These were specifically indicated and later excluded from analysis.

We performed univariate analysis using chi-squared test to assess the association between substance use and each of the categorical covariates. To test for linear trend in substance use-related visits over time, we applied a logistic regression model with substance use as the dependent variable and time (measured in years) as the independent variable. Univariate and multivariable logistic regression were used to assess the unadjusted and adjusted associations between substance use and each of the outcomes, respectively. All listed covariates, with the exception of mental health disorder, were included in the multivariable model. We reported odds ratios for all logistic regression analyses, along with 95% confidence intervals. For the primary and secondary outcomes of interest, *P*-value for significance was determined to be 0.005 after applying Bonferroni correction, to minimize family-wise error rate in the setting of multiple comparisons. To evaluate mental health disorder as a potential effect modifier, we assessed the relationship between substance use and primary outcomes using a stratified analysis. The *P*-value for interaction was obtained from a multivariable logistic regression model. Missing data were handled using complete case analysis, given that the percentage of missingness was small, and complete data were available for both the exposures and outcomes. All data analyses were carried out using STATA version 15 (StataCorp LLC, College Station, TX).

RESULTS

From 2013–2018, substance use-related ED visits increased from 2.926 to 4.132 million visits, or from 2.93% to 4.25% of total ED visits during the same period, which translates to a 45% relative increase. Non-substance use-related ED visits (reference group) remained stable during the same period, with 93.17 million visits in 2018 compared to 96.98 million visits in 2013. The rise in substance use-related ED visits was driven by sedatives, stimulants, and hallucinogens, with alcohol and other substance use-related visits being relatively stable **(Figure 1)**.There was a parallel increase in mental health-related visits, with these visits making up 2.34% of total ED visits in 2013 and 3.88% in 2018, representing a 66% relative increase.

Among substance-use related visits, the 25-44 age group made up 44.58% of visits, as compared to 35.49% of the non-substance related group (P <0.0001). There was also a male predominance among substance use-related visits: males accounted for 63.38% of visits in the substance group vs 41.74% in the reference group (P <0.0001). While the West geographic area accounted for only 21.34% of all ED visits, it made up 29.67% of substance use-related visits. In addition, substance use-related visits were much more likely to happen during the night shift (11 PM – 7 AM), with 27.07% of all substance use-related visits taking place then compared to 14.81% in the reference group (P <0.0001) **(Table 1).** Mental health issues were more prevalent in the substance use group compared to the reference group, present in 14.48% vs 2.99%, respectively.

With regard to the primary outcomes, patients associated with substance use-related visits were more likely to undergo any diagnostic study (adjusted odds ratio [aOR] 1.28; 95% CI: 1.11-1.47, P = 0.001) and toxicology screening (aOR 10.15; 95% CI: 8.84-11.66; P <0.0001); however, they were less likely to have imaging studies (aOR 0.62; 95% CI: 0.56-0.68; P <0.0001) **(Table 2).**

There were no significant differences in the use of medications or procedures between the substance use and reference groups, with the differences in means being 0.08 (95% CI: -0.06-0.21; P = 0.28) and 0.04 (95% CI: 0.01-0.07; P = 0.02), respectively **(Table 3).** Substance use-related visits were associated with higher odds of admission or transfer to another facility (aOR 1.73; 95% CI: 1.53-1.96; P <0.0001) and higher odds of receiving a mental health consult [aOR 5.70; 95% CI: 4.47-7.28; P <0.0001).

With regard to stratified analyses those patients with

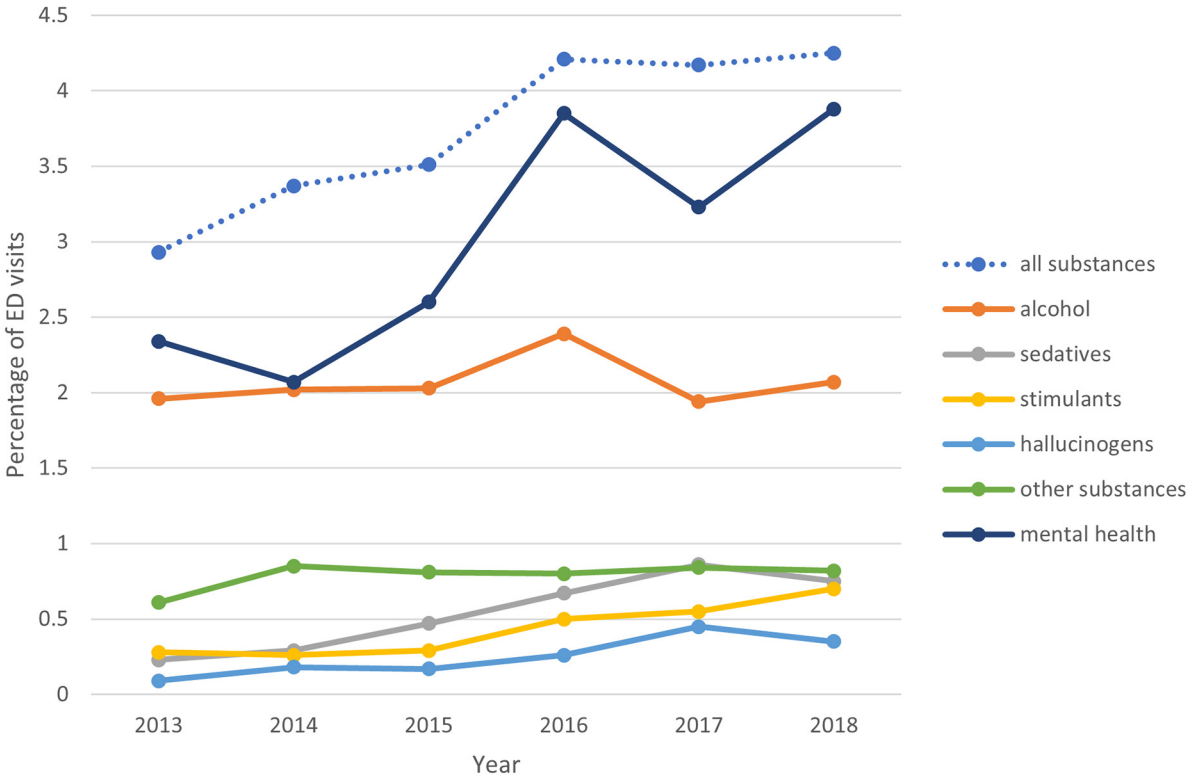


Figure 1. Temporal trend of substance use- and mental health-related emergency department visits over time. *ED*, emergency department.

Table 1. Descriptive table of baseline demographic characteristics of study population by exposure categories.

	All visits (%/N) N = 95,506	Substance use (%/N) N = 4,050	Non- substance use (%/N)* N = 91,456
Age			
18-24	14.30 (13,386)	14.49 (552)	14.29 (12,834)
25-44	35.83 (34,561)	44.58 (1,787)	35.49 (32,774)
45-64	29.00 (27,974)	34.38 (1,467)	28.79 (26,507)
65-74	9.55 (8,952)	5.25 (193)	9.72 (8,759)
≥75	11.31(10,633)	1.31 (51)	11.70 (10,582)
Gender			
Male	42.55 (41,253)	63.38 (2,680)	41.74 (38,573)
Female	57.45 (54,253)	36.62 (1,370)	58.26 (52,883)
Ethnicity			
Non-Hispanic White	61.05 (57,890)	62.43 (2,402)	60.99 (55,488)
Non-Hispanic Black	23.12 (21,871)	19.98 (945)	23.24 (20,926)
Hispanic	13.02 (12,572)	14.18 (554)	12.98 (12,018)
Non-Hispanic other	2.82 (3,173)	3.41 (149)	2.79 (3,024)
Residence			
Homeless / shelter	0.89 (1,355)	6.65 (398)	0.66 (957)
Private residence / nursing home	95.13 (90,338)	86.46 (3,382)	95.47 (86,956)
Other	1.52 (1,466)	3.19 (121)	1.45 (1,345)
Missing	2.46 (2,347)	3.70 (149)	2.42 (2,198)

Table 1. Continued.

	All visits (%/N) N = 95,506	Substance use (%/N) N = 4,050	Non- substance use (%/N)* N = 91,456
Mental health disorder			
Present	2.99 (3,513)	14.48 (602)	2.55 (2,911)
Absent	97.01 (91,993)	85.52 (3,448)	97.45 (88,545)
Number of chronic conditions (mean/SE)	1.09(0.03)	1.94 (0.05)	1.06 (0.03)
Payment source			
Private insurance	26.84 (26,149)	18.90 (744)	27.15 (25,405)
Public insurance	49.72 (47,971)	48.83 (2,046)	49.76 (45,925)
Self-pay	11.31 (10,295)	15.73 (609)	11.14 (9,686)
Other	2.68 (2,697)	3.17 (167)	2.66 (2,512)
Missing	9.45 (8,412)	13.36 (484)	9.29 (7,928)
Geographic region			
Northeast	16.04 (17,938)	18.35 (945)	15.95 (16,993)
Midwest	24.33 (23,022)	23.53 (790)	24.36 (22,232)
South	38.29 (33,625)	28.46 (1,068)	38.67 (32,557)
West	21.34 (20,921)	29.67(1,247)	21.01 (19,674)
Metropolitan statistical area status (MSA)			
MSA	83.46 (81,054)	89.76 (3,734)	83.22 (77,320)
Non-MSA	16.64 (14,452)	10.24 (316)	16.78 (14,136)
Day of week			
Weekday	73.44 (70,225)	70.21 (2,853)	73.57 (67,372)
Weekend	26.56 (25,281)	29.79 (1,197)	26.43 (24,084)
Arrival time			
7 AM - 2:59 PM	42.32 (39,981)	29.37 (1,212)	42.82 (38,769)
3 PM - 10:59 PM	41.04 (38,946)	42.26 (1,675)	40.99 (37,281)
11 PM - 6:59 AM	15.27 (14,575)	27.07 (1,055)	14.81 (13,520)
Missing	1.37 (1,994)	1.30 (108)	1.37 (1,886)

*Numbers represent the actual number of observations and percentages obtained after applying sampling procedures to account for complex sampling design.

mental health disorders were more likely to have imaging studies, and this reached statistical significance for interaction (P <0.0001). For substance use-related visits without the concurrent presence of a mental health disorder, the aOR of undergoing any imaging study was 0.65 (95% CI: 0.58-0.72), and for substance use-related visits with concurrent mental health disorder, the aOR of undergoing any imaging study was 1.44 (95% CI: 1.03-2.00). All substance use-related ED visits were more likely to undergo toxicology screening, but those without concurrent mental health disorders were even more likely to receive screening, with aOR of 11.47 (95% CI: 9.87-13.35). The presence of a mental health disorder did not have an impact on the relationship between undergoing any diagnostic study in ED and substance use **(Table 4).**

DISCUSSION

Consistent with previously published work, our study shows that sedative-, stimulant-, and hallucinogen- related ED visits continue to increase rapidly compared to alcohol and other substances of abuse.[6,13,14] Substance use-related ED visits are more likely to result in diagnostic investigations overall, admission or transfer to another facility, and mental health consultations. Conversely, they are less likely to result in imaging studies. While the higher rate of admission/transfer and mental health consultations for substance use- related ED visits has been reported previously,[7,15] to our knowledge the use of diagnostic services has not yet been assessed at the national level.

Among the common substances of abuse, the rapid increase in stimulant-related ED visits in recent years is remarkable; in 2018, the percentage of stimulant-related visits matched that of sedative-related visits (including opioid, benzodiazepines, and other sedatives), representing approximately 0.7% of total ED visits. This is consistent with other study findings that have reported a rise in prevalence of stimulant use across all age groups from 2010–2014, with adults between 20-64 years

Table 2. Logistic regression models predicting any diagnostic test and any imaging performed in the emergency department.

	Any substance use ***
Any diagnostic study (unadjusted OR and 95% CI)*	1.17 (1.02-1.34)
Any diagnostic study (adjusted OR and 95% CI)**	1.28 (1.11-1.47)
Toxicology screen (unadjusted OR and 95% CI)	14.45 (12.82-16.30)
Toxicology screen (adjusted OR and 95% CI)	10.15 (8.84-11.66)
Any imaging (unadjusted OR and 95% CI)	0.58 (0.53-0.64)
Any imaging (adjusted OR and 95% CI)	0.62 (0.56-0.68)

*Reference group consists of visits without substance use as a diagnosis.
**Adjusted variables include age, gender, race, number of chronic conditions, region, metropolitan statistical area, payment method, residence, arrival time, and day of the week.
***Complete case analysis was used to handle missing data. N = 95,506 for all logistic regression analyses performed.
Any diagnostic study includes laboratory investigations, radiology services, and others such as cardiac monitoring. Any imaging includes all radiology services such as radiographs, computed tomography, magnetic resonance imaging, and ultrasound.
OR, odds ratio; *CI*, confidence interval.

Table 3. Regression models predicting use of medications and procedures, disposition, and mental health consultations in the emergency department.

	Medications* (mean, 95% CI)**	Procedures* (mean, 95% CI)**	Admission/ transfer (OR)**	Mental health consult
Any substance use	0.08 (-0.06-0.21)	0.04 (0.01-0.07)	1.73 (1.53-1.96)	5.70 (4.47-7.28)
Alcohol use	-	-	1.28 (1.07-1.55)	3.91 (2.87-5.34)
Sedative use	-	-	2.31 (1.80-2.97)	3.81 (2.55-5.69)
Stimulant use	-	-	2.20 (1.64-2.95)	6.93 (4.53-10.60)
Hallucinogen use	-	-	2.62 (1.52-4.52)	4.20 (2.34-7.54)
Other substance use	-	-	2.40 (1.78-3.24)	5.60 (4.00-7.84)

*Mean value represents the difference in the mean between visits with substance use and those without.
** Means and odds ratios were adjusted for gender, age, race, total number of chronic conditions, payment method, residence, region, metropolitan statistical area, day of the week, and arrival time.
Reference group consists of visits without substance use as a diagnosis.
OR, odds ratio; *CI*, confidence interval.

the most affected.[16] Our study also showed that the rise in stimulant-related visits was more pronounced in the 18-44 age group (OR 1.28), compared to the > 45 years age group (OR 1.13). The most frequently cited motivation for stimulant use among adults was performance enhancement,[17] which supports the need to improve public education for young adults on the addictive potential of stimulants and restricting prescriptions to appropriate clinical indications only.

Regarding the use of diagnostic services in the ED for substance use-related visits, research has been relatively sparse. Our study showed that substance use-related visits are more likely to receive diagnostic services overall (including both laboratory and imaging studies) and toxicology screening. Some studies have called into question the routine practice of ordering urine drug screens for substance-related visits and laboratory studies in general for mental health-related visits, as they have rarely led to changes in management.[18,19] The American Psychiatric Association (APA) and the American College of Emergency Physicians (ACEP) both support targeted diagnostic investigations for patients presenting with acute psychiatric symptoms, instead of routine testing.[20,21] However, drug testing is often required as part of initial assessment to enter treatment facilities, regardless of medical indication or emergency healthcare team preferences.[22] Although most of the studies on this topic focused on mental health-related ED visits, the often-overlapping presentations of substance- and mental health-related visits argue for standardization of practices to diagnostic services.

In terms of the use of imaging studies specifically, both ACEP and the APA support individual assessment of risk factors to guide brain imaging in the ED for mental health-related visits, due to low yield of routine imaging.[20,21] There are no recommendations made regarding substance use-related visits given limited evidence. In contrast to our finding of substance use-related visits being associated with less use of imaging studies, previous work has shown a rising trend in the use of CT

Table 4. Subgroup analysis for primary outcomes by presence of mental health disorder.

	Presence of mental health disorder	Absence of mental health disorder	*P*-value *
Any diagnostic test (OR and 95% CI)	1.04 (0.76-1.43)	1.33 (1.15-1.53)	0.14
Toxicology screen (OR and 95% CI)	2.23 (1.68-2.97)	11.47 (9.87-13.35)	<0.0001
Any imaging (OR and 95% CI)	1.44 (1.03-2.00)	0.65 (0.58-0.72)	<0.0001

**P*-values for interaction obtained from adjusted Wald test.
OR, odds ratio; *CI*, confidence interval.

along with the rise of opioid-related visits.[6] However, that study did not assess the use of CT in relation to a non-substance use reference group and did not include other imaging modalities. The lower rate of utilization of imaging studies could be explained by the possibility that imaging was not needed for management or disposition after completion of laboratory screening in substance use-related visits. In addition, since substance use-related visits occurred disproportionately after hours, imaging might not be readily available after hours in smaller centers. Visiting hours were adjusted for as a potential confounder; so the latter explanation is considered less likely.

Notably, the presence of a mental health disorder made it more likely for patients with a substance use diagnosis to undergo imaging studies. It is well documented that patients with serious mental health disorders have higher mortality rates than those without, attributable to both injuries and chronic diseases.[2] It is, therefore, possible that additional imaging studies were needed because of increased medical complexity. Furthermore, the presence of SUDs was associated with significantly increased rates of mental health consultations in the ED, which in turn have been shown to be associated with increased ED length of stay.[24] These findings support the fact that healthcare is more costly for patients with mental health or SUDs, highlighting the need to address physical and mental health in an integrated fashion.[23] In fact, multiple studies have shown the effectiveness of case coordination and combined medical and behavioral health clinics to help decrease substance use- or mental health-related ED visits.[25,26]

LIMITATIONS

Our study results should be interpreted in the context of several limitations. First, only associations and no causal relationships could be made due to the cross-sectional nature of the study. Second, it is possible that some substance use-related ED visits represented repeated visits over time, meaning the statistical methods used in the analysis could yield biased results away from the null. As the NHAMCS is an event-level database, it is not possible to ascertain this as data linkage could not be performed. Third, the study results relied heavily on ED reporting and ICD codes, which could be subject to inaccuracies and bias the results toward the null, although steps were taken to mitigate this through staff training.

Fourth, due to limitations in sample size, detailed analysis on the specific types of diagnostic services or imaging modalities, with the exception of toxicology screening, were not done. Further studies incorporating data from previous years would be needed to obtain more granular data. Fifth, due to concerns about multiplicity, resource utilization pattern with respect to the subgroups of substances analyzed can only be used for hypothesis-generating purposes. Furthermore, improved screening strategies for substance use in the ED could have contributed to the increase in visits, following the emergence of evidence demonstrating improved outcomes associated with ED-initiated interventions, biasing the results away from the null.[27] Finally, this study did not include information on ED-initiated substance use treatment or outpatient referral pattern over time, making it difficult to comment on specific strategies to help improve care for patients with SUD in the ED. In summary, many of the limitations arose from the design of the survey itself and were difficult to mitigate at the data analysis stage.

CONCLUSION

Substance use- and mental health-related ED visits are rising and are associated with increased resource utilization. Increasing mental health support will continue to be needed in the ED, along with support for ED clinicians in the management of common substances of abuse, especially sedatives and stimulants. Additional studies are needed to understand the pattern of resource utilization in the ED for substance use- and mental health-related visits, and to assess the optimal approach to acute care management for these visits.

Address for Correspondence: Weiwei Beckerleg, MD, The Ottawa Hospital – General Campus, Department of Medicine, Box 209, 501 Smyth Road, Ottawa, Ontario, Canada, K1H8L6. Email: wbeckerleg@toh.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. Dwyer-Lindgren L, Bertozzi-Villa A, Stubbs RW, et al. Trends and patterns of geographic variation in mortality from substance use disorders and intentional injuries among US counties, 1980-2014. *JAMA*. 2018;319(10):1013-23.
2. Aldridge RW, Story A, Hwang SW, et al. Morbidity and mortality in homeless individuals, prisoners, sex workers, and individuals with substance use disorders in high-income countries: a systematic review and meta-analysis. *Lancet.* 2018;391(10117):241-50.
3. Creedon TB, Cook BL. Access to mental health care increased but not for substance use, while disparities remain. *Health Aff (Millwood).* 2016;35(6):1017-21.
4. Substance Abuse and Mental Health Services Administration (US), Office of the Surgeon General (US). (2016). Chapter 6: Healthcare systems and substance use disorders. In: *Facing Addiction in America: The Surgeon General's Report on Alcohol, Drugs, and Health*. Washington (DC):US Department of Health and Human Services.
5. Weiss AJ, Barrett ML, Heslin KC, et al. Trends in Emergency Department Visits Involving Mental and Substance Use Disorders, 2006–2013: Statistical Brief #216. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville (MD): Agency for Healthcare Research and Quality (US); December 2016.
6. Salzman M, Jones CW, Rafeq R, et al. Epidemiology of opioid-related visits to US emergency departments, 1999-2013: a retrospective study from the NHAMCS (National Hospital Ambulatory Medical Care Survey). *Am J Emerg Med.* 2020;38(1):23-7.
7. Fahimi J, Aurrecoechea A, Anderson E, et al. Substance abuse and mental health visits among adolescents presenting to US emergency departments. *Pediatr Emerg Care*. 2015;31(5):331-8.
8. Ayangbayi T, Okunade A, Karakus M, et al. Characteristics of hospital emergency room visits for mental and substance use disorders. *Psychiatr Serv*. 2017;68(4):408-10.
9. Graham K, Cheng J, Bernards S, et al. How much do mental health and substance use/addiction affect use of general medical services? Extent of use, reason for use, and associated costs. *Can J Psychiatry*. 2017;62(1):48-56.
10. Dieleman JL, Squires E, Bui AL, et al. Factors associated with increases in US health care spending, 1996–2013. *JAMA*. 2017;318(17):1668–78.
11. Centers for Disease Control and Prevention. Ambulatory Health Care Data. Available at: www.cdc.gov/nchs/ahcd.htm. Accessed September 21, 2021.
12. Owens PL, Fingar KR, McDermott KW, et al. Inpatient Stays Involving Mental and Substance Use Disorders, 2016: Statistical Brief #249. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville (MD): Agency for Healthcare Research and Quality (US); March 26, 2019.
13. Lapham GT, Campbell CI, Yarborough BJH, et al. The prevalence of Healthcare Effectiveness Data and Information Set (HEDIS) initiation and engagement in treatment among patients with cannabis use disorders in 7 US health systems. *Subst Abus*. 2019;40(3):268-77.
14. Vivolo-Kantor AM, Hoots BE, Seth P, et al. Recent trends and associated factors of amphetamine-type stimulant overdoses in emergency departments. *Drug Alcohol Depend*. 2020;216:108323.
15. Jørgensen KB, Nordentoft M, Hjorthøj C. Association between alcohol and substance use disorders and psychiatric service use in patients with severe mental illness: a nationwide Danish register-based cohort study. *Psychol Med.* 2018;48(15):2592-600.
16. Burcu M, Zito JM, Metcalfe L, et al. Trends in stimulant medication use in commercially insured youths and adults, 2010-2014. *JAMA Psychiatry.* 2016;73(9):992-3.
17. Compton WM, Han B, Blanco C, et al. Prevalence and correlates of prescription stimulant use, misuse, use disorders, and motivations for misuse among adults in the United States. *Am J Psychiatry.* 2018;175(8):741-55.
18. Bahji A, Hargreaves T, Finch S. Assessing the utility of drug screening in the emergency: a short report. *BMJ Open Qual.* 2018;7(4):e000414.
19. Tobin MR, Hartline JR, Sullivan SB, et al. Utility of nonspecific laboratory testing for psychiatric patients undergoing medical screening in a military emergency department. *Mil Med*. 2020 Dec 30;185(11-12):e1941-5.
20. American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on the Adult Psychiatric Patient, Nazarian DJ, Broder JS, et al. Clinical Policy: Critical Issues in the Diagnosis and Management of the Adult Psychiatric Patient in the Emergency Department. *Ann Emerg Med*. 2017;69(4):480-98.
21. Silverman JJ, Galanter M, Jackson-Triche M, et al. American Psychiatric Association. The American Psychiatric Association Practice Guidelines for the Psychiatric Evaluation of Adults. *Am J Psychiatry*. 2015;172(8):798-802.
22. Jarvis M, Williams J, Hurford M, et al. Appropriate use of drug testing in clinical addiction medicine. *J Addict Med*. 2017;11(3):163-73.
23. Crowley RA, Kirschner N. Health and Public Policy Committee of the American College of Physicians. The integration of care for mental health, substance abuse, and other behavioral health conditions into primary care: executive summary of an American College of Physicians position paper. *Ann Intern Med*. 2015;163(4):298-9.
24. Pearlmutter MD, Dwyer KH, Burke LG, et al Analysis of emergency department length of stay for mental health patients at ten Massachusetts emergency departments. *Ann Emerg Med*. 2017;70(2):193-202.e16.
25. Komaromy M, Bartlett J, Gonzales-van Horn SR, et al. A novel intervention for high-need, high-cost Medicaid patients: a study of ECHO care. *J Gen Intern Med*. 2020;35(1):21-7.
26. Bouchery EE, Siegwarth AW, Natzke B, et al. Implementing a whole health model in a community mental health center: impact on service utilization and expenditures. *Psychiatr Serv*. 2018;69(10):1075-80.
27. D'Onofrio G, O'Connor PG, Pantalon MV, et al. Emergency department-initiated buprenorphine/naloxone treatment for opioid dependence: a randomized clinical trial. *JAMA*. 2015;313(16):1636-44.

Incidence of Emergency Department Visits for Electric Rental Scooters Using Detailed Ridership Data

Chelsea Williams, MD, MPH*
Cindy C. Bitter, MD, MPH†
Steven Lorber, MD†
Caleb R. Overfelt, MD†
Holly Zehfus, MD†
Andrea Spangler, MD‡
Valerie Lew, MD‡
Lawrence M. Lewis, MD‡
Rosanne S. Naunheim, MD‡

*University of Washington, Department of Emergency Medicine, Seattle, Washington
†Saint Louis University School of Medicine, Division of Emergency Medicine, St. Louis, Missouri
‡Washington University in St. Louis/Barnes Jewish Hospital, Department of Emergency Medicine, St. Louis, Missouri

Section Editor: Tony Zitek, MD
Submission history: Submitted December 7, 2020; Revision received June 2, 2021; Accepted June 12, 2021
Electronically published January 31, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.6.51101

Introduction: Electric scooter (e-scooter) rental usage has increased exponentially around the country, expanding to more than 120 cities by the end of 2018. Early attempts to capture the safety effects of widespread adoption of this technology have been hampered by lack of accurate ridership data. Here we describe a 17-month evolution of ridership characteristics in St. Louis, Missouri, and the frequency of e-scooter rental-related injuries serious enough to require an emergency department (ED) visit over this time frame; we also provide estimates of incidence rates of injuries based on company ridership data.

Methods: We performed a combination retrospective chart review and prospective questionnaire-based analysis of adult e-scooter rental-related ED visits in both downtown St. Louis Level 1 trauma centers during the first 17 months of e-scooter rental usage (August 2018-December 2019). The retrospective portion focused on demographics, alcohol use, helmet use, disposition, operative repair, and temporal and severity markers. The prospective portion focused on more detailed crash and rider data. Finally, we used ridership data from both e-scooter rental companies in St. Louis to estimate incidence and temporal trends.

Results: A total of 221 patients had e-scooter rental-related ED visits. The median age of our population was 31 years with 58.8% male and 53.8% White. There were no deaths. Ninety-two patients were found to have fractures with 38% requiring surgery. Of the 21 patients diagnosed with head injury, five had an intracranial bleed. Overall incidence of ED visits related to e-scooters was 2.1 per 10,000 trips and 2.2 per 10,000 miles with the number of ED visits by month closely correlated with the number of rides per month (Pearson correlation coefficient = 0.95).

Conclusion: The number of e-scooter rental-related injuries seen in St. Louis trauma centers was relatively low and correlated closely with overall number of rides. The number of injuries decreased and were less severe from 2018 to 2019 with infrequent intracranial injuries and a large percentage of fractures requiring operative repair. [West J Emerg Med. 2022;23(2)174–182.]

INTRODUCTION

The first standing electric scooter (e-scooter) rentals were introduced in the United States (US) in September 2017 and expanded to more than 120 cities by the end of 2018.[1] The first death in the US was reported in 2018, and there have been several case series of injury patterns related to their use.[2,3,4,5,6,7] Two prior nationwide studies used queries of the National Electronic Injury Surveillance System (NEISS) to estimate injury rates from e-scooters, but the time frame included only the first five months of e-scooter rentals.[8,9] These early attempts to capture the effects of widespread adoption did not fully capture the period of rapid growth of e-scooter rentals. However, a subsequent query of NEISS showed a sevenfold increase in injuries related to e-scooters between 2014–2019, before and after e-scooter rentals became widespread.[8,10] No studies have compared incidence of injuries or ridership data in the same locale over an extended period of time. We are the first to report detailed e-scooter rental-related injury incidence rates based on company ridership data.

We followed e-scooter rental-related injuries at the two downtown St. Louis emergency departments (ED) since Lime (Neutron Holdings, Inc., San Francisco, CA) and Bird (Bird Rides, Inc., Santa Monica, CA) e-scooter rentals first arrived in our metropolitan area in August 2018. We describe the 17-month evolution of ridership characteristics in the city, the frequency of e-scooter rental-related injuries serious enough to require an ED visit over this time frame, and provide estimates of the incidence rate of injuries based on company ridership data.

Population Health Research Capsule

What do we already know about this issue?
Previous case series examined trends in e-scooter usage and injury patterns related to their use. showing wide variety in the severity and breadth of injuries.

What was the research question?
We aimed to provide e-scooter rental injury-incidence rates and characteristics based on ridership data from the scooter companies.

What was the major finding of the study?
The incidence of e-scooter rental injuries treated in the emergency department was 2.1 per 10,000 trips.

How does this improve population health?
More accurate injury incidence rates from e-scooter rentals will aid future work in understanding injury patterns in comparison to other methods of transport.

METHODS

We performed a retrospective analysis of all patients 18 years or older presenting to the Barnes Jewish Hospital (BJH) or the Saint Louis University Hospital (SLUH) EDs for an e-scooter related injury during the first five months (August–December 2018) of e-scooter rental rollout in the St. Louis metropolitan area. These facilities are the two major adult hospitals and only Level 1 trauma centers located within the city limits. We then performed a prospective analysis of patients meeting the same selection criteria for calendar year 2019 at BJH and continued the retrospective review at SLUH through calendar year 2019. The study had institutional board review approval from Washington University in St. Louis and from Saint Louis University with waiver of consent for SLUH given the retrospective nature of the study. Our methods and results are reported as per the guidelines of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist.[11]

For the retrospective component of the study, we queried the electronic health record for all ED visits that contained the word "scooter" in the diagnosis, chief complaint, or clinical notes. Charts were included for review if documentation noted any of the following keywords: "electric," "rental," "standing motorized," "lime" or "bird." Lime and Bird were the only two companies offering rentals during the study period and thus the terms were used as confirmation of an e-scooter rental. In 16 cases the keywords were not found, and we contacted the clinical provider caring for the patient to clarify whether the scooter in question was a standing e-scooter rental. Three cases were excluded as a result of this follow-up. Charts were also excluded if the above criteria were not met, if the chart reflected a subsequent encounter, or the scooter was determined to be an alternative means of transportation (Figure 1). We could not use an International Classification of Diseases, 10th Revision (ICD-10) code to identify cases as during the study period one did not exist for e-scooter related injury.

For the prospective arm of the study, research assistants (RA) were notified by an automatic trigger for the words "scooter," "lime," or "bird" in the nurse triage note. The care team (attending or resident) also contacted them directly if the e-scooter-related mechanism was ascertained after triage. The RAs were available to respond 24 hours a day/7 days a week. They obtained consent to administer a questionnaire and review the patient's medical record. The questionnaire included similar chart review elements (age, gender, time of injury, helmet use, intoxication) with the goal of ascertaining more accurate and complete information. The questionnaire also included more specific questions regarding the injury (cause of crash, prior rental use, duration, purpose of rental).

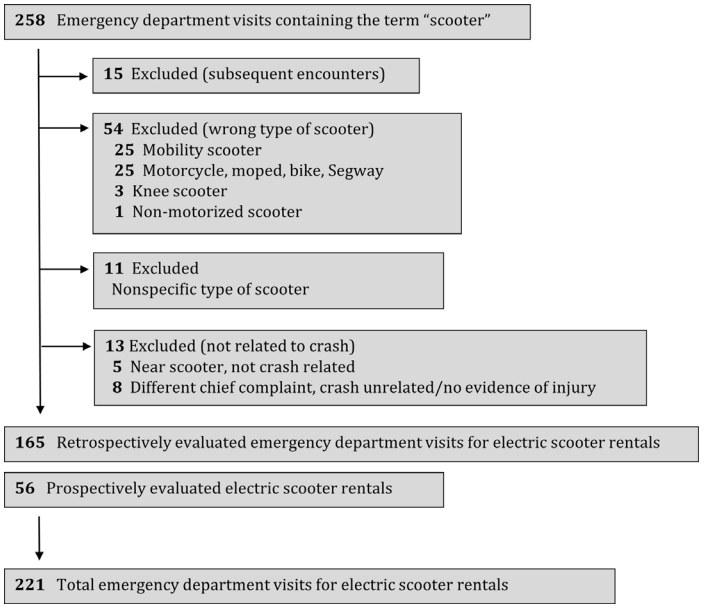


Figure 1. Identifying total emergency department visits for electric scooter-related injury.

Cause of crash was divided into mechanical problem (such as brake problems or loose handlebar); obstacles (curbs, pedestrians, etc); operator error (turned too quickly, multiple riders); street conditions (icy, potholes, etc); struck by vehicle; or unknown. We defined prior rental use as first-time user; intermittent user (five trips or less, but not the first time, or responses of "several times"; and frequent user (over five trips, or responses such as weekly, daily, often). The prospective sample comprised only a quarter of the total patient population (56 of 221).

Reviewers and abstractors were not blinded. For the retrospective arm, charts were abstracted by three physicians at each hospital (AS, VL, CW at BJH and SL, CO, HZ at SLUH) after training on chart review methodology. Senior researchers audited the first 10 charts completed by each abstractor and 10% of subsequent charts. An Excel spreadsheet (Microsoft Corporation, Redmond, WA) and codebook defining variables and preferred chart locations for abstraction of data were generated and shared between institutions. We collected the following variables: age; race; ethnicity; gender; day of week; time of day; drug or alcohol use; helmet use; injury diagnosis; and patient disposition (operating room, admit, home). For the prospective arm one of the senior researchers (LL) trained the RAs on the type of scooter required for inclusion into the study and how to elicit this information. We gave all RAs written survey questions to ask the subjects once they consented to participate in the study. The self-reported responses were recorded in real time. The RAs were given follow-up training, as needed, based on review of their questionnaire data.

We reported frequency statistics of basic demographics (race defined as White, Black or other/unknown and ethnicity defined as non-Hispanic, Hispanic or unknown) as well as intoxication (alcohol or drug use either from lab values, patient reported, or clinically determined), helmet use, disposition, operative repair, and temporal markers (time of day, day of week, month). Time of day was divided into three eight-hour periods – 5 AM-12:59 PM, 1 PM-8:59 PM, and 9 PM-4:59 AM – to distinguish higher commuter times (morning and afternoon) from more recreational, nighttime usage. When time of injury was not specifically noted either prospectively, in the chart, or through ambulance run sheets, we used time at presentation to the ED as a proxy.

We divided injury type into categories: head injury (diagnosis of concussion, intracranial bleeding of any kind, or traumatic head injury); upper extremity fracture/dislocation; facial fracture; spinal injury (diagnosis of fracture or cord compression); minimal injury (abrasions, lacerations, sprains, strains); and other. Severity scales were measured with Emergency Severity Index (ESI) triage scoring. Patients were considered to have sustained a severe injury if they were triaged as immediate (ESI level 1) or emergent (ESI level 2) or had injuries significant enough to require hospital admission. We used the $\chi 2$ test to assess for differences between categorical variables in the 2018 and 2019 data to investigate changing trends with the second season of scooter rental. We used Fisher's exact test to determine differences in groups with more than two variables. We did not make corrections for multiple comparisons.

The two companies that offered e-scooter rentals in our locale during the study period provided aggregate data regarding e-scooter rental usage in the St. Louis metro area. They provided ridership data by hour of day, day of week, and month of year, median distance per ride, average time per ride, and average vehicular speed. The companies did not provide any financial support for the project and were not involved in the analysis or submission. Due to non-disclosure agreements, we were unable to report total numbers of riders, trips, or cumulative mileage.

We used Pearson correlation to determine whether injury rates were correlated with monthly ridership trends and number of injuries. We performed multivariate linear regression to assess for time of day as a potential independent risk factor for an e-scooter-related injury. We entered the following variables via single block entry into the model: average rides per hour and time of day in the three previously listed categories.

RESULTS

During the 17 months of study, we identified 221 patients with scooter-related ED visits, 94 in the last five months of 2018 and 127 in all of 2019. Basic demographic and injury features of the 221 patients can be found in Table 1.

The median age of our population was 31 years, 58.8% were male, and 53.8% were White. There were no major

Table 1. Demographic and characteristics related to patients with scooter-related injuries who presented to the emergency department.

	2018 Number (%)	2019 Number (%)	Total Number (%)
Demographic characteristics			
Age			
18-25	31 (33%)	36 (28.3%)	67 (30.3%)
26-40	36 (38.3%)	54 (42.5%)	90 (40.7%)
41-64	26 (27.7%)	37 (29.1%)	63 (28.5%)
≥65	1 (1.1%)	0 (0%)	1 (0.5%)
Age (Median [IQR])	31 (21.5-40.5)	31 (24-42)	31 (22-40)
Gender			
Male	52 (55.3%)	78 (61.4%)	130 (58.8%)
Female	42 (44.7%)	49 (38.6%)	91 (41.2%)
Race*			
White	43 (45.7%)	76 (59.8%)	119 (53.8%)
Black	35 (37.2%)	47 (37.0%)	82 (37.1%)
Other/Unknown	16 (17%)	4 (3.1%)	20 (9.0%)
Ethnicity*			
Non-Hispanic	85 (90.4%)	123 (96.9%)	208 (94.1%)
Hispanic	2 (2.1%)	3 (2.4%)	5 (2.3%)
Unknown	7 (7.4%)	1 (0.8%)	8 (3.6%)
Injury characteristics			
Intoxication*			
Yes	17 (18.1%)	37 (29.1%)	54 (24.4%)
No	10 (10.6%)	44 (34.6%)	54 (24.4%)
Unknown	67 (71.3%)	46 (36.2%)	113 (51.1%)
Helmet*			
Yes	1 (1.1%)	3 (2.4%)	4 (1.8%)
No	31 (33%)	70 (55.1%)	101 (45.7%)
Unknown	62 (66%)	54 (42.5%)	116 (52.5%)
Main injury*			
Head injury	12 (12.8%)	9 (7.1%)	21 (9.5%)
Lower extremity fracture	10 (10.6%)	14 (11.0%)	24 (10.9%)
Upper extremity fracture	13 (13.8%)	35 (27.6%)	48 (21.7%)
Facial fracture	4 (4.3%)	14 (11.0%)	18 (8.1%)
Spinal injury	2 (2.1%)	1 (0.8%)	3 (1.4%)
Minor injury	48 (51.1%)	49 (38.6%)	97 (43.9%)
Other	5 (5.3%)	5 (3.9%)	10 (4.5%)
Disposition*			
Floor	10 (10.6%)	9 (7.1%)	19 (8.6%)
ICU or OU	3 (3.2%)	0 (0%)	3 (1.4%)
Discharge	76 (80.9%)	114 (89.8%)	190 (86%)
Left without being seen	5 (5.3%)	2 (1.6%)	7 (3.2%)
Left against medical advice	0 (0%)	2 (1.6%)	2 (0.9%)
Surgical repair	14 (14.9%)	21 (16.5%)	35 (15.8%)

*Fisher's exact test < 0.05.
IQR, interquartile range; *ICU*, intensive care unit; *OU*, observation unit.

Table 1. Continued.

	2018 Number (%)	2019 Number (%)	Total Number (%)
ESI triage			
1 (immediate)	1 (1.1%)	0 (0%)	1 (0.5%)
2 (emergent)	20 (21.3%)	17 (13.4%)	37 (16.7%)
3 (urgent)	55 (58.5%)	85 (66.9%)	140 (63.3%)
4 (less urgent)	17 (18.1%)	24 (18.9%)	41 (18.6%)
5 (least urgent)	1 (1.1%)	0 (0%)	1 (0.5%)
Unknown	0 (0%)	1 (0.8%)	1 (0.5%)
Severe injury‡	29 (30.9%)	20 (15.7%)	49 (22.2%)
Temporal characteristics			
Day of week			
Sunday	20 (21.3%)	20 (15.7%)	40 (18.1%)
Monday	10 (10.6%)	14 (11%)	24 (10.9%)
Tuesday	12 (12.8%)	16 (12.6%)	28 (12.7%)
Wednesday	12 (12.8%)	15 (11.8%)	27 (12.2%)
Thursday	9 (9.6%)	19 (15.0%)	28 (12.7%)
Friday	10 (10.6%)	16 (12.6%)	26 (11.8%)
Saturday	21 (22.3%)	27 (21.3%)	48 (21.7%)
Time of day			
5 AM-12:59 PM	26 (27.7%)	27 (21.3%)	53 (24%)
1 PM -8:59 PM	45 (47.9%)	60 (47.2%)	105 (47.5%)
9 PM -4:59 AM	23 (24.5%)	40 (31.5%)	63 (28.5%)

‡$\chi 2 < 0.05$.
ESI, Emergency Severity Index.

differences in age, gender, need for operative repair, triage score, or temporal characteristics between 2018 and 2019. However, more patients were White and non-Hispanic in 2019. Heat map data, a visual representation of the location and density of rides provided by the companies, is shown in Figure 2. We have also indicated the location of the two study centers showing that these facilities are the two hospitals located within the areas with nearly all rental scooter use. No other Level 1 trauma centers are located on the map.

Across the entirety of the time period, the majority of injuries were minor (77.8%) with 90.1% of patients sent home from the ED (discharged, left without being seen, or left against medical advice). There were no deaths. Twenty-two patients (10.0%) were admitted to the hospital, and three (1.4%) of these patients were admitted to the intensive care unit (ICU) or observation unit for closer monitoring. Of the 21 patients diagnosed with head injury, five were found to have an intracranial bleed. Of the 92 patients diagnosed with fracture, 13 were admitted on their index visit for operative repair and another 22 were scheduled or recommended for operative repair as outpatients. Overall, 38% of patients with fractures had or were recommended to have surgery.

Of the 105 patients for whom helmet use was documented, only 4 (3.8%) reported wearing helmets. There was no evidence of association between helmet use and severity of injury. The presence or absence of alcohol or drugs was documented in 108 of the 221 charts reviewed. Fifty-four patients (24.4% of the entire population) were intoxicated with alcohol or drugs. A higher proportion of intoxicated patients met our criteria for severe injury compared to non-intoxicated patients (35.2% vs 16.7%) (Appendix A). In addition, more patients were intoxicated in the overnight period (42.9% from 9 PM – 4:59 AM vs 7.5% from 5 AM-12:59 PM and 21.9% from 1 PM -8:59 PM) (Appendix B). The highest rate of ED visits and scooter usage was during the afternoon period (Figure 3) with 47.5% of all e-scooter-related ED visits between 1PM-8:59 PM.

Visits to the ED were also more common on the weekends (39.8%) and during September 2018 (14.5%), the second month of rental scooter operation in St. Louis. Severe injuries were more likely to occur in the afternoon (28.6% of severe injuries) compared to the other two time periods (20.6% from 9 PM-4:59 AM, and 11.3% from 5 AM-12:59 PM) (Appendix C). There was no association between injury severity and month of the year or day of the week.

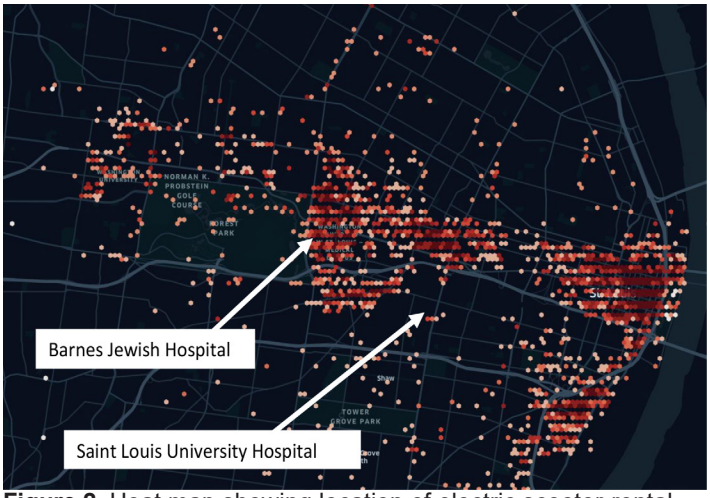


Figure 2. Heat map showing location of electric scooter-rental rides in St. Louis. Darker colors represent a higher density of rides in that location.

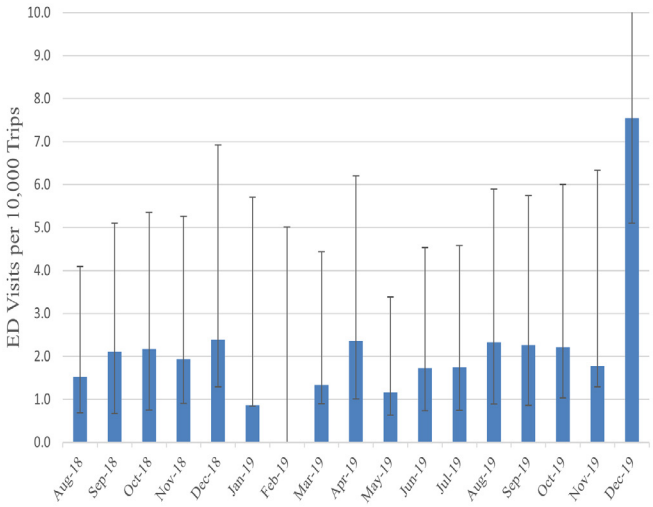


Figure 4. Emergency department visits for electric-scooter rental-related injuries by company-reported trips by month. *Confidence intervals estimated assuming a Poisson distribution. *ED*, emergency department.

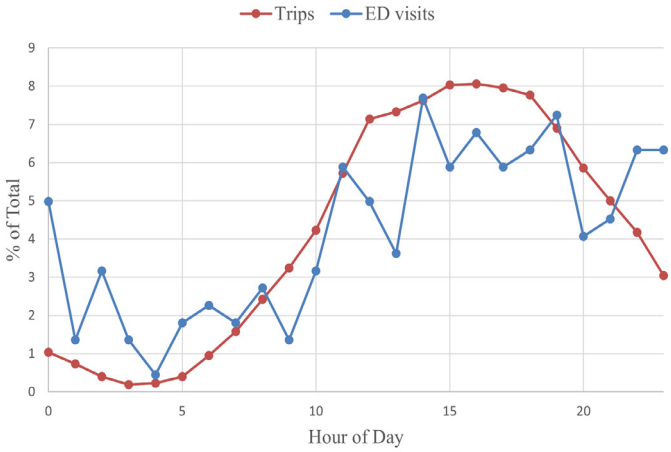


Figure 3. Hourly rides and emergency department visits for electric scooter rental-related injuries by percentage of total. *ED*, emergency department.

The overall incidence of e-scooter rental-related injuries treated in the ED was 2.1 per 10,000 trips (Figure 4) and 2.2 per 10,000 miles.

The questionnaire responses with more specific injury details for the 56 patients from the prospective arm of the study are shown in Table 2.

The data show that the majority (75%) of patients with e-scooter rental-related injuries were not first-time users with 39.3% being frequent users. There was no clear difference between severity or type of injury between first-time users and more experienced users. However, 42.8% of first-time users required operative repair for their injuries compared to only 13.5% of more experienced riders. Most riders were using the scooters for transportation (55.4%). In addition, the cause of injury in most cases was due to road surface conditions (53.2%) or obstacles (14.5%), with few cases involving motor vehicles (10.7%). Most users reported ride length <30 minutes (67.7%) with most frequently a duration of 5 minutes or less (40.3%), which is consistent with company ridership data showing a median trip length of 8.43 minutes/ride.

Unique rider data was only available for 2018. Based on this data, each rider took an average of 2.7 trips, with an incidence of 5.7 ED visits per 10,000 unique riders. The average speed was 4.39 miles per hour. Figure 5 shows the general trends of ridership and injuries over the entire study period. Due to specific non-disclosure agreements with both e-scooter companies, the trips taken and ED visits for e-scooter rentals per month are shown using percentages of the total.

The overall number of ED visits and trips per month decreased between 2018 and 2019. However, the number of ED visits by month were very closely correlated with the number of rides per month, with a Pearson correlation coefficient of 0.95. When assessed by time of day using a multivariate linear regression model, ED visits were closely correlated with the number of rides (P <0.001). However, riding between the hours of 9 PM and 4:59 AM was an independent risk factor for ED visits, after accounting for the number of rides during that time frame (P = 0.04) (Appendix D).

DISCUSSION

Electric scooter rentals have become a popular alternate source of transportation in many cities, both in the US and elsewhere. The media and early reports regarding e-scooter

Table 2. Prospective data questionnaire responses.

Questionnaire responses	Number (%)
Injury trigger	
Mechanical error	2 (3.2%)
Obstacles	9 (14.5%)
Operator error	4 (6.5%)
Road surface conditions	33 (53.2%)
Struck by vehicle	6 (10.7%)
Unknown	2 (3.6%)
User characteristics	
First-time user	14 (25%)
Intermittent user	20 (35.7%)
Frequent user	22 (39.3%)
Purpose	
Transportation to/from work/school	14 (25%)
Other transportation	17 (30.4%)
Recreational	24 (42.9%)
Unknown	1 (1.8%)
Duration	
≤ 5 min	25 (40.3%)
>5 min and ≤ 30 min	17 (27.4%)
>30 min	12 (19.4%)
Unknown	2 (3.2%)

Min, minutes.

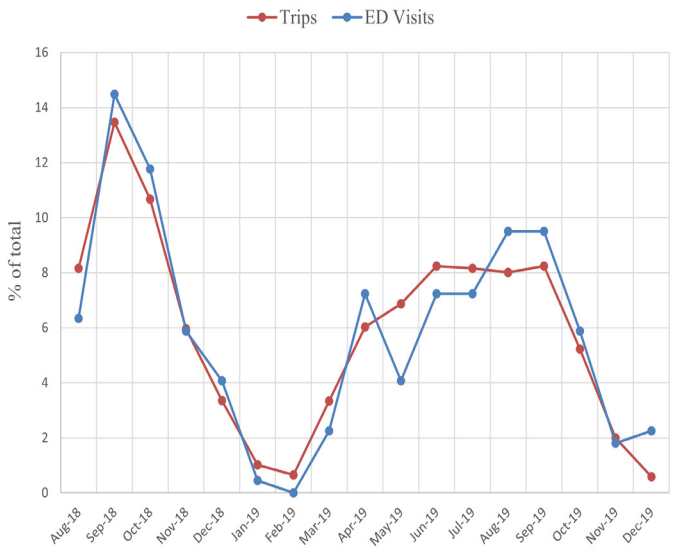


Figure 5. Monthly rides and emergency department visits for electric-scooter rental-related injuries by percentage of total. *ED*, emergency department.

related injuries tended to focus on severe injuries resulting from e-scooter usage. To our knowledge no previously published studies have examined injury rates based on ridership data to better analyze the relative safety of e-scooter use. In St. Louis we found approximately 2.1 visits to the ED per 10,000 rides. Non-peer reviewed data calculated by the Austin, TX, public health department found similar incidence rates (20 per 100,000 trips) over their initial three-month rollout period.[12]

Overall injury rates for e-scooters should be put into context. Comparative data with other forms of non-automobile transportation is difficult to find. The National Highway and Traffic Safety Association reported between 45,000–50,000 bicycle-related injuries nationwide per year in 2014 and 2015[13]; however, this is thought to be a gross underestimate as hospital-based injury rates appear to be about 10 times the injury rate associated with police reports.[14] The NEISS reports an estimated 123 bicycle-related injuries per 100,000 population.[15] Based on St. Louis city census population data from 2019, our data show a rate of 51 e-scooter related ED visits per 100,000 population.[16] Based on the US Centers for Disease Control and Prevention unadjusted injury data from 2017 in combination with estimated national ridership data, there were approximately 8.3 nonfatal injuries and 0.04 fatal, bicycle-related injuries treated in US EDs per 10,000 riders in the adult US population.[17,18] In our data there were approximately 5.7 nonfatal injuries per 10,000 unique riders. Future work comparing local rates of bicycle injury would better quantify this relationship.

The number of ED visits overall was very closely correlated to the number of rides both by hour of day and month of year. This correlation argues that the most significant predictor for the number of e-scooter rental-related ED visits appears to be the number of rides. However, based on the multivariate analysis, riding during nighttime hours (9 PM - 4:59 AM) was an independent risk factor. While nighttime injuries were less severe, this time period is associated with an increased injury risk serious enough to require an ED visit. This increased risk may be due to more reckless behaviors or intoxication: 42.9% of patients presenting in the nighttime hours were intoxicated compared to an average of 15% during the other time periods, although decreased visibility and other factors may also have played a role. One company in St. Louis already restricts rides from 2 AM - 5 AM. Our data would suggest that later nighttime hours present an increased risk of injury for operators of e-scooters. Restrictions on nighttime hour availability should be considered by all vendors.

While research behind incidence trends was previously lacking, our study results focusing on injury patterns are similar to those of previously published studies. An analysis of mass media coverage of e-scooter injuries found 169 incidents with more than 50% involving fatalities or severe injuries.[19] During the first year of rental scooter usage in the St. Louis metro area we found no fatalities. Among those riders who sustained a scooter-related injury requiring an ED visit, 22.2%

met our criteria for a severe injury, 9.5% sustained a head injury, 10% required admission, and 15.8% required operative repair for a fracture.

Case series investigating the number and types of injuries secondary to e-scooter use found varying rates of severe injuries depending on inclusion criteria. Head injuries were the most reported injury, affecting as many as 27.9-40.2% of patients in prior series.[3,5] Our series had a lower incidence of head injuries at 9.5%. This discrepancy may partially be due to differences in reporting. Lacerations and contusions on the scalp were categorized as minor injuries rather than head injuries in this study. Other studies isolating minor from major head trauma have found rates of major head trauma similar to those in this study.[4,7] However, unique vehicular characteristics may also play a role. Among our ridership population the mean speed was under five miles per hour, and few of the patients in the prospective portion of our study had injuries that involved cars (10.7%). Larger cities, with more congested traffic patterns where more riders share the road with cars, may have different results.

Fractures accounted for 30.1-36% of injuries in prior series and 42% in our study. Trivedi et al. reported a 6% admission rate with less than 1% of patients requiring ICU-level care, while Badeau et al. reported a 16% admission rate.[3,4] We found an admission rate of 10% with 1.4% requiring ICU-level care. This is consistent with those studies with similar inclusion criteria, ie, all patients presenting to an ED rather than only trauma activations or patients in trauma registries. In the series published by Dhillon et al., which included only patients requiring services of the trauma team, the ICU admission rate was 20.7%. The Bauer et al. series similarly only included those patients requiring higher level trauma care and reported an admission rate of 43% with 25% requiring ICU-level care.[5,6]

This report is the first to assess trends in incidence of e-scooter rental-related ED visits based on reliable ridership data and to compare the incidence longitudinally over time, seasonally by month, and by time of day. Further evaluation of incidence trends is important to help guide necessary safety choices.

LIMITATIONS

There are several limitations we must note. Although the data come from the only two trauma centers located within the city limits and corresponds to the areas of most frequent scooter usage, it is likely that some patients with scooter-related injuries were seen elsewhere. Several patients in the data set were transferred after initially being seen at urgent care centers. Whereas less severely injured riders may not have presented to our facilities, we believe that the most seriously injured riders were ultimately seen in one of the two downtown EDs, either through initial transport or by transfer. While our data provide one of the longest study periods for e-scooter rental surveillance, it was still isolated to 17 months. We believe this is likely to capture the majority of clear trends in injuries based on initial rollout and novelty; however, there is still a possibility that these trends could manifest with further long-term study.

Additionally, there is no ICD-10 code specific for injuries related to e-scooters, and the search strategy may have missed cases. We also did not include any pediatric cases. While the companies restrict users under 18, there are still likely pediatric cases missed by this study. It is also possible that in the retrospective portion of the study we could have included injuries to individuals who personally owned electric scooters. However, we consider it to be unlikely or a minimal contribution as we used every measure possible to exclude injuries that occurred with personally owned e-scooters (searching for company names or "rental," discussion with providers), and none of the patients prospectively screened for inclusion in the study were riding a personally owned e-scooter. We also have limitations in the data, since many of the questions such as helmet use, intoxication, and causation were not consistently documented.

CONCLUSION

The number of electric scooter rental-related injuries seen in our two adult Level I ED trauma centers in the St. Louis metro area was relatively low, correlated closely with overall number of rides, and decreased in both quantity and severity between the first and second years of operation. Documented helmet use was rare. Importantly, the injuries that did occur were occasionally serious, including a small number of intracranial injuries and a large percentage of fractures requiring operative repair.

Address for Correspondence: Rosanne S. Naunheim, MD, Washington University in St. Louis/Barnes Jewish Hospital, Division of Emergency Medicine, 1 Barnes Jewish Hospital Plaza, St. Louis, Missouri 63110. Email: naunheir@wustl.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. Yakowicz W. 14 months, 120 cities, $2 billion: There's never been a company like Bird. Is the world ready? *Inc.* 2018. Available at: https://www.inc.com/magazine/201902/will-yakowicz/bird-electric-scooter-travis-vanderzanden-2018-company-of-the-year.html. Accessed August 21, 2020.

2. Tsiaperas T. Dallas man, 24, dies a day after apparent electronic scooter accident. 2018. *The Dallas Morning News*. Available at: https://www.dallasnews.com/news/2018/09/04/dallas-man-24-dies-a-day-after-apparent-electric-scooter-accident/. Accessed August 21, 2020.
3. Trivedi TK, Liu C, Antonio ALM, et al. Injuries associated with standing electric scooter use. *JAMA Netw Open*. 2019;2(1):e187381-e187381.
4. Badeau A, Carman C, Newman M, et al. Emergency department visits for electric scooter-related injuries after introduction of an urban rental program. *Am J Emerg Med*. 2019;37(8):1531–3.
5. Bauer F, Riley JD, Lewandowski K, et al. Traumatic injuries associated with standing motorized scooters. *JAMA Netw Open.* 2020;3(3):e201925.
6. Dhillon NK, Juillard C, Barmparas G, et al. Electric scooter injury in southern California trauma centers. *J Am Coll Surg*. 2020;231(1):133-8.
7. Bloom MB, Noorzad A, Lin C, et al. Standing electric scooter injuries: impact on a community. *Am J Surgery*. 2020;221(1): 227–32.
8. Aizpuru M, Farley KX, Rojas JC, et al. Motorized scooter injuries in the era of scooter-shares: a review of the National Electronic Surveillance System. *Am J Emerg Med*. 2019;37(6):1133-8.
9. DiMaggio CJ, Bukur M, Wall SP, et al. Injuries associated with electric-powered bikes and scooters: analysis of US consumer product data. *Inj Prev*. 2019;26(6):524-8.
10. Farley KX, Aizpurur M, Wilson JM, et al. Estimated incidence of electric scooter injuries in the US from 2014-2019. *JAMA Netw Open*. 2020;3(8):e2014500.
11. Cuschieri S. The STROBE guidelines. *Saudi J Anaesth*. 2019;13(Suppl 1):S31-S34.
12. Austin Public Health. Dockless electric scooter-related injuries study. 2019. Available at: http://austintexas.gov/sites/default/files/files/Health/Epidemiology/APH_Dockless_Electric_Scooter_Study_5-2-19.pdf. Accessed October 10, 2019.
13. National Center for Statistics and Analysis. Bicyclists and other cyclists. 2017. Available at: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812382. Accessed October 1, 2020.
14. Stutts JC, Williamson JE, Sheldon FC. Bicycle accidents: an examination of hospital emergency room reports and comparison with police accident data. Paper presented at: Transportation Research Board National Research Council; 1988 Jan 11; Washington D.C.
15. Sanford T, McCulloch CE, Callcut RA, et al. Bicycle trauma injuries and hospital admissions in the United States, 1998-2013. *JAMA*. 2015;314(9):947-9.
16. United States Census Bureau. *American Community Survey*: Total population 18 and older*, 2010-2019*. 2011. Available at: https://data.census.gov/cedsci/. Accessed October 1, 2020.
17. Centers for Disease Control and Prevention. Nonfatal injury reports, 2000-2019. 2017. Available at: https://webappa.cdc.gov/sasweb/ncipc/nfirates.html. Accessed July 20, 2019.
18. Breakaway Research Group. U.S. Bicycling Participation Benchmarking Study Report. 2015. Available at: https://b.3cdn.net/bikes/7b69b6010056525bce_ijm6vs5q1.pdf. Accessed July 20, 2019.
19. Yang H, Ma Q, Wang Z, et al. Safety of micro-mobility: analysis of e-scooter crashes by mining new reports. *Accid Anal Prev*. 2020;143:105608.

Up in Flames: The Safety of Electrocautery Trephination of Subungual Hematomas with Acrylic Nails

Claude Blereau, MD*
Steven Radloff, MD*
Justin Grisham, MD†

*Madigan Army Medical Center, Department of Emergency Medicine, Joint Base Lewis-McChord, Washington
†Evans Army Community Hospital, Department of Emergency Medicine, Fort Carson, Colorado

Section Editor: Andrew W. Phillips, MD, MEd
Submission history: Submitted June 8, 2021; Revision received August 16, 2021; Accepted October 7, 2021
Electronically published February 23, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.10.53567

Introduction: Subungual hematomas are fingertip injuries, generally secondary to blunt trauma, that cause pain due to an accumulation of blood under the fingernail. It is generally considered standard of practice to relieve this accumulation by means of trephination with a hollow tip needle, a heated paper clip, or electrocautery. It has been assumed that due to the flammable properties of acrylic, trephination via electrocautery has the potential to ignite acrylic nails and cause burns and other potentially serious injury, making electrocautery contraindicated in patients with acrylic nails. Our thorough literature review failed to support or refute this assumption; so in the interest of ensuring that this practice is evidence-based, we sought to explore this topic.

Methods: In this study we used electrocautery trephination on acrylic nail products attached to simulated digits and recorded the presence and frequency of ignition events. We hypothesized that ignition would occur with sufficient frequency to support continuing the practice of avoiding electrocautery trephination in subungual hematomas with overlying acrylic nails.

Results: In our study, we exposed 200 acrylic nails to trephination with electrocautery, and 83 nails ignited (41.5%).

Conclusion: While other variables exist, these findings do support the current practice pattern of avoiding trephination with electrocautery in those patients with acrylic nails overlying subungual hematomas. [West J Emerg Med. 2022;23(2)183–185.]

INTRODUCTION

A subungual hematoma is an accumulation of blood under the fingernail that develops when damage occurs to the richly vascular nail bed, generally as the result of a blunt trauma or crush injury to that nail bed.[1,2] These injuries present to the emergency department (ED) frequently[3,4]; they classically present with pain and a dark discoloration under the nail following a minor crush injury to the distal finger. The pain is reduced by relieving the pressure built up between the nail and the distal phalanx.[2] Until relatively recently, the recommended process of evaluation and treatment for these injuries frequently included removal of the nail to evaluate the underlying nail bed for laceration.[5] Recent studies have shown trephination of the nail to be as efficacious and without additional risk, and trephination with a hollow tip needle, a heated paper clip, or electrocautery has become the standard of practice.[3,5]

The presence of acrylic nails complicates treatment and evaluation of distal finger injuries in several ways. First, visualization of the nail bed is obviously limited. There has also been speculation that the presence of infectious agents in acrylic nails has the potential to cause harm.[6] Additionally, it has been assumed that due to the flammable properties of acrylic,[7] trephination via electrocautery has the potential to ignite acrylic nails and cause burns as well as other serious injury.[2] In this study we sought to explore this assumption, as

a thorough literature review found no prior studies to either support or refute it. We exposed acrylic nail products with simulated digits to a common form of electrocautery pen used in the ED, the Bovie electrocautery pen (Symmetry Surgical Inc., Antioch, TN), and recorded the presence and frequency of adverse events. We hypothesized that ignition would occur with sufficient frequency to make the use of electrocautery for trephination of subungual hematomas with overlying acrylic nails ill advised.

METHODS

We conducted a non-randomized experimental trial. The desired outcome was to determine the likelihood of combustion involved with the use of electrocautery for trephination of acrylic nails. No human or animal subjects were used, and no patient data was collected; this study received approval from the Madigan Institutional Review Board. We created faux fingers with acrylic fingernails using consumer-available hot dogs and a "do-it-yourself" acrylic nail kit: KISS French Acrylic Sculpture Kit (KISS Products Inc, Port Washington, NY). The manufacturer's instructions were followed,[8] other than that the acrylic nails were applied to the faux fingers rather than human fingernails. Using the kit's provided glue, we secured the plastic fingernails to the simulated digits made from pieces of a hot dog cut longitudinally and transversely to mimic fingertips. After allowing the glue adequate time to dry, per the manufacturer's instructions, we mixed the acrylic liquid and polymer powder and applied it to each nail with a focus on distributing the acrylic mix evenly. A total of 200 fingernails were assembled for this study.

The fabricated fingernails were then allowed to harden for 24 hours prior to the trephination trials with electrocautery pens. We used the high temperature, battery-operated Bovie electrocautery pen (Symmetry Surgical Inc., Antioch, TN) throughout the trial. In total, seven electrocautery pens were used during the trephination of the 200 acrylic nails. Each trial consisted of the electrocautery pen being turned on and allowed to reach maximum temperature, which was considered to be achieved when the electrocautery tip reached a white-hot glow. Trephination of the acrylic nail was performed at a perpendicular angle until the tip of the electrocautery pen completely penetrated through the plastic fingernail (Figure). The results were recorded on a data sheet as "Ignition" or "No Ignition." Each electrocautery pen was used until it failed to reach maximum temperature as defined above. Once all fingernails were used, we compiled and processed the data to determine the percentage of fingernails that ignited.

RESULTS

Of the total 200 acrylic nails exposed to electrocautery trephination in this study (n = 200), 83 ignited (Table). This represents 41.5% combustion when electrocautery was used. Each of seven Bovie pens was used for multiple trephinations to reduce waste and cost. Of note, the percentage of acrylic nails that ignited due to trephination varied widely from pen to pen, with the highest percentage being 76.2% and the lowest 13.0%. Early in our study we did not record which pens were used. For the first 84 trephinations, we used three pens, none of which were used again thereafter. We did not record which of those three pens was used to demonstrate either ignition or no ignition. For the remaining 116 trephinations, four pens were used. We recorded the incidence of ignition for each of the four pens (Table).

Figure. Acrylic nail igniting on simulated fingertip after trephination with an electrocautery pen.

DISCUSSION

We used disposable electocautery pens multiple times, which revealed a wide range of variation between them in the number of nails ignited. This was a relatively unexpected finding, and not the primary outcome of our study; thus, early in the data-gathering phase of our study, we did not record the particular pen used. As we began to notice that some electrocautery devices had a notably higher rate of ignition than others, we began to record which of four Bovie pens was used in each of the trephinations. The variation in ignition rates per pen was likely due to variation in the temperature achieved by the pens both inherently and as the single-use pens continued to be used. Nevertheless, the percentage of acrylic nails that were ignited during trephination was clinically significant and provides evidence to support the current practice of avoiding electrocautery for trephination as treatment for subungual hematomas in the presence of acrylic nails.

LIMITATIONS

This was a relatively small study conducted using only one brand of do-it-yourself acrylic nail kit and store-bought hot dogs to represent human digits. There are minor differences in the application process and the chemicals used in other brands, as well as in professionally applied acrylic nails. The rate of ignition may vary as a result of these differences. Additionally, there were significant differences in

Table. Incidence of acrylic nail ignition when using electrocautery pen.

Electrocautery pen #	Unknown		1		2		3		4		Total	
	I	NI	I	NI	I	NI	I	NI	I	NI	I	NI
	27	57	7	14	3	20	34	17	16	5	83	117
Total	84		21		23		51		21		200	
Percentage	32.1	67.9	33.3	66.7	13.0	87.0	66.7	33.3	76.2	23.8	41.5	58.5

I, ignition; *NI,* no ignition.

the percentage of ignitions caused by different electrocautery pens, although we used all the same type and brand. This implies the possibility that there may be a temperature range at which electrocautery is both safer for use with acrylic and capable of trephination. While further studies could be conducted to determine this, the presence of other treatment options, and the relative paucity of patients having both subungual hematomas and acrylic nails, may limit the utility of further investigation in the future.

CONCLUSION

Subungual hematomas are relatively common blunt or crush injuries to the fingertip that are presented to the ED. Treatment by trephination of the nail has become the standard of practice, and the use of electro-cautery as a means of trephination is common. Use of electrocautery for trephination of acrylic nails has long been thought to be contraindicated due to the known propensity for acrylic to ignite; however, there have been no previous studies to validate this assumption. Our study demonstrated a rate of ignition of 41.5% when electrocautery pens were used in the trephination of 200 acrylic nails on simulated human digits. While the sample size is small, the high incidence of ignition validates the current practice pattern of avoiding electrocautery for trephination of the nail bed as treatment for subungual hematomas when acrylic nails are present.

Address for Correspondence: Claude Blereau, MD, Madigan Army Medical Center, Department of Emergency Medicine, 9040A Jackson Avenue, Joint Base Lewis-McChord, Washington 98431. Email: claude.a.blereau.mil@mail.mil.

Conflicts of Interest: By the WestJEM 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. The views expressed here are those of the authors and do not reflect the official policy of the Department of the Army, the Department of Defense, or the U.S. Government. The authors disclosed none.

REFERENCES

1. Salter S, Ciocon D, Gowrishankar T, et al. Controlled nail trephination for subungual hematoma. *Am J Emerg Med*. 2006;24(7):875-7.
2. Pirzada A and Waseem M. Subungual hematoma. *Pediatr Rev*. 2004;25(10):369.
3. Seaberg D, Angelos W, Paris P. Treatment of subungual hematomas with nail trephination: a prospective study. *Am J Emerg Med*. 1991;9(3):209-10.
4. Fetter-Zarzeka A, Joseph M. Hand and fingertip injuries in children. *Pediatr Emerg Care*. 2002;18(5):341-5.
5. Dean B, Becker G, Little C. The management of the acute traumatic subungual haematoma: a systematic review. *Hand Surgery*. 2012;17(01):151-4.
6. Gil J, DeFroda S, Reid D, et al. Closed traumatic finger tip injuries in patients with artificial nails: removal of UV gel and acrylic nails. *Am J Emerg Med*. 2016;34(2):335-7.
7. Vanover W, Woods J, Allin S. Synthetic fingernails as a fire hazard in the chemistry laboratory. *J Chem Educ*. 1999;76(11):1521.
8. Search results for: 'nails kiss french'. Kissusa.com. https://www.kissusa.com/nails/kiss-french. Published 2021. Accessed April 20, 2021.

Educating and Empowering Inner-City High School Students in Bleeding Control

Millicent Okereke, MD
Jessica Zerzan, MD
Elizabeth Fruchter, MD
Valerie Pallos, MD
Maya Seegers, MD
Mehr Quereshi, MD
Lynn Model, MD
Monique Jenkins, PhD, BC-FNP
Gia Ramsey
Christine Rizkalla, MD

Maimonides Medical Center, Department of Emergency Medicine, Brooklyn, New York

Section Editor: Pierre Borczuk, MD
Submission history: Submitted March 24, 2021; Revision received November 16, 2021; Accepted December 6, 2021
Electronically published February 14, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.12.52581

Introduction: Unintentional bleeding is the leading cause of death in people 1-44 years of age in the United States. The Stop the Bleed (STB) campaign is a nationwide course that teaches the public to ensure their own safety, call 911, find the bleeding injury, and achieve temporary hemorrhage control by several techniques. Although the national campaign for the training course was inspired by active shooter events, the training can be applied to motor vehicle accidents and small-scale penetrating and gunshot wounds. Extending the audience to inner-city high school students in a violence-prone neighborhood has the potential to save lives if they are first on the scene.

Objectives: We hypothesized that students would have a greater degree of comfort, willingness, and preparedness to intervene in acute bleeding after taking the course.

Methods: This was a prospective, interventional pilot study in one inner-city high school in Brooklyn, New York. Students were given the option to participate in the STB course with pre- and post-surveys. We recruited 286 students from physical education or health education class to take a 50-minute bleeding control training course. Mean age was 15.7 years old. Students were divided into groups of 20-25 and taught by 2-3 emergency medicine, pediatric, or trauma surgery STB instructors. Each course included 2-3 skills stations for placing a tourniquet, wound packing, and pressure control.

Results: Prior to the course, only 43.8% of the students reported being somewhat likely or very likely to help an injured person who was bleeding. After the course, this increased to 80.8% of students even if no bleeding control kit was available. Additionally, there were significant improvements in self-rated comfort level from pre- to post-course 45.4% to 76.5%, and in self-rated preparedness from 25.1% to 83.8%. All three measures showed statistically significant improvement, P <.0001.

Conclusion: Teaching the STB course to high school students from a community with high levels of violence resulted in increased comfort level, willingness, and preparedness to act to control bleeding. If these opinions translate into action, students' willingness to act could decrease pre-hospital blood loss and empower youth to perform life-saving interventions. [West J Emerg Med. 2022;23(2)186–191.]

INTRODUCTION

Unintentional and uncontrolled bleeding is the leading cause of death in people ages 1-44 in the United States. Per the US Centers for Disease Control and Prevention, trauma, most commonly traumatic brain injury and uncontrolled hemorrhaging, is the leading cause of death among pediatric populations. Exsanguinating hemorrhage can lead to death within a matter of minutes, making prompt hemorrhage control imperative in bleeding scenarios.[1] In 2015 the National Trauma Institute estimated that severe bleeding accounts for greater than 35% of prehospital deaths and 80% of mass casualty victims are transported to the hospital by non-ambulance.[2] Therefore, in the minutes before emergency medical technicians (EMT) can arrive to the scene, non-medical bystanders who are trained in basic techniques to control bleeding can be active participants in decreasing rates of preventable deaths.[3]

The Stop the Bleed (STB) campaign was started in 2013 to reduce the morbidity and mortality associated with hemorrhage secondary to traumatic injury.[4] While STB initially developed from the US military, it has emerged as a major public health initiative.[5] By 2015 the Department of Homeland Security launched a nationwide STB campaign to teach bystanders hemorrhage control. The STB training course, called Bleeding Control or B-Con, teaches the public to ensure their own safety, call 911, find the bleeding injury, and compress (either by covering the wound/direct pressure or using a tourniquet). The STB course can motivate participants by teaching them how to distinguish between life-threatening and non-life-threatening hemorrhage, and then slow it down.[6] At its inception, the STB campaign had two main goals: 1) to inform as well as empower laypersons to be trained in basic trauma care to stop or slow bleeding during an emergency; and 2) to increase bystanders' access to bleeding control kits. Using these skills, participants may be more likely to intervene in a time of need.[1]

While these techniques were initially used in mass casualty settings such as warfare, the national campaign for STB training course was inspired by the Sandie Hook elementary school shooting. The utility of these skills in other scenarios or injuries causing massive hemorrhage, such as motor vehicle accidents or penetrating wounds, has been increasingly recognized.[1] Hemorrhage control techniques have the potential to be readily acquired by teenagers and could be particularly applicable in violence-prone areas with high rates of neighborhood shootings and stabbings.[7]

We believe that inner-city high school students can learn techniques to intervene in a bleeding injury if a family member, friend, or community member is involved in a violent event. The specific aim of this investigation was to teach bleeding control to high school students from the Brownsville neighborhood of Brooklyn and assess whether it increased their comfort level, willingness, and preparedness to intervene in hemorrhage control after taking part in the STB training course. In this investigation we trained the students in bleeding control techniques to empower them to use these skills before EMTs arrive.

Population Health Research Capsule

What do we already know about this issue?
Stop the Bleed (STB) training prepares the public to save lives by teaching them bleeding control measures.

What was the research question?
Can students increase their comfort level, willingness, and preparedness to intervene after taking a bleeding control training course?

What was the major finding of the study?
Students had an increase in comfort level, willingness, and preparedness to intervene in controlling life-threatening bleeding.

How does this improve population health?
High school students trained in STB can help save lives before paramedics arrive by performing bleeding control measures.

METHODS

Study Design and Setting

We chose to extend training to high school students in Brownsville because of the potential exposure to and crucial implications for survival of violent incidents. The neighborhood's poverty rate is nearly double that of New York City and is the second highest in the borough of Brooklyn. Nearly 40% of Brownsville's residents live below the federal poverty level compared to 21% in New York City.[8] Brownsville ranks highest compared to other areas of New York City in the injury assault rate and non-fatal assault-related hospitalizations (180 per 100,000 population compared to 59 per 100,000 in other parts of New York City).[9] Nearly three-quarters of the Brownsville section of Brooklyn is Black, and these neighborhoods have suffered disproportionately from a history of racial injustice, inequality, and poverty.[8] From 2013-2017 it had the city's highest homicide rate, with 16.9 deaths for every 1000 residents, four times the New York City average of 3.8 per 1000.[9] With this disproportionate exposure to violence, our subjects are more likely to encounter a bleeding individual.

This was a prospective, interventional pilot study performed by physicians from the departments of emergency medicine and trauma surgery of an inner-city medical center in Brooklyn, New York. Investigators had prior exposure to

STB in an introductory course during their medical training; however, for this study each physician successfully completed a STB instructor course to receive certification to teach participants. The investigation was conducted at a charter high school located in the Brownsville section of eastern Brooklyn during January–March 2020. In 2016 the Community Health Profile ranked the Brownsville section of Brooklyn, NY, fourth of 59 community districts across New York City in overall risk, including economic security, education, housing, health, youth issues, and violence, making it one of the highest overall risk-prone communities.[10] All participation was voluntary and pre- and post-course paper surveys were anonymous. Investigators provided information about the study to students and parents, including the option to opt out without influence on school grades. The eligibility criteria included students ages 13-19. There were no exclusions, including prior training in a STB course. Approval for the study was obtained from our institutional review board.

Data Collection and Analysis

The STB instructors distributed and collected data in a paper survey format before and after the student training course. There is no standard or validated tool from the STB campaign to assess participants' attitudes regarding comfort or likelihood to intervene with a bleeding victim; therefore, the pilot pre- and post-course surveys were created by study investigators. Survey data was summarized as proportions. We compared the students' likelihood/willingness, comfort, and preparedness before and after the training course was implemented. Students who were more likely, comfortable, and prepared to help an injured person were categorized as *positive,* and those who were more worried about causing further harm to an injured person were cartegorized as *negative*. We performed statistical analysis using the McNemar test, with statistical significance set to $P < 0.05$. The McNemar test, which is used to analyze categorical data in surveys/ questionnaires, determines differences on a dichotomous dependent variable between two related groups.

Self-Reported Inclination

We assessed participants' attitudes and inclination to intervene in caring for victims experiencing severe bleeding secondary to traumatic injury in terms of their self-reported comfort level, willingness, and preparedness.

Procedure

We trained high school students on tourniquet placement, wound packing, and pressure application. The training courses were held during physical education or health education class throughout the school day. Participation in the program was optional, with an alternate assignment/activity provided by their teacher during that class period. Students completed a seven-item pre- and post-intervention anonymous paper survey and rated their experiences on a five-point Likert scale.

The training course and survey took the duration of the 55-minute class period. Each class included 25-30 students taught by 2-3 STB instructors. Courses included a 20-25 minute STB interactive PowerPoint, with time allotted for discussion, followed by a 15-minute skills station in which students were divided into three equal groups. One course instructor led each skills group, teaching hands-on practice with tourniquet placement, wound packing, and pressure control. At the end of the training, we provided students an eight-item post-intervention, anonymous, paper survey to complete before the class period was over. The additional question added to the post-survey concerned student apprehension or willingness to help a bleeding victim. A STB certificate was given to each student upon completion of their training.

RESULTS

We recruited 290 high school students to participate in the pilot study, and 286 of those students chose to take part. In total, 98.6% (40.8% female) of the recruited students completed surveys and participated in the course. Mean age (±standard deviation [SD] was 15.7 years old ±1.2). As per Table 1, prior to the course only 43.8% of the students were

Table 1. Demographics and surveys pre- and post-training in a Stop the Bleed course.

Question	Pre n (%)	Post n (%)
Age, mean(std)	15.7 (1.2)	
Gender, female	115 (40.8%)	
Prior Training	32 (11.4%)	
How likely are you to help an injured person that is bleeding?		
Not at all likely	22 (7.8%)	2 (0.7%)
Not likely	40 (14.2%)	5 (1.8%)
Not sure	96 (34.2%)	31 (10.8%)
Somewhat likely	86 (30.6%)	97 (33.9%)
Very likely	37 (13.2%)	134 (46.9%)
How comfortable are you with helping an injured person that is bleeding?		
Not at all comfortable	23 (8.1%)	5 (1.9%)
Not comfortable	51 (18.0%)	15 (5.6%)
Not sure	81 (28.5%)	43 (16.0%)
Somewhat comfortable	99 (34.9%)	150 (56.0%)
Very comfortable	30 (10.6%)	55 (20.5%)
How prepared are you to help stop bleeding on an injured person?		
Not at all prepared	43 (15.2%)	2 (0.8%)
Not prepared	83 (29.3%)	8 (3%)
Not sure	86 (30.4%)	33 (12.4%)

std, standard deviation.

Table 1. Continued.

Question	Pre n (%)	Post n (%)
Somewhat prepared	65 (23.0%)	127 (47.6%)
Very prepared	6 (2.1%)	97 (36.3%)
How worried are you about causing more harm to an injured person that is bleeding?		
Very worried	74 (26.2%)	19 (7.1%)
Somewhat worried	77 (27.2%)	43 (16.1%)
Not sure	75 (26.5%)	60 (22.5%)
Not worried	40 (14.1%)	113 (42.3%)
Not at all worried	17 (6.0%)	32 (12.0%)
After participating in Stop the Bleed training, how important do you feel it is to have bleeding control equipment available in your school building or other public places?		
Not at all important	n/a	1 (0.4%)
Not important	n/a	4 (1.5%)
Not sure	n/a	31 (11.7%)
Somewhat important	n/a	66 (24.9%)
Very important	n/a	163 (61.5%)
How likely would you be to help a bleeding person if you did not have a bleeding control kit available?		
Not at all likely	n/a	7 (2.7%)
Not likely	n/a	16 (6.1%)
Not sure	n/a	48 (18.2%)
Somewhat likely	n/a	138 (52.3%)
Very likely	n/a	55 (20.8%)
After participating in Stop the Bleed training, do you have any concerns about helping to stop the bleed on an injured person?		
Safety/physical danger	n/a	74 (27.7%)
Disease Transmission	n/a	79 (29.6%)
Sight of blood	n/a	50 (18.7%)
Legal Responsibility/ Consequences	n/a	52 (19.5%)
Risk of causing further injury to the person	n/a	63 (23.6%)
Lack of training on how to stop the bleed	n/a	46 (17.2%)
None	n/a	60 (22.5%)
other	n/a	3 (1.1%)

n/a, not applicable.

somewhat likely or very likely to help an injured person who was bleeding. After the course, this increased to 80.8% of students even if no bleeding control kit was available. Additionally, there were significant improvements in self-related comfort level from pre- to post-course – 45.4% to 76.5% – and in self-rated preparedness from 25.1% to 83.8%. All three measures (willingness, comfort level, and preparedness) showed statistically significant improvement (P <.0001). As per Table 2, students post-STB course demonstrated a change in their likelihood, comfort level, and preparedness to help a bleeding person. Pre- and post-course surveys showed the following: 79.6% of students became somewhat to very likely to render aid; 63.1% were somewhat to very comfortable; and 81.2% were somewhat to very prepared. It should be noted that after the STB course, 6.8% of students reported they were less likely to intervene in helping a bleeding person, 8.8% less comfortable, and 8.9% less prepared.

As per Figure 1, following the STB training course, students showed a statistically significant improvement (P <.0001) in attitude from pre- to post-surveys in their likelihood, comfort, and preparedness to help a bleeding person. The greatest concern students reported in bleeding intervention following the training course was disease transmission, followed by a concern about their safety or threat of physical danger
(Figure 2). Subjects were allowed to choose more than one concern, or as many as applicable.

DISCUSSION

In this study, high school students who participated in the STB training course were shown to have an increase in their comfort level, willingness, and preparedness to intervene in controlling life-threatening bleeding. While the STB training course has not been specifically validated in the adolescent population, popular media has reported on the ease of course delivery to high school students.[11] Goolsby et al previously examined high school students' ability to learn hemorrhage control skills and knowledge using the STB training course. This is the first study to demonstrate that high school students can learn hemorrhage control via multiple educational modalities: instructor-led; web-only; or a combination were assessed. Results showed all modalities improved participants' self-reported willingness and comfort in using tourniquets.[12] To the best of our knowledge, this is the only study to assess whether the STB training course increases the comfort level, willingness, and preparedness of inner-city students in particular. A similar study by Nanassy et al showed an increase in perceptions of self-efficacy and preparedness of school personnel at an urban high school in responding to a life-threatening bleeding emergency after completing a STB training course.[13] The Nanassy study included school personnel, while our study involved high school students; however, the similar findings of increased preparedness lend validity to the importance of STB training.

Since the course was established to teach the layperson without specifying an age group or reading level, bleeding

Table 2. Pre- to post-changes in attitude toward helping a bleeding victim.

Question	Change from negative to positive feelings	Change positive to negative feelings	p-value*
How likely are you to help an injured person that is bleeding?	Of the 147 people who answered not at all likely through not sure, 117 switched to somewhat to very likely	Of the 117 people who answered Somewhat to Very Likely, 8 switched to not at all likely through not sure.	<.0001
How comfortable are you with helping an injured person that is bleeding?	Of the 141 people who answered not at all comfortable through not sure, 89 switched to somewhat to very comfortable	Of the 125 people who answered somewhat to very comfortable, 11 switched to not at all comfortable through not sure.	<.0001
How prepared are you to help stop bleeding on an injured person?	Of the 197 people who answered not at all prepared through not sure, 160 switched to somewhat to very prepared	Of the 67 people who answered somewhat to very prepared, 6 swtiched to not at all through not sure.	<.0001
How worried are you about causing more harm to an injured person that is bleeding?	Of the 211 people who answered very worried to not sure, 103 switched to not worried or not at all worried	Of the 53 people who answered not worried or not at all worried, 12 switched to very worried through not sure.	<.0001

*McNemar's Test

control is, therefore, a skill that both teenagers and adults can learn to prevent further blood loss, and may be more crucial in communities with higher rates of violence. The results from pre-course to post-course surveys revealed a significant change in the participants' willingness and comfort level in helping others. Thematic analysis of self-reported concerns about helping to stop active bleeding revealed that participants were more concerned about personal safety or physical danger and disease transmission to themselves when it came to helping a bleeding victim. We believe these findings have important implications for public health. Our results show that with a single STB course, high school students become more willing and more comfortable helping others.

LIMITATIONS

This investigation was a small pilot study in a single environment, which may not be representative of other communities. It was conducted in a space that may not have been optimized for proper instruction; the health education classroom used was smaller than the physical education gymnasium, which was larger and potentially more conducive to hands-on, multi-group, and skills station instruction. The number of participants and classroom environments were not standardized. Of note, 11.4% of participants had prior training in a STB course, the context/location of which was not ascertained.

This pilot study assessed the efficacy of an educational intervention from self-reported survey responses; therefore, the impact may be limited due to its very design. However, it is an essential first step in assessing the potential benefits of this public health intervention. Our findings have implications for future research, practice, and education. We are unaware of whether comfort with bleeding control gained after this course will be maintained over time. In the study by Nanassy

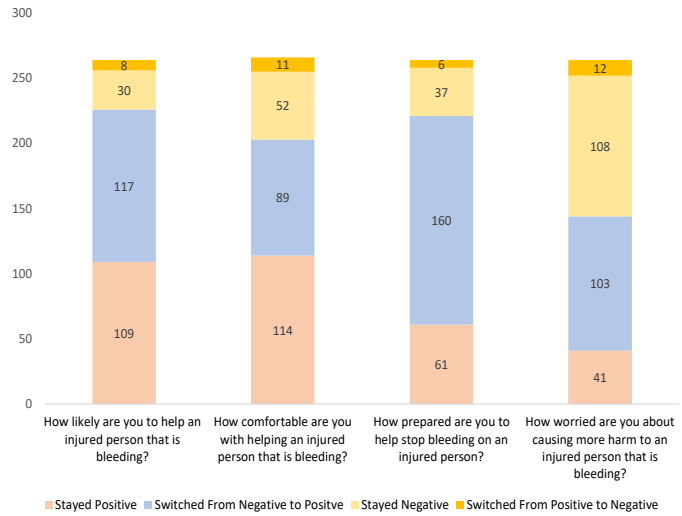


Figure 1. Pre-post intervention demonstrating changes in comfort level and willingness to render aid.

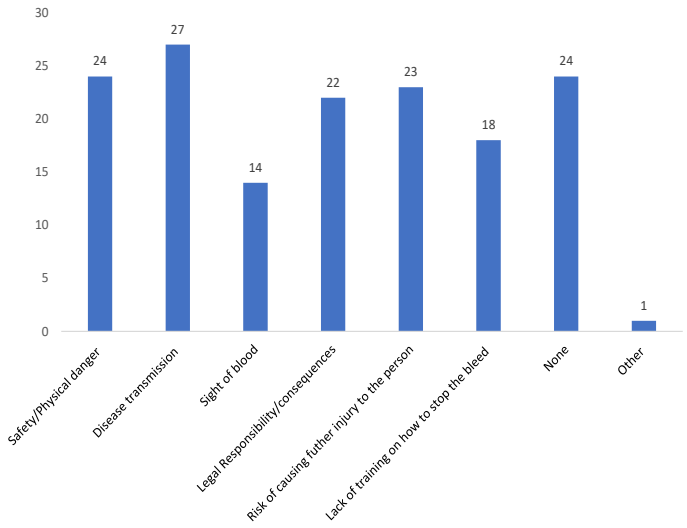


Figure 2. Self-reported concerns.

et al, thematic analysis of written responses showed that participants desired higher frequencies of STB training, more equipment, clearer school procedures, and realistic training scenarios with students.[13] Similar investigations can be applied to studies in the future, such as follow-up surveys six months to a year after the course to assess retention and application in a real-life scenario. In addition to the follow-up surveys, focus groups and qualitative reporting on students' experiences may lead to adjustments to the STB course, making the training better tailored for the age/population at hand. This was initially intended to occur after the completion of this pilot study in March 2020; however, the COVID-19 pandemic limited accessibility to the students.

CONCLUSION

Teaching the Stop the Bleed course to inner-city high school students from a community with high levels of violence resulted in increased comfort, willingness, and preparedness to act to control bleeding in a victim. If these opinions translate into action, the students' willingness to act could impact clinical practice and outcomes for EMTs and emergency physicians by decreasing prehospital blood loss and empower youth to perform life-saving interventions.

Address for Correspondence: Millicent Okereke, MD, Maimonides Medical Center, Department of Emergency Medicine, Tenth Avenue Brooklyn, NY 11219. Email: millicent.okereke@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. Lei R, Swartz M, Harvin J, et al. STBing training empowers learners to act to prevent unnecessary hemorrhagic death. *Am J Surg*. 2018;217(2):368-72.
2. Chambers JA, Seastedt K, Krell R, et al. STB: A U.S. military installation's model for implementation of a rapid hemorrhage control program. *Mil Med*. 2019;184(3-4):67-71.
3. Fischer A. STBing - Educating the public. *JAMA*. 2018;320(6):589-90.
4. Oyeniyi BT, Fox EE, Scerbo M, et al. Trends in 1029 trauma deaths at a Level 1 trauma center. *Injury.* 2017;48(1):5-12.
5. Neal M, Reynolds B, Bertoty D, et al. Design and implementation of Western Pennsylvania regional STB initiative. *J Trauma Acute Care Surg*. 2018;85(4):684-90.
6. Goolsby C, Jacobs L, Hunt R, et al. STB Education Consortium: education program content and delivery recommendations. *J Trauma Acute Care Surg*. 2017;84(1):205-10.
7. National Center for Injury Prevention and Control. Key Injury and Violence Data. 2017. Available at: https://www.cdc.gov/injury/wisqars/fatal.html. Accessed November 26, 2001.
8. New York City Department of Health and Mental Hygiene's Bureau of Vital Statistics. Community Health Profile: Brownsville. 2018. Available at: https://www1.nyc.gov/assets/doh/downloads/pdf/data/2018chp-bk16.pdf. Accessed November 26, 2021.
9. New York City Department of Health and Mental Hygiene's Bureau of Vital Statistics. Community Health Profile: Brownsville. 2018. Available at: https://www1.nyc.gov/assets/doh/downloads/pdf/data/2015chp-bk16.pdf. 2015. Accessed: November 26, 2021.
10. Citizens Committee for Children of New York Inc. From strengths to solutions: an asset based approach to meeting community needs in Brownsville. 2017. Available at: https://www.cccnewyork.org/wp-content/uploads/2017/03/CCC-Brownsville.pdf. Accessed November 26, 2021.
11. Degrane S. "A 7-year-old can do this': In era of school shootings, high school students learn how to STB. 2020. Available at: https://www.chicagotribune.com/suburbs/daily-southtown/ct-sta-stop-the-bleed-st-0214-20200213-mgyayn2qfnby3jjp4szilxlmb4-story.html. Accessed November 26, 2021.
12. Goolsby C. High-school students can Stop the Bleed: a randomized, controlled educational trial. *Acad Pediatr*. 2020;21(2):321-8.
13. Nanassy AD, Graf RL, Budziszewski R, et al. STB: the impact of a basic bleeding control course on high school personnel's perceptions of self-efficacy and school preparedness. *Workplace Health Saf.* 2020;68(12):552-9.
14. AlSabah S, Al Haddad E, AlSaleh F. STB campaign: a qualitative study from our experience from the Middle East. *Ann Med Surg (Lond)*. 2018;36:67-70.
15. Goolsby C, Strauss-Riggs K, Klimczak V, et al. Brief, web-based education improves lay rescuer application of a tourniquet to control life-threatening bleeding. *AEM Educ Train*. 2018;2(2):154-61.
16. Haider AH, Haut ER, Velmahos GC. Converting bystanders to immediate responders: we need to start in high school or before. *JAMA Surg*. 2017;152:909-10.
17. Jacobs LM. Empowering the public to improve survival in mass casualty events. *Ann Surg.*. 2016;263(5):860-1.
18. Kragh J. Survival with emergency tourniquet use to stop bleeding in major limb trauma. *Ann Surg.* 2009;249(1):1-7.
19. McCarty JC, Hashmi ZG, Herrera-Escobar JP, et al. Effectiveness of the American College of Surgeons Bleeding Control Basic Training among laypeople applying different tourniquet types: a randomized clinical trial. *JAMA Surg*. 2019;154(10):923-9.
20. Scerbo M. The trauma center is too late: major limb trauma without a pre-hospital tourniquet has increased death from hemorrhagic shock. *J Trauma Acute Care Surg*. 2016;83(6):1165-72.

Training Leaders in Trauma Resuscitation: Teacher and Learner Perspectives on Ideal Methods

Samantha Quon, MD*
Jeffrey Riddell, MD†
Kelsey Ford Bench, MD†
Clare Roepke, MD‡
Elizabeth Burner, MD, MPH*

*Keck School of Medicine of the University of Southern California, Department of Internal Medicine, Los Angeles, California
†Keck School of Medicine of the University of Southern California, Department of Emergency Medicine, Los Angeles, California
‡Lewis Katz School of Medicine of Temple University, Department of Emergency Medicine, Philadelphia, Pennsylvania

Section Editor: Fred Severyn, MD
Submission history: Submitted January 3, 2021; Revision received May 17, 2021; Accepted May 21, 2021
Electronically published February 13, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.5.51428

Introduction: Effective leadership improves patient care during medical and trauma resuscitations. While dedicated training programs can improve leadership in trauma resuscitation, we have a limited understanding of the optimal training methods. Our objective was to explore learners' and teachers' perceptions of effective methods of leadership training for trauma resuscitation.

Methods: We performed a qualitative exploration of learner and teacher perceptions of leadership training methods using a modified grounded theory approach. We interviewed 28 participants, including attending physicians, residents, fellows, and nurses who regularly participated in trauma team activations. We then analyzed transcripts in an iterative manner to form codes, identify themes, and explore relationships between themes.

Results: Based on interviewees' perceptions, we identified seven methods used to train leadership in trauma resuscitation: reflection; feedback; hands-on learning; role modeling; simulation; group reflection; and didactic. We also identified three major themes in perceived best practices in training leaders in trauma resuscitation: formal vs informal curriculum; training techniques for novice vs more senior learner; and interprofessional training. Participants felt that informal training methods were the most important part of training, and that a significant part of a training program for leaders in trauma resuscitation should use informal methods. Learners who were earlier in their training preferred more supervision and guidance, while learners who were more advanced in their training preferred a greater degree of autonomy. Finally, participants believed leadership training for trauma resuscitation should be multidisciplinary and interprofessional.

Conclusion: We identified several important themes for training leaders in trauma resuscitation, including using a variety of different training methods, adapting the methods used based on the learner's level of training, and incorporating opportunities for multidisciplinary and interprofessional training. More research is needed to determine the optimal balance of informal and formal training, how to standardize and increase consistency in informal training, and the optimal way to incorporate multidisciplinary and interprofessional learning into a leadership in trauma resuscitation training program. [West J Emerg Med. 2022;23(2)192–199.]

INTRODUCTION

Effective leadership during trauma resuscitations requires collaboration, communication, and decisiveness.[1-3] Dedicated leadership training programs can improve team performance and nonclinical skills such as identification of a team leader, role assignment, situation monitoring, mutual support,

and communication.[4-7] Clinical outcomes such as time to computed tomography, time to endotracheal intubation, time to operating room, total resuscitation time, percentage of task completion, and skills assessment also improve with formal team training.[4,7-10]

Targeted training of trauma leadership skills is necessary to achieve proficiency.[11] Despite consensus on the importance of leadership training, team leadership is often a small component of broader trainings.[12,13] The ATLS curriculum recommends leadership training, but does not provide specific guidelines or desired skills.[14] Simulation training and video debriefing individually improve trauma resuscitation performance; however, their role is unclear in the milieu of other training methods.[9,10] Up to 14 teaching methods have been identified in ED medical resuscitations but have not been studied simultaneouly.[15]

We do not know the extent to which informal and interprofessional education aids in acquiring trauma leadership skills, despite the significant role informal curriculum plays in resident education.[16,17] Additionally, the perspectives of both learners and teachers on ideal methods of teaching communication and leadership in trauma resuscitations are not well understood. These insights into where and how training occurs can provide an important perspective to consider in the development of effective training programs. To better understand these perspectives, we explored learners' and teachers' perceptions of effective methods of leadership training for trauma resuscitation.

Population Health Research Capsule

What do we already know about this issue?
Effective leadership improves patient care during medical and trauma resuscitations, and dedicated training programs can improve leadership in trauma resuscitation.

What was the research question?
We explored learners' and teachers' perceptions of effective methods of leadership training for trauma resuscitation.

What was the major finding of the study?
Perceived ideal training includes interprofessional training, informal and formal methods, and adapts to learner experience.

How does this improve population health?
Understanding best methods of training leaders in trauma resuscitation will contribute to better care and outcomes for critically ill trauma patients.

MATERIALS AND METHODS

We performed a qualitative exploration of learner and teacher perceptions of leadership training methods using a modified grounded theory approach.

Setting, Population and Sampling Strategy

We purposively sampled providers from different levels of training and professional backgrounds. As leaders progress in training, their perceptions of their training may change, and viewpoints from different training levels are needed for a more complete understanding of the best ways to train leaders in trauma resuscitation. Senior EM residents and trauma fellows provided the perspective of recently trained leaders, while attending physicians provided their insight from training multiple generations of trauma resuscitation leaders. Experienced ED nurses provided an important ancillary view as witnesses and participants in this training. As leadership and communication in trauma resuscitations is transdisciplinary and involves multiple specialties, we purposively sampled EM attending physicians, senior EM residents, trauma fellows, and ED nurses who regularly participate in trauma team activations (TTA) at an urban, academic teaching hospital and Level 1 trauma center. Senior EM residents and trauma-trained ED nurses were selected randomly from a list of all possible participants at our hospital. All trauma fellows participated. The EM attendings were purposively selected for those who had been at the institution for at least 10 years.

Study participants were recruited through email, electronic listservs, and personal solicitation. Participants were told that the study was to understand the role of leadership in trauma resuscitations. No one who was approached to be interviewed declined. This study was approved by the local institutional review board prior to the start of data collection. Each participant was verbally consented prior to the interview.

Protocol

The interview guide was developed with input from senior emergency and trauma physicians to explore perceptions of training strategies. The interviewer, who completed several rounds of training with mock interviews, was a graduate student at the time of data collection. Interviews were audio recorded for accuracy and professionally transcribed. Participants were given a $20 gift card to compensate for their time. We conducted 28 one-on-one, semi-structured interviews with trauma team providers between February 9–April 28, 2015 in quiet public areas and personal offices in the medical center, with no observers. Three interviews had substantial issues with audio quality and were not included in the analysis. Interview duration ranged from 12-30 minutes, with a median of 22 minutes. We conducted 56% (14/25) of

interviews with female participants; 68% (17/25) participants were affiliated with the ED. This included five ED nurses, six senior EM residents, and six ED attendings. Of the participants 32% (8/25) were involved with the department of trauma surgery, which included four trauma fellows and four trauma attendings.

Analysis

We developed a codebook and thematic structure using modified grounded theory and an iterative process.[18] During the initial review of the interview transcripts, three coders developed an initial set of codes using three interview transcripts. Using Charmaz's modified grounded theory methodology, themes were open coded into overarching phenomenon categories and then reanalyzed and selectively coded into categories that describe methods of leadership training in trauma resuscitation.[19] The initial proposed codebook was then applied to four additional interview transcripts. Anonymized transcripts and codes were reviewed by a senior EM resident interviewee who added to the developing coding framework. As further participant quotations were coded and analyzed, concepts and phenomena were compared to one another to ensure the coding structure continued to accurately represent the experiences of the participants. The final codebook was further developed until theoretical saturation was reached. (See online appendix for codebook and application instructions.)

Transcripts were analyzed using Dedoose software (Sociocultural Research Consultants LLC, Manhattan Beach, CA) to organize, tally and investigate the themes identified.[19] Two coders went through three rounds of individual coding training, and completed the embedded Dedoose inter-coder reliability test with a final inter-rater pooled kappa of 0.96, which quantified excellent level of agreement of code application between coders.[20] Each of the remaining 18 interviews were then coded by one of the trained coders. To increase trustworthiness, we maintained an audit trail, created memos on developing codes and themes, and conducted biweekly reflection sessions with the principal investigator and coders to remain grounded in the data. The analysis was informed by the authors' backgrounds as both students and trauma team leaders, as well as sensitizing concepts drawn from informal learning frameworks.[17,21] As the transcripts were coded, themes of ideal perceptions of training methods and when to use each training methods arose and were discussed on a biweekly basis.

RESULTS

Through analysis of a total of 175 pages of interview transcripts with 25 different participants, we identified 25 unique codes and seven training techniques (Table 1). Based on interviewees' perceptions, we identified seven training methods used to train leadership in trauma resuscitation: reflection; feedback; hands-on learning; role modeling; simulation; group reflection; and didactic. We identified three major themes of training leaders in trauma resuscitation: formal vs informal curriculum; training techniques for novice vs more senior learners; and interprofessional training.

Formal vs Informal Curriculum

Training methods for leadership in trauma resuscitation generally fell into informal or formal curriculum. The informal curriculum included hands-on learning, role modeling of seniors and attendings, reflection and assessment, and feedback from seniors and attendings. Informal methods were used when training was unscheduled and took place during a shift, when time or the scenario permitted. In contrast, formal techniques were used in more organized or structured training that took place outside of clinical work. These techniques included simulation, didactics. and group reflection. Group reflection included conferences such as morbidity and mortality conferences, organized group feedback, and video review. Both the formal and informal curriculum were considered valuable aspects of leadership training.

Interviewees identified informal curriculum as a crucial part of their training. Modeling by seniors and attending physicians allowed learners to develop their own style. Through role modeling, learners observed techniques they would incorporate in their future practice as well as techniques they viewed as ineffective. Feedback was an important technique because it allowed learners to receive constructive criticism and reinforcement of what they did well. Hands-on learning was viewed as the most effective method of training. Interviewees described informal training as a combination of several methods used concurrently. For example, learners first gained new leadership skills through role-modeling of seniors and improved these skills through hands-on practice. Learners continued to improve through reflection and feedback from teachers.

As one interviewee stated,

> *"Top 3 things, 1 is watching my seniors … there is definitely the people who are frantic and disorganized and the forest before the trees thing, and there are people who are very calm and collected and yet effective … Attending feedback … and then mainly just doing it and messing up a ton … as you run it, you just get better." – EM resident*

However, participants perceived drawbacks to the informal curriculum. One limitation of feedback was that it took place during a shift and was conditional on the availability of the learner and teacher to discuss feedback while simultaneously providing patient care. A negative aspect of hands-on learning was that trauma resuscitations were viewed as high-pressure environments that required speed and precision, making it difficult for learners to practice new skills. For example, as one participant explained,

> *"I think that the most effective thing would probably be … when you actually run a TTA and then talking about it afterwards … it's hard though, too, because*

Table 1. Summary of identified training methods and relationship to major themes.

Training method	Definition	Informal vs formal	Best for novice vs more senior learners	Quote
Reflection	The learner analyzes his/her own performance	Informal training	All levels	*…if things don't go well or we look back and [I] think to myself … that took a long time in the ER, was there something that I could have done sooner to get the patient either to the OR or ICU … why did the work-up take that long? – trauma attending*
Feedback	The teacher gives the learner feedback regarding their performance in real practice in an informal setting (i.e., during a shift)	Informal training	More senior training	*There is no formal system, usually the attendings will just pull you aside and say, hey, what do you think went well, [or] if something was clearly wrong … there is no formal system. – EM attending* *Absolutely … if something isn't perfect then … we'll address it afterwards … debriefing is always important, especially if something goes wrong. - trauma attending*
Hands-on learning	Learners get training through real-time, hands-on/direct experience in treating real patients in trauma scenarios (rather than in practice scenarios or simulation)	Informal training	More senior training	*There's no preparation enough; it's the experience of it where you start to learn … you really get that on the job training so to speak. – EM attending* *Ultimately, I would say that you can't learn it just by observing, you got to live it. – EM attending*
Role modeling	Learners observe peers, seniors, and attendings in their real practice, good and bad examples	Informal training	Novice training	*My previous leaders, basically, just watching them, seeing what I liked and what I didn't like, and then … trying to model what I thought was a good leader, and just practice. – EM resident*
Simulation	Leadership training through practice scenarios, e.g., sim lab, Advanced Trauma Life Support, mock scenarios.	Formal training	Novice training	*I think … simulation is very important… [for] walking through-- what would you do in this situation? Just practicing, being in that role of being decisive. – EM attending*
Group reflection	Leadership training through an organized or formal event, or feedback given in a group format, e.g., morbidity and mortality conferences, grand grounds, or tape review.	Formal training	All levels	*It would be … more of a situation where you … videotape a TTA as it's happening and then, postmortem, going back and reviewing it with … all the people involved-- I think that would be helpful. – trauma fellow* *One of the things that I've wanted to do is seeing if we can get cameras in there … Because people don't know what they don't do or what they do do, until they see it. – trauma attending*
Didactic	Learners gain leadership skills through formal lecture-based learning	Formal training	Novice training	*That's tough to do in terms of just … sitting down in a classroom in a lecture type thing, it definitely needs to be more of an active participation type thing. – trauma fellow*

TTA, trauma team activation.

when you're really busy, sometimes you don't have time to go sit down with your attending afterwards and talk for 15 minutes about how the TTA went because you have another TTA coming in" – EM resident

Furthermore, another participant explained that

"… a lot of it is learned by doing, I think that is hard, obviously in trauma, because it is high stakes … if you have seen it a bunch of times, a lot of time it goes a little bit more smoothly, but you have to do it for the first time at some point, and, so learn by doing definitely." – Trauma attending

Overall, formal training was perceived as less effective than informal techniques but was still valued. Simulation was effective because learners could scrutinize performances to identify potential weaknesses and could practice in a lower stress situation—as opposed to learning informally on a busy shift with high stakes. Participants thought didactics combined with other methods, such as simulation or hands-on training,

would be most beneficial. Didactic training alone was not considered effective because interviewees also wanted more active, hands-on learning. For example, one participant described an ideal training,

> *"A [refresh] on ATLS … And then, I think a lot of it would be … real hands-on training … I think a lot of it would need to be actual 'in the moment' events." – EM resident*

Another participant explained:

> *"For the first time, it's kind of nerve wracking, especially if you get a trauma patient you need a chest tube and you need the rapid transfuser… yes you've seen it done before … but have you never done it before? It's kind of nerve wracking if you have to do it right now 'cause I need it right now rather than talking you through it when nothing's going on… So that's why simulation would be great." – ED nurse*

Perceived drawbacks of simulation were inadequate re-creation of a pressured environment, and the time and money required to organize simulation sessions. When considering feedback, simulation training techniques, and tape review or postmortem training, interviewees preferred tape review or feedback immediately after a real-life scenario to simulation. For example, one participant stated,

> *"We had a mock trauma situation and they try to make it … genuine. But, it comes off as very … fake because there's not that sense of real urgency, which I think it's hard to simulate." – Trauma fellow*

Methods for Novice vs More Senior Learners

Participants distinguished between ideal training methods for novice and more senior learners. For example, novice learners were perceived to benefit more from a low-pressure learning environment and increased support and guidance. In contrast, more senior learners required more individualized training and autonomy to prepare them for caring for patients independently.

Tape review, simulation, role modeling of seniors or attendings, didactic learning, and peer advice were identified as important training techniques for novice learners. Role modeling of seniors and attending physicians was also perceived as better for novice learners. Participants considered tape review, simulation, and didactics to be important training techniques for novice learners because it provided a way to introduce residents to leading trauma resuscitations in a lower stress environment. For example, one junior participant explained that she learned from observing others:

> *Just watching them, seeing what I liked and what I didn't like, and then … trying to model what I thought was a good leader, and just practice." – EM resident*

Another participant found simulation to be very valuable:

> *"Simulation is very important [for] practicing being decisive… That's one of the biggest challenges for a junior resident that's becoming a senior resident, you step into that role of just be the one to make a decision" – EM resident*

Hands-on practice and feedback were important learning techniques for more senior learners. These techniques allowed senior learners to continue to improve their existing leadership skills. Feedback after running trauma resuscitations was particularly important for more senior learners. The ideal timing of feedback changed based on the training level of the learner. For example, feedback given after a resuscitation to a senior learner allowed for more autonomy. In contrast, feedback given during a resuscitation was perceived as better for a novice learner.

One participant explained how to adjust a teaching style depending on the learner's experience:

> *"There were times when the residents were running things very smoothly, and then, maybe just give them feedback at the end of the case, try to minimally intervene … [residents] haven't run traumas before in their PGY* [postgraduate year] *2 year, so I'll watch them do it, and I'll interject comments as they are doing it" – EM attending*

Interprofessional and Multidisciplinary Training

The third prominent theme was the benefit of interprofessional and multidisciplinary training involving trauma surgeons, emergency physicians, and nurses. This approach was perceived to improve the quality of leadership training and strengthen interdepartmental relationships. Multidisciplinary and interprofessional training were discussed in the context of simulation, role modeling, postmortem, and feedback training techniques. One strategy was for learners to observe providers from other departments, such as EM residents observing how trauma surgery fellows run codes and vice versa. Another offered example was multidisciplinary debriefs or feedback sessions with all team members after codes or trauma resuscitations to get additional perspectives on team performance. Cross-department training sessions were considered beneficial because they mimic the collaborative nature of caring for trauma patients as well as strengthening interdepartmental relationships. Nurses supported joint training sessions with nurses and doctors, such as simulations and morbidity and mortality conferences.

One participant explained how multidisciplinary training would simulate real situations:

> *"You want to be as life-like as possible, and the ER doesn't operate in isolation for a lot of these patients, to have the trauma team there running in too, and they have as much reason to benefit as we do … [Trauma is] going to have a different set of expectations" – EM attending*

Another participant stated,

> *"I know they talk about … certain cases that go bad. And I think if we were invited to come to a lot more that would help overall because then if we would understand more of their perspective on … their outcomes, what their solutions are, how they would manage certain things. And then it would … help us*

work better as a team." – ED nurse

DISCUSSION

Effective leadership in trauma resuscitation improves care; however, the best ways to train physicians to be leaders in trauma resuscitation is not fully known. From the experiences each of our participants shared, we identified several modalities currently used for training in trauma resuscitation at our institution and explored perceptions of these strategies. Participants described both informal and formal curricula that were important to training. Participants identified ideal training methods based on learner experience. Importantly, participants felt that leadership training for trauma resuscitation should be multidisciplinary and inter-professional and include ED nurses and emergency physicians, as well as trauma surgeons.

Participants identified both formal and informal curricula as important to training leaders in trauma resuscitation. Overall, informal training was perceived as more important for leadership in trauma resuscitation, consistent with prior work on the significance and benefits of informal training in residency.[16,22] However, participants reported inconsistent experiences with informal training. Other studies have demonstrated this variation in learning opportunities with informal curricula,[22-24] creating potential gaps in the training of learners or even exposing learners to curricula that is unapproved or may even contradict formal curricula.[22,23,25] Our findings indicate trauma resuscitation leadership curriculum should include both formal and informal training components.

Learners' and teachers' perceptions of ideal training methods differed based on the learner's level of training. Novice learners require more supervision and guidance, while more advanced learners need a greater degree of autonomy, consistent with prior work that demonstrated autonomous clinical practice is a valuable part of training,[26-29] and that learners require a decreasing level of oversight as they progress.[30-33] Furthermore, confronting progressively more challenging clinical scenarios based on the learner's stage of development is itself critical for learners to progress.[32] In our study, novice learners were perceived to benefit when teachers directly provided new information or demonstrated a skill to them (role modeling, peer advice, and didactics). More senior learners were perceived to learn best through performing a skill themselves, with less active instruction from the teacher. This highlights the importance of graduated responsibility in leadership training. Despite the barriers to progressive independence,[34] training should initially involve techniques with an active supervisor role, with learners gradually gaining more autonomy as they gain more experience.

The importance of interprofessional and multidisciplinary training in trauma leadership was a recurrent theme in this study. Trauma resuscitations involve the combined efforts of an interprofessional team, including emergency physicians, trauma surgeons, and ED nurses.[4,35,36] Multidisciplinary and interprofessional training improves both teamwork and clinical measurement outcomes and provides valuable experience to physicians in training.[37,38] Our study complements these outcome-based studies as our participants desired increased interprofessional and multidisciplinary leadership training. These principles can also be incorporated into the assessment of the Accreditation Council for Graduate Medical Education milestones for EM: Leading interprofessional debriefing sessions after major trauma resuscitations would demonstrate level 4 competency.[39] Emphasizing interprofessional and multidisciplinary communication and input in this competency will augment this training.

LIMITATIONS

Our study has several limitations. It was performed at a large. urban trauma center and may not be generalizable to hospitals with a smaller volume of trauma patients or fewer resources. However, while the proportion of trauma patients seen and availability of resources such as simulation centers may vary greatly between EDs, the concepts of using both formal and informal training methods, altering the training methods used for novice and more senior learners, as well as incorporating multidisciplinary and interprofessional training would be valuable for many different training programs and should be emphasized in all settings. There is also a potential for social desirability bias, although this was minimized by making the interview transcripts anonymous to the study team and using an interviewer who was not affiliated with the training program.

Another potential limitation is that we only sought the perspectives of providers who routinely lead trauma resuscitations. At our institution only senior EM residents and trauma fellows are permitted to lead trauma resuscitations; therefore, we only interviewed PGY 4 level residents and PGY 7 level trauma fellows. (Junior EM and general surgery residents were not included in this study.) Finally, we investigated trainee perceptions of training methods and did not look at measured changes in learning, behavior, or clinical outcomes. Therefore, our participants' narratives about the aspects of training that were most beneficial for their learning should be contextualized within the literature on the limitations of self-assessment.[40]

CONCLUSION

In this qualitative study, we identified important methods and themes for improving the training of leaders in trauma resuscitation based on the perspectives of both learners and teachers. We recommend that training programs in leadership for trauma resuscitations consist of a variety of training methods, adapt based on the learner's level of training, and incorporate both multidisciplinary and interprofessional training. Future studies should include outcomes-based research to determine whether these strategies result in improved leadership skills and clinical performance, as well as

longitudinal studies with recent graduates to explore changes in perceptions of training as they transition from learner to teacher.

Address for Correspondence: Samantha Quon, MD, Keck School of Medicine of the University of Southern California, Department of Internal Medicine, 1200 N. State Street, GNH 1011, Los Angeles, California 90033. Email: samantha.quon@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. Mo D, O'Hara NN, Hengel R, et al. The preferred attributes of a trauma team leader: evidence from a discrete choice experiment. *J Surg Educ*. 2019;76(1):120-6.
2. Yeung JH, Ong GJ, Davies RP, et al. Factors affecting team leadership skills and their relationship with quality of cardiopulmonary resuscitation. *Crit Care Med*. 2012;40(9):2617-21.
3. Ford K, Menchine M, Burner E, et al. Leadership and teamwork in trauma and resuscitation. *West J Emerg Med*. 2016;17(5):549-56.
4. Capella J, Smith S, Philp A, et al. Teamwork training improves the clinical care of trauma patients. *J Surg Educ*. 2010;67(6):439-43.
5. Hughes KM, Benenson RS, Krichten AE, et al. A crew resource management program tailored to trauma resuscitation improves team behavior and communication. *J Am Coll Surg*. 2014;219(3):545-51.
6. Fernandez R, Rosenman ED, Olenick J, et al. Simulation-based team leadership training improves team leadership during actual trauma resuscitations: a randomized controlled trial. *Crit Care Med*. 01 2020;48(1):73-82.
7. Steinemann S, Berg B, Skinner A, et al. In situ, multidisciplinary, simulation-based teamwork training improves early trauma care. *J Surg Educ*. 2011;68(6):472-7.
8. Gillman LM, Brindley P, Paton-Gay JD, et al. Simulated trauma and resuscitation team training course: evolution of a multidisciplinary trauma crisis resource management simulation course. *Am J Surg*. 2016;212(1):188-193.e3.
9. Knobel A, Overheu D, Gruessing M, et al. Regular, in-situ, team-based training in trauma resuscitation with video debriefing enhances confidence and clinical efficiency. *BMC Med Educ*. 2018;18(1):127.
10. Auerbach M, Roney L, Aysseh A, et al. In situ pediatric trauma simulation: assessing the impact and feasibility of an interdisciplinary pediatric in situ trauma care quality improvement simulation program. *Pediatr Emerg Care*. 2014;30(12):884-91.
11. Leenstra NF, Jung OC, Johnson A, et al. Taxonomy of trauma leadership skills: a framework for leadership training and assessment. *Acad Med*. 2016;91(2):272-81.
12. Rosenman ED, Shandro JR, Ilgen JS, et al. Leadership training in health care action teams: a systematic review. *Acad Med*. 2014;89(9):1295-306.
13. Rosenman ED, Vrablik MC, Brolliar SM, et al. Targeted simulation-based leadership training for trauma team leaders. *West J Emerg Med*. 2019;20(3):520-6.
14. Subcommittee A, Trauma ACoSCo, group IAw. *Advanced Trauma Life Support (ATLS®)*: the ninth edition. *J Trauma Acute Care Surg*. 2013;74(5):1363-6.
15. Weichenthal LA, Ruegner R, Sawtelle S, et al. Teaching methods utilized during medical resuscitations in an academic emergency department. *West J Emerg Med*. 2018;19(4):756-61.
16. Varpio L, Bidlake E, Casimiro L, et al. Resident experiences of informal education: how often, from whom, about what and how. *Med Educ*. 2014;48(12):1220-34.
17. Swanwick T. Informal learning in postgraduate medical education: from cognitivism to 'culturism.' *Med Educ*. 2005;39(8):859-65.
18. Charmaz K. (2014). *Constructing Grounded Theory* (Introducing Qualitative Methods series). New York, New York: SAGE Publications.
19. Sociocultural Research Consultants, LLC. Dedoose. 2018. Available at: https://www.dedoose.com/. Accessed Septemeber 1, 2015.
20. De Vries H, Elliott MN, Kanouse DE, et al. Using pooled kappa to summarize interrater agreement across many items. *Field Methods*. 2008;20(3):272-82.
21. Bowen GA. Grounded theory and sensitizing concepts. *Int J Qual Methods*. 2006;5(3):12-23.
22. Balmer DF, Master CL, Richards B, et al. Implicit versus explicit curricula in general pediatrics education: Is there a convergence? *Pediatrics*. 2009;124(2):e347-54.
23. Greysen SR, Schiliro D, Curry L, et al. "Learning by doing"--resident perspectives on developing competency in high-quality discharge care. *J Gen Intern Med*. 2012;27(9):1188-94.
24. Haidet P, Stein HF. The role of the student-teacher relationship in the formation of physicians. The hidden curriculum as process. *J Gen Intern Med*. 2006;21 Suppl 1:S16-20.
25. Stern DT. In search of the informal curriculum: when and where professional values are taught. *Acad Med*. 1998;73(10 Suppl):S28-30.
26. Kennedy TJ, Regehr G, Baker GR, et al. Progressive independence in clinical training: a tradition worth defending? *Acad Med*. 2005;80(10 Suppl):S106-11.
27. Kemper AR, Freed GL. Hospitalists and residency medical education: measured improvement. *Arch Pediatr Adolesc Med*. 2002;156(9):858-9.
28. Landrigan CP, Muret-Wagstaff S, Chiang VW, et al. Effect of a pediatric hospitalist system on housestaff education and experience. *Arch Pediatr Adolesc Med*. 2002;156(9):877-83.

29. Busari JO, Weggelaar NM, Knottnerus AC, et al. How medical residents perceive the quality of supervision provided by attending doctors in the clinical setting. *Med Educ*. 2005;39(7):696-703.
30. Farnan JM, Petty LA, Georgitis E, et al. A systematic review: the effect of clinical supervision on patient and residency education outcomes. *Acad Med*. 2012;87(4):428-42.
31. Velmahos GC, Fili C, Vassiliu P, et al. Around-the-clock attending radiology coverage is essential to avoid mistakes in the care of trauma patients. *Am Surg*. 2001;67(12):1175-7.
32. Persky AM, Robinson JD. Moving from novice to expertise and its implications for instruction. *Am J Pharm Educ*. 2017;81(9):6065.
33. Olmos-Vega F, Dolmans D, Donkers J, et al. Understanding how residents' preferences for supervisory methods change throughout residency training: a mixed-methods study. *BMC Med Educ*. 2015;15:177.
34. Franzone JM, Kennedy BC, Merritt H, et al. Progressive independence in clinical training: perspectives of a national, multispecialty panel of residents and fellows. *J Grad Med Educ*. 2015;7(4):700-4.
35. Tiel Groenestege-Kreb D, van Maarseveen O, Leenen L. Trauma team. *Br J Anaesth*. 2014;113(2):258-65.
36. Driscoll PA, Vincent CA. Organizing an efficient trauma team. *Injury*. 1992;23(2):107-10.
37. Spiotta AM, Sivapatham T, Hussain MS, et al. Benefits of a multidisciplinary environment for neurointerventional training: Fellows' perspectives. *J Neurointerv Surg*. 2012;4(4):238-40.
38. Kirschbaum KA, Rask JP, Brennan M, et al. Improved climate, culture, and communication through multidisciplinary training and instruction. *Am J Obstet Gynecol*. 2012;207(3):200.e1-7.
39. Beeson MS, Carter WA, Christopher TA, et al. Emergency medicine milestones. *J Grad Med Educ*. 2013;5(1 Suppl 1):5-13.
40. Eva KW, Cunnington JP, Reiter HI, et al. How can I know what I don't know? Poor self assessment in a well-defined domain. *Adv Health Sci Educ Theory Pract*. 2004;9(3):211-24.

Comorbid Patterns in the Homeless Population: A Theoretical Model to Enhance Patient Care

Kanwalgeet Hans, MS* *Kansas City University, Department of Emergency Medicine, Kansas City, Missouri
Luke Mike, DO, MS* †University of Tennessee, Knoxville, Tennessee
Robert Heidel, PhD†
Paula Benavides, MS*
Robert Arnce, MD*
Jan Talley, PhD, MSW, MS, MA*

Section Editor: Mandy J. Hill, DrPH, MPH
Submission history: Submitted March 20, 2021; Revision received October 3, 2021; Accepted September 2, 2021
Electronically published February 23, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.10.52539

Introduction: From the perspective of social determinants, homelessness perpetuates poor health and creates barriers to effective chronic disease management, necessitating frequent use of emergency department (ED) services. In this study we developed a screening algorithm (checklist) from common comorbidities observed in the homeless population in the United States. The result was a theoretical screening tool (checklist) to aid healthcare workers in the ED, including residents, medical students, and other trainees, to provide more efficacious treatment and referrals for discharge.

Methods: In this retrospective cohort study we used the Nationwide Emergency Department Sample (NEDS) to investigate comorbidities and ED utilization patterns relating to 23 injury-related, psychiatric, and frequent chronic medical conditions in the US adult (≥18 years of age) homeless population. Cases were identified from the NEDS database for 2014–2017 using International Classification of Diseases, 9th and 10 revisions, and Clinical Classification Software diagnosis codes. We performed a two-step cluster analysis including pathologies with ≥10% prevalence in the sample to identify shared comorbidities. We then compared the clusters by sociodemographic and ED-related characteristics, including age, gender, primary payer, and patient disposition from the ED. Chi-square analysis was used to evaluate categorical variables (ie, gender, primary payer, patient disposition from the ED), and analysis of variance for continuous variables (age).

Results: The study included 1,715,777 weighted cases. The two-step cluster analysis identified nine groups denominated by most prevalent disease: 1) healthy; 2) mixed psychiatric; 3) major depressive disorder (MDD); 4) psychosis; 5) addiction; 6) essential hypertension; 7) chronic obstructive pulmonary disease (COPD); 8) infectious disease; and (9) injury. The MDD, COPD, infectious disease, and Injury clusters demonstrated the highest prevalence of co-occurring disease, with the MDD cluster displaying the highest proportion of comorbidities. Although the addiction cluster existed independently, substance use was pervasive in all except the healthy cluster (prevalence 36-100%). We used the extracted screening algorithm to establish a screening tool (checklist) for ED healthcare workers, with physicians as the first point of contact for the initial use of the screening tool.

Conclusion: Healthcare workers in the ED, including residents, medical students, and other trainees, provide services for homeless ED users. Screening tools (checklists) can help coordinate care to improve treatment, referrals, and follow-up care to reduce hospital readmissions. The screening tool may expedite targeted interventions for homeless patients with commonly occurring patterns of disease. [West J Emerg Med. 2022;23(2)200–210.]

INTRODUCTION

Homelessness, which we define in this study as self-identified, ongoing problems with access to safe and affordable housing,[1] is a major societal issue worldwide. The United States Interagency Council on Homelessness released a strategic plan to end homelessness, and defined homelessness as the following: 1) rooflessness; 2) houselessness; 3) living in an insecure accommodation; or 4) living in an inadequate accommodation.[2] The US recorded an increase of 2.7% in homeless persons from 2018 through 2019, or approximately 570,000 people living without a residence.[3] The homeless population in the US has been composed of a wide range of people, including single women (40%), families (36%), and unaccompanied adolescents (6.5%).[3] The World Health Organization has reported that consistent with the US population in general, the US homeless population is living longer and the number of co-existing disorders for individuals has increased, resulting in higher rates of morbidity and premature mortality.[1]

The causes of homelessness are multidimensional and include poverty, unemployment, lack of affordable housing, domestic violence, sexual assault, family breakdown, and adverse childhood experiences.[4–8] O'Neill has recommended that a screening tool for social determinants of health should be used to evaluate risk factors related to health outcomes[9] because homelessness is also associated with concomitant medical, psychiatric, and addictive disorders.[10] Traditionally EDs have addressed homeless patients within the context of disease and the episodic need for treatment. More research is needed to determine the prevalence and characteristics of home-less persons treated in EDs to develop evidence-based treatment strategies that address social determinants of health for homeless persons, such as the need for stable and secure housing, access to follow-up care appropriate to the need for care, food, and clean clothing as well as hygienic facilities.[3,4-6,8-12]

Social determinants of health affect exposure, onset, access to treatment, and response to communicable diseases. Where the homeless live and are treated affect non-communicable diseases as well.[12-17] Emergency departments need to become part of a continuum of care that begins with acute care and seamlessly transfers to primary care as well as to global healthcare. Clinicians in the ED may benefit from formal education in screening, brief intervention and referral to treatment (SBIRT) training, addiction medicine, the pernicious effects of stigma, and other social determinants of health to increase efficacious treatment for homeless patients who must navigate the healthcare system.[18]

Previous studies using data from the Veterans Health Administration to perform cluster analyses identified sociodemographic characteristics and patterns of psychiatric and general medical comorbidities of homeless veterans to improve care for these patients.[2–5] General recommendations for treatment have also been established for homeless individuals in the primary care setting, although not in the ED, according to the National Health Care for the Homeless Council in 2020.[10] More research is needed to determine the prevalence and characteristics of homeless persons treated in EDs as well as to develop evidence-based treatment strategies that address social determinants of health for homeless persons,[4,5] such as the need for stable and secure housing, access to appropriate follow-up care, availability of medical respite programs, and hygienic facilities.[2,8–12] In a review of the research published to date we found few studies that described the most common comorbidities seen among homeless persons seeking ED services in the US.

A screening tool (checklist) for ED healthcare workers, residents and medical students is needed.[19-21] Screening tools (checklists) used in hospital settings have been documented to improve medical performance in the following ways: 1) establishing a higher baseline of performance[22]; 2) improving physician protocols for the unexpected patient response to a procedure[23]; and 3) training physicians to attend to important stimuli by using checklists during complicated clinical encounters to enhance memory and attention, and improve problem solving.[24] Three types of checklists that have improved healthcare worker performance in medical settings included the following: 1) protocols for normal, routine treatment; 2) protocols for communication; and 3) protocols to manage nuance and unpredictability.[25,26] In addition to improving the efficacy of care delivered in EDs by residents and medical

Population Health Research Capsule

What do we already know about this issue?
Adult homelessness, a social determinant of health, contributes to poor health outcomes and ineffective chronic disease management that in turn leads to frequent ED use.

What was the research question?
Can a screening tool (checklist) be developed to describe protocols for common comorbidities for homeless adults in EDs in the US?

What was the major finding of the study?
Screening algorithms (checklists) were developed using a national ED database to treat adult homeless patients.

How does this improve population health?
Clinicians in the ED can use screening tools (checklists) to expedite targeted interventions for adult, homeless patients with commonly co-occurring disorders.

students, data acquired from an ED checklist could serve to improve performance for all healthcare workers.[25-27]

Emergency physicians and residents may benefit from formal education in SBIRT training, addiction medicine, the pernicious effects of stigma, and learning the effects of social determinants of health to deepen their understanding of the context in which homeless patients navigate the healthcare system to seek treatment.[5,18] According to the literature, evidence-based curricula focusing on educating residents and other healthcare professionals on effective approaches in caring for homeless ED patients have been lacking.[5] A prior study, which elaborated on these training deficits with medical residents, reported the use of stereotypical presentations of poverty and lack of cleanliness to identify homeless patients in the ED. As a consequence, substandard delivery of care was found to be associated with the preconceived perception of homeless persons being a difficult population to treat.[5,19] General recommendations for treatment have been established for homeless individuals in the primary care setting but not in the ED, according to the National Health Care for the Homeless Council in 2020.[10] These protocols, which were developed in primary care settings with sample populations, may not be generalizable to the homeless population.[28]

In this study our goal was to establish a screening tool (checklist) for emergency clinicians and trainees to improve the treatment of homeless patients in the ED. Grouping patients by similar comorbidities, social factors, demographics, and ED utilization may assist by providing a template from the first point of contact with the physician and continuing to discharge and referral for follow-up care to improve the efficacy of treatment protocols for the homeless throughout their care. This retrospective cohort study used the Nationwide Emergency Department Sample (NEDS) from 2014–2017 to investigate multimorbidity and ED utilization patterns seen in the US adult homeless population during that timeframe.[29] We hypothesized that an analysis of this database using cluster analysis based on primary and secondary diagnoses and patient dispositions would provide information about the more common co-occurring disorders for homeless persons presenting to EDs, and thus contribute to the development of checklists for protocols to improve treatment by reducing errors caused by lack of attention to social determinants of health, as well as stereotyping and misinformation regarding treatment of homeless persons.

METHODS

Study Design and Sample

This retrospective cohort study used the NEDS to investigate multimorbidity and ED utilization patterns seen in the US adult homeless population from 2014–2017.[29] The NEDS belongs to a network of databases formulated by the Healthcare Cost and Utilization Project (HCUP) sponsored by the Agency for Healthcare Research and Quality (AHRQ). The NEDS contains discharge data collected using a stratified, random sample design from 984 EDs in 36 states. It is the largest ED database, providing US national estimates on trends and other healthcare-specific factors seen in the ED setting. We selected cases for adults 18 years of age or older who self-identified as homeless and were treated in an ED. We identified ED visits in the NEDS database using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM), *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10-CM), and *Clinical Classifications Software* (CCS) diagnostic codes.[29]

Within the NEDS database, homelessness was defined based on patients' "yes" or "no" responses to the question of being homeless. Based on the literature review performed for this study, 23 conditions were found to be the most prevalent pathologies and psychiatric disorders treated in the homeless population.[30-37] However, we used only disorders with a prevalence rate above 10%. Nine disorders met this criterion, accounting for 1,715,777 weighted cases. Variables investigated were patient diagnosis, patient demographics (ie, age, gender), payment source (ie, Medicaid, Medicare, private insurance, self-pay, no charge, and other insurance), and disposition from the ED (ie, routine, transfer to short-term hospital, transfer to other hospital, home healthcare, against medical advice, and inpatient admission).[29] Institutional review determined that this study was exempt from oversight for human participants' protection due to the de-identified nature of the database.

Data Analysis

To investigate the conditions with the highest prevalence rates observed in the ED, we used only those disorders with a prevalence rate above 10% to maintain optimal separation and cohesion between and among the various clusters. Cases were entered into a two-step cluster analysis as appropriate for categorical variables for large datasets.[32] We assessed cluster quality using the silhouette measure of cohesion and separation. We also calculated the cluster sizes and ratio of the largest to the smallest cluster sizes. We reported and inter-preted descriptive and frequency statistics for the characteristics in each cluster. The clusters obtained from the analysis were compared with respect to sociodemographic and ED-related characteristics, including age, gender, primary payer, and patient disposition from the ED. We used chi-square analysis for evaluating categorical variables (gender, primary payer, patient disposition from the ED) and analysis of variance for continuous variables (age). All analyses were performed using SPSS version 26 (IBM Corporation, Armonk, NY), and we assumed statistical significance at an alpha value of 0.05. To illustrate nationally representative results, the discharge-level weight variable, built into the NEDS database, was subsequently used upon completion of the cluster analysis.[29]

Screening Algorithm

The screening tool used the comorbidity groupings from the two-step cluster analysis to create a stepwise progression through an algorithmic process, with focus placed on maximizing

efficiency when screening disease states. To increase the specificity of patient placement within the algorithm, we used only disease states with a 20% prevalence or higher from that respective cluster. We developed disposition recommend-ations for each cluster using clinical guidelines published by the National Health Care for the Homeless Council.[10]

RESULTS

Sample Characteristics

Listed in order from most to least prevalent, the nine conditions examined in this sample were as follows: substance use disorder (SUD; 43.4%); essential hypertension (HTN; 24.8%); major depressive disorder (MDD; 19.7%); psychotic disorders (16.1%); injuries and accidents (not self-inflicted; 16.1%); anxiety disorders (14.2%); bipolar disorder (13.2%); suicidal ideation (12.9%); infectious disease (10.5%); and chronic obstructive pulmonary disease (COPD; 10.3%). A comprehensive list of relevant ICD-9-CM, ICD-10-CM, and CCS diagnosis codes defining each disease category by specific conditions investigated is available upon request in table format. The 10 disorders with prevalence rates equaling 10% or higher used in the cluster analysis are listed in Table 1.

Cluster Analysis

Table 1. Sample demographics and disease prevalence of the homeless emergency department cases.

	Frequency, n (%)
Sex	
Male	1,251,869 (73)
Diagnosis	
Hypertension	426,302 (24.8)
Psychosis	275,796 (16.1)
COPD	176,123 (10.3)
Anxiety	244,298 (14.2)
Bipolar	226,987 (13.2)
MDD	337,199 (19.7)
Addictive Disorders	744,261 (43.4)
Injuries and Accidents	276,282 (16.1)
Infectious Diseases	180,567 (10.5)
Suicide	221,156 (12.6)

COPD, chronic obstructive pulmonary disease; *MDD*, major depressive disorder.

Two-step cluster analysis yielded a nine-cluster solution with a silhouette measure of 0.47 indicating fair cohesion and separation among the various clusters. Each cluster was named for the most prevalent disease or disease-type within that cluster, with the exceptions being the "healthy" and "mixed psychiatric" clusters. The prevalence of SUD was 36% or greater in all except the healthy cluster. Another common comorbidity found within more than half the clusters was HTN, which was present in all except the healthy, mixed psychiatric, and addictive disorders clusters (Table 2).

Demographics

We found that most groups for age were found to have averages ranging from 40-49 years. However, cases from the COPD cluster had an average age of 56.5 years ($P < 0.001$) while those within the mixed psychiatric cluster averaged 39.2 years ($P < 0.001$). The HTN cluster also correlated with an aged patient demographic, with an average of 53.1 years ($P < 0.001$). In terms of patient gender, males predominated, constituting 73% of this sample of ED visits, and nearly 65% ($P < 0.001$) of each cluster, with the exceptions of the mixed psychiatric and addictive disorders clusters exhibiting the high and low ends of this spectrum (proportion of females, 34.6% and 19.6%, respectively; $P < 0.001$). The infectious disease cluster contained the second lowest proportion of females at 22.4% ($P < 0.001$; Table 3).

Primary Payer

Overall, the primary insurance used by homeless patients in this sample was Medicaid, representing the primary payer-type of nearly 50% of cases ($P < 0.001$) from each cluster. This was especially true for the addictive disorders and injury and accidents clusters (Medicaid coverage for associated charges, 56.0% and 57.5%, respectively; $P < 0.001$). Medicare coverage only accounted for 11.6% of cases ($P < 0.001$), with the psychotic disorders and COPD clusters seeing higher Medicare utilization rates of 27.7% and 32.6%, respectively ($P < 0.001$). Interestingly, the healthy and addictive disorders clusters saw a higher percentage of self-paying patients (21.2% and 21.7%, respectively; $P < 0.001$; Table 3).

Disposition from the Emergency Department

The patient disposition-type from the ED demonstrated a large variance between clusters. As expected, the healthy cluster showed the highest rate of receiving routine care (79.8%, $P < 0.001$) and being discharged from the ED against medical advice (3.4%, $P < 0.001$). This cluster also showed the lowest rate of inpatient hospital admission (15.1%, $P < 0.001$). Although the addiction, HTN, and injury and accident clusters likewise showed high percentages of routine care (57.8%, 56.8%, 56.1%, respectively; $P < 0.001$), these clusters were also associated with greater percentages of hospital admissions compared to the healthy group (37.1%, 38.0%, and 39.0%, respectively; $P < 0.001$). The highest rate of hospital admission was noted in the infectious disease group, with an admittance rate of 62.4% ($P < 0.001$). Similarly, the COPD and MDD clusters also showed high rates of hospital admission (56.9% and 56.6%, respectively; $P < 0.001$), although the MDD cluster showed the lowest proportion of cases receiving routine care (33.9%, $P < 0.001$). The mixed psychiatric cluster included the youngest cases (39.2 years, $P < 0.001$), the highest proportion of female patients

Table 2. Two-step cluster analysis of psychiatric, injury-related, and medical conditions with a prevalence of 10% or higher in the emergency department.

Cluster	Sampled weighted ED visits n (%)	SI n (%)	INJ n (%)	HTN n (%)	COPD n (%)	MDD n (%)	BP n (%)	Psychosis, n(%)	ANX n (%)	Infectious n (%)	Addictive n (%)
1	315,373 (18.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	360 (0.1)	0 (0.0)
2	156,295 (9.1)	73,337 (46.9)	3,724 (2.4)	0 (0.0)	516 (0.3)	0 (0.0)	77,197 (49.4)	23,007 (14.7)	61,181 (39.1)	4,157 (2.7)	79,031 (50.6)
3	337,199 (19.7)	112,973 (33.5)	46,404 (13.8)	97,468 (28.8)	36,156 (10.7)	337,199 (100.0)	47,333 (14.0)	54,424 (16.1)	110,222 (32.7)	43,628 (12.9)	194,650 (57.7)
4	145,522 (8.5)	5,595 (3.8)	0 (0.0)	33,849 (23.3)	0 (0.0)	0 (0.0)	27,553 (18.9)	145,522 (100.0)	14,431 (9.9)	74 (0.1)	54,491 (37.4)
5	155,064 (9.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	107 (0.1)	155,064 (100.0)
6	169,495 (9.9)	10,582 (6.2)	0 (0.0)	169,495 (100.0	0 (0.0)	0 (0.0)	20,727 (12.2)	0 (0.0)	180,900 (10.6)	100 (0.1)	62,469 (36.9)
7	115,691 (6.7)	6,423 (5.6)	937 (0.8)	50,138 (43.3)	115,691 (100.0)	0 (0.0)	16,460 (14.2)	14,522 (12.6)	13,273 (11.9)	14,875 (12.9)	45,416 (39.3)
8	95,922 (5.6)	5,608 (5.8)	0 (0.0)	25,531 (26.6)	25,531 (26.6)	0 (0.0)	14,076 (14.7)	15,411 (16.1)	9,035 (9.4)	95,922 (100.0)	59,514 (62.0)
9	22,216 (13.1)	6,639 (2.9)	225,216 (100.0)	49,821 (22.1)	17,769 (7.9)	0 (0.0)	23,640 (10.5)	22,910 (10.2)	17,707 (7.9)	21,668 (9.6)	93,624 (41.6)

SI, suicidal ideation; *INJ*, injury; *HTN*, hypertension; *COPD*, chronic obstructive pulmonary disease; *MDD*, major depressive disorder; *BP*, bipolar affective disorder; *ANX*, anxiety.

(34.6%, $P < 0.001$), and showed the highest percentage of transfers to another facility (9.4%, $P < 0.001$; Table 4).

Emergency Department Screening Algorithm

The screening algorithm yielded a maximum of eight steps beginning with a positive screen for homelessness. Disease states commonly seen within a cluster were screened for first, and less common disorders were screened in subsequent steps, thereby ensuring that each disease state was screened for only once. This stepwise progression used recommendations for each cluster providing post-discharge treatment options focusing primarily on referrals to primary care and medical specialists capable of delivering definitive treatment (Figures 1 and 2).[38]

DISCUSSION

Identification of novel strategies to mitigate ED utilization has been a central objective among policy makers in the debate over healthcare reform.[32-35] Evidence suggests that homeless individuals endure a high disease burden and seek ED services at an increased frequency due to a lack of access to chronic disease management services.[21,33-35] With the expansion of Medicaid enrollment under the Affordable Care Act, ED interventions identifying comorbidities within the homeless population to provide effective treatment and follow-up care may contain healthcare costs, and improve patient outcomes. The AHRQ has supported several initiatives to enhance the quality of healthcare for people of all social demographics by introducing resources and training, including culturally appropriate methods for communicating with culturally diverse patients in the primary care setting.[31]

In this study we used a two-step cluster analysis method with the NEDS database to examine co-occurring chronic medical, injury-related, and psychopathologies within the adult US homeless population who received ED services from 2014–2017. The resulting nine-cluster solution identified

Table 3. Demographics, primary payer, associations with distributions among nine clusters.

Variable	Healthy, n (%)	Mixed Psychiatric, n (%)	MDD, n (%)	Psychotic, n (%)	Addictive, n (%)	HTN, n (%)	COPD, n (%)	Infectious, n (%)	Injury and Accident, n (%)
Age at admission	46.0 (14.2)	39.2 (12.4)	43.9 (13.1)	42.5 (13.0)	44.6 (12.9)	53.1 (11.2)	56.5 (9.7)	48.0 (11.6)	46.6 (13.5)
Gender (female)	90,051 (28.6)	54,088 (34.6)	103,632 (30.7)	39,316 (19.6)	30,428 (19.6)	41,428 (24.7)	31,709 (27.4)	21,492 (22.4)	51,169 (22.7)
Primary Payer									
Medicare	58,764 (18.7)	29,164 (18.7)	62,055 (18.4)	40,320 (27.7)	17,915 (11.6)	41,104 (24.3)	37,668 (32.6)	17,003 (17.8)	40,055 (17.8)
Medicaid	158,977 (50.5)	80,800 (51.8)	174,007 (51.7)	69,043 (47.5)	86,851 (56.0)	82,683 (48.8)	55,274 (47.8)	55,020 (57.5)	114,910 (51.1)
Private	16,916 (5.4)	12,068 (7.7)	26,209 (7.8)	7,363 (5.1)	8,374 (5.4)	8,923 (5.3)	4,846 (4.2)	4,596 (4.8)	13,366 (5.9)
Self-pay	66,755 (21.2)	27,107 (174)	55,807 (16.6)	23,440 (16.1)	33,557 (21.7)	27,917 (16.5)	12,641 (10.9)	15,555 (15.2)	44,792 (19.9)
No charge	4,966 (1.6)	2,177 (1.4)	6,649 (2.0)	1,494 (1.0)	3,310 (2.1)	3,101 (1.8)	1,472 (1.3)	1,573 (1.6)	3,611 (1.6)
Other	8,476 (2.7)	4,658 (3.0)	11,735 (3.5)	3,702 (2.5)	4,997 (3.2)	5,541 (3.3)	3,660 (3.2)	3,000 (3.1)	8,086 (3.6)

All analyses were statistically significant with a *P*-value less than 0.001.
MDD, major depressive disorder; *HTN,* hypertension; *COPD,* chronic obstructive pulmonary disease.

groups of homeless individuals sharing specific demographic characteristics and possessing comorbidities with distinct patterns of ED utilization, possibly contributing important information about the health trends specific to the ED setting and the adult homeless population.

Homeless individuals have been at greater risk for negative health outcomes than the general population, and have exhibited high rates of unintentional injury, psychiatric disorders, substance use, and infectious and chronic diseases.[31-34] The MDD, COPD, infectious disease, and injury and accidents clusters together constituted 45% of all examined cases. These clusters also exhibited the highest prevalence of co-occurring disorders with the MDD cluster having the greatest proportion of comorbidities. While cases in the addiction cluster existed independently from other medical diagnoses, along with psychiatric disorders and HTN, SUD was pervasive among most clusters, with its prevalence ranging from 36-100% in all except the healthy cluster. Substance use disorder was the most commonly diagnosed chronic condition within this study sample.

This study has described potential sociodemographic and ED utilization characteristics of homeless individuals that have been associated with increased hospital costs.[11,12,35-38] For instance, six of the nine clusters (addiction, infectious disease, HTN, injury and accidents, COPD, and MDD) revealed high rates of hospital admissions, underscoring the need for efficient and effective treatment strategies that can focus on mitigating hospital admission rates. Identification of homeless individuals based on their cluster designations may expedite interventions to ensure treatment that is properly coordinated before discharge. Critical time interventions were found to be effective in mitigating ED utilization by homeless individuals using strategies for enhancing quality of life, securing stable housing, obtaining public income assistance, arranging follow-up primary and specialty care, and increasing accessibility to mental health and substance use treatment.[39,40] These models facilitating continuity of care were also correlated with reduced costs incurred by overburdened hospital systems caring for frequent homeless ED users and those diagnosed with psychiatric disorders.[35-37]

The screening tool (checklist) as an algorithm might also provide a template for electronic applications (ie, electronic health records [EHR], smart devices) for EDs, specifically to streamline post-discharge planning for vulnerable homeless patients. EDs have used EHR to provide the following: 1) needed documentation such as referral letters for same-day, primary care appointments; 2) patient records for follow-up care; 3) notifications to prevent the termination of needed services such as housing to prevent eviction notices; and 4) vouchers for travel.[28]

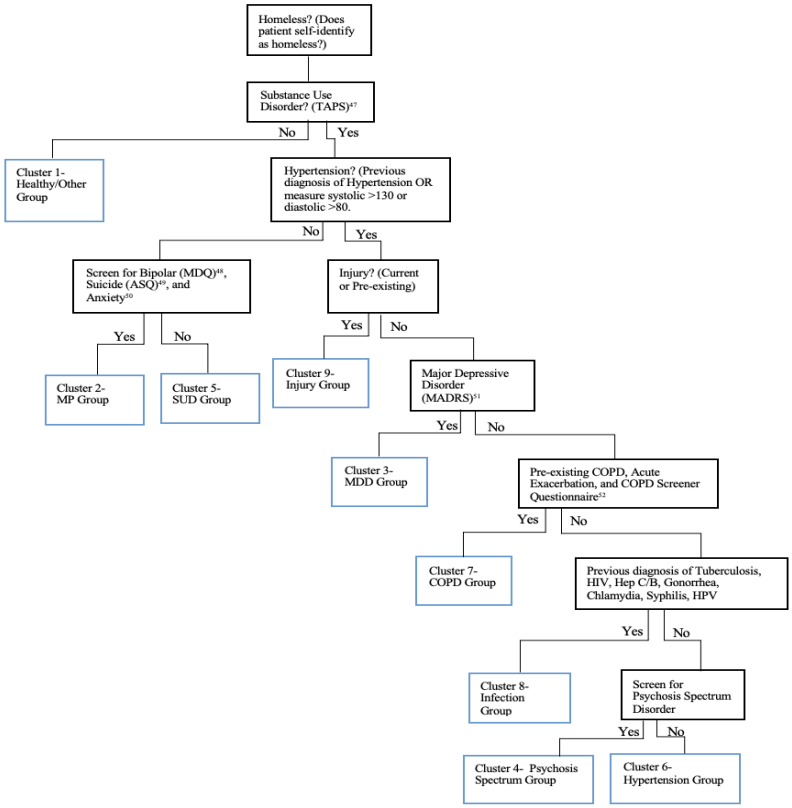
Emergency department-based models that enable real-time collaboration among emergency clinicians and case managers may address some of the unmet healthcare and psychosocial needs of these patients. In-person follow-up by case management after ED discharge was associated with greater costs than telephone-based outreach; however, face-to-

Table 4. Disposition from emergency department associations with distributions among nine clusters.

Variable	Healthy, n (%)	Mixed Psychiatric, n (%)	MDD, n (%)	Psychotic, n (%)	Addictive, n (%)	HTN, n (%)	COPD, n (%)	Infectious, n (%)	Injury and Accident, n (%)
Disposition from ED									
Routine	215,146 (79.8)	69,595 (44.6)	114,211 (33.9)	69,704 (48.0)	89,416 (57.8)	96,111 (56.8)	44,762 (38.8)	32,545 (34.0)	126,078 (56.1)
Transfer to short-term hospital	3,183 (1.0)	14,700 (9.4)	23,473 (7.0)	10,928 (7.1)	2,409 (1.6)	3,622 (2.1)	1,783 (1.5)	1,349 (1.4)	4,451 (2.0)
Transfer to other hospital	3,183 (1.0)	14,700 (9.4)	23,473 (7.0)	10,928 (7.1)	2,409 (1.6)	3,622 (2.1)	1,783 (1.5)	1,349 (1.4)	4,451 (2.0)
HHC	259 (0.1)	169 (0.1)	334 (0.1)	145 (0.1)	90 (0.1)	156 (0.1)	118 (0.1)	60 (0.1)	166 (0.1)
AMA	10,826 (3.4)	2,378 (1.5)	3,188 (0.9)	2,592 (1.8)	4,336 (2.8)	3,752 (2.2)	2,442 (2.1)	1,669 (1.7)	4,322 (1.9)
Admitted to inpatient at current hospital	47,393 (15.1)	66,759 (42.8)	190,419 (56.6)	59,677 (41.1)	57,406 (37.1)	64,302 (38.0)	65,740 (56.9)	58,742 (62.4)	87,774 (39.0)

All analyses were statistically significant with a P-value less than 0.001.
MDD, major depressive disorder; *HTN,* hypertension; *COPD,* chronic obstructive pulmonary disease; *HHC,* home healthcare; *AMA,* against medical advice.

Figure 1. Emergency department medical and psychiatric screening algorithm for homeless individuals.



TAPS, tobacco, alcohol, prescription medication, and other substance use tool; *MDQ,* mood disorder questionnaire; *ASQ,* ages and stages questionnaire; *MP,* Mixed Psychiatric group; *SUD,* substance use disorder; *MADRS,* Montgomery-Asberg depression rating scale; *MDD,* major depressive disorder; *COPD,* chronic obstructive pulmonary disease; *HIV,* human immunodeficiency virus; *Hep C/B,* hepatitis C and B; *HPV,* human papilloma virus.

Table 3. Demographics, primary payer, associations with distibutions

Cluster 1-Healthy Group • Proceed with standard medical exam. • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social services based on needs assessment.	Cluster 4-Psychosis Spectrum Cluster • Proceed with standard medical exam. • Psychiatry Consult with pending admit to Acute Inpatient Psychiatric Facility and provide appropriate referral. • Perform Urinary Drug Screen and give appropriate referral. • Define Severity of psychosis through PANSS[56] • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social • services based on needs assessment. • Patient meets Homeless Vulnerability Index, prioritize needs for housing.[54]	Cluster 7-COPD Cluster • Proceed with standard medical exam. • Perform Urinary Drug Screen and give appropriate referral. • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social services based on needs assessment.
Cluster 2-Mixed Psychiatric Group • Proceed with standard medical exam. • Psychiatry Consult with pending admit to Acute Inpatient Psychiatric Facility and provide appropriate referral. • Perform Urinary Drug Screen and provide appropriate referral. • Define Suicide Ideation Severity with C-SSRS[54] • Define Anxiety Severity with HAM-A[50] • Define Severity of Mania Symptoms with YMRS[48] • Define Depression Severity with MADRS[51] • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social services based on needs assessment.	Cluster 5-Substance Use Disorder Cluster • Proceed with standard medical exam. • Psychiatry Consult with pending admit to Acute Inpatient Psychiatric Facility and provide appropriate referral. • Perform Urinary Drug Screen and give appropriate referral • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social services based on needs assessment.	Cluster 8-Infection Cluster • Proceed with standard medical exam. • Perform Urinary Drug Screen and give appropriate referral. • Define HIV/STD/Hepatitis Infection status through HIV/STD/Hepatitis Risk Assessment Questionnaire[57] and provide referral to PCP. • Symptoms of Tuberculosis (productive cough >3 weeks, hemoptysis, unexplained weight loss, fever/chills/night sweats, unexplained fatigue, chest pain and provide referral to PCP • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social services based on needs assessment.
Cluster 3-MDD Group • Proceed with standard medical exam. • Psychiatry Consult with pending admit to Acute Inpatient Psychiatric Facility and provide appropriate referral. • Perform Urinary Drug Screen and give appropriate referral. • Define Suicide Ideation Severity with C-SSRS[54] • Define Depression Severity with MADRS[51] • Define Anxiety Severity with HAM-A[49] • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social services based on needs assessment. • Patient meets Homeless Vulnerability Index, prioritize needs for housing.[55]	Cluster 6-Hypertension Cluster • Proceed with standard medical exam. • Perform Urinary Drug Screen and give appropriate referral • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social services based on needs assessment.	Cluster 9-Injury Group • Proceed with standard medical exam. • Perform Urinary Drug Screen and provide appropriate referral. • Perform standardized needs assessment with Family Development Matrix[53] • Coordinate care with social services based on needs assessment.

C-SSRS, Columbia-Suicide Severity Rating Scale; HAM-A; Hamilton Anxiety Rating Scale; YRMS, Young Mania Rating Scale; HIV, human immunodeficiency virus; STD, sexually transmitted disease; PCP, primary care physician.

face engagement with patients has been associated with better adherence for initial outpatient mental health appointments.[41]

Because addictive disorders were the most prevalent diagnoses found in this study sample, ED treatment protocols need to be augmented with resources and strategies to improve outcomes for addictive disorders, specifically for homeless persons. One evidence-based intervention used by emergency physicians, the SBIRT tool, has been effective at treating both

alcoholics and addicts in the ED setting.[1,18] The use of the SBIRT tool to provide referrals for substance use treatment services for a large group of diversified patients resulted in reduced expression of criminal behavior, ameliorated health status, acquisition of safe and affordable housing, and employment. Participants reported a significant reduction in recreational drug use and excessive alcohol consumption with perceived betterment in general and mental health states.[18]

The use of checklists for treatment protocols has been studied and found to increase the use of evidence-based practices for homeless individuals based on cluster designation. Various clinical settings, such as surgery, have used checklists extensively in protocol development and have exhibited improved patient outcomes.[21-27] While recent research has explored the use of electronic checklists, the application of checklists in the ED setting to promote better patient care needs to be explored.[28] This study's screening algorithm and associated checklist may also expedite post-ED treatment planning and efficiency by providing necessary medical and psychiatric referrals. Although the proposed screening tool is entirely theoretical because reliability in the ED setting has not been tested, the tool is offered as a template for future research to establish the potential for increased efficacy and efficiency.

While this study described clusters of homeless individuals sharing common comorbidities, addressing the social determinants of health will require action by many community stakeholders including local, state, and federal agencies for funding as well as policy and procedural oversight of services for the homeless. The use of patient-centered medical teams that foster real-time collaboration among all healthcare professionals who work with a patient has been found to contribute to improved health outcomes for that patient.[42] Patient-centered treatment teams have been established but have had limited application in low-income areas, decreasing the likelihood of providing effective treatment for homeless individuals.[42]

The federal ARHQ report for 2018 stressed the need to examine health-promotion and disease-prevention efforts within the context of populations that are at greater risk as a means to modify and improve exposure to positive social determinants of health. The report stressed the need to examine health promotion and disease prevention efforts not because demographics such as race/ethnicity are genetic but to modify and improve exposure to positive social determinants of health.[31]

LIMITATIONS

This study had several limitations, especially in relation to the use of the HCUP NEDS database. First, the HCUP did not use a working definition of homelessness; instead it depended on the reporting of partner hospitals for categorizing homeless patients. While this strategy simplified the identification of homeless persons seeking care in the ED, certain state-specific guidelines hindered full reporting practices. As an example, the state of New York did not record non-US born homeless individuals treated in the ED, but rather listed these patients as missing values in their data provided to the HCUP.[43] Such reporting practices prevented an accurate representation of the actual healthcare and ED utilization trends exhibited by homeless individuals in the US.

Second, in defining case-specific characteristics represented by each cluster, the NEDS database did not record the race of each patient. The National Institute of Human Genome Research has defined race as a fluid dimension that is better understood as ancestral background and/or social identity. Geneticists have proposed that race would be more accurately described as a social and not a biological construct.[44-46] The use of race as a social determinant of health rather than as a genetic construct may contribute to more effective treatment.[44] Even so, the unfair burden of disease by minority populations as well as disparities in the provision of healthcare must be addressed.[44-46] The medical community must revise medical school curricula as well as treatment protocols by using an equity lens to evaluate medical practice to improve the quality of care for all persons.[9]

Moreover, the NEDS database provides visit-level analysis without identifying individual patients and considers recurrent hospitalizations as distinct cases. With each NEDS entry not being equivalent to one ED admission, there is a potential for one patient to account for multiple entries. While this type of data acquisition exemplifies true adherence to the Health Insurance Portability and Accountability Act privacy rules, it can result in the overestimation of certain diagnoses within the homeless population, with multiple cases associated with the same patient being subject to different outcomes. Another factor complicating the identification of disease patterns in the US homeless population has been variation in the interpretation of medical records by reviewers entering ICD-9 and ICD-10 codes into the EHR. Lack of rater training and retraining may increase the potential for error.

Lastly, because this study used the NEDS database to examine over 1.715 million weighted (or over 390,000 unweighted) cases, very small differences in sociodemographic and ED utilization variables between clusters produced statistically significant differences, making interpretation of valid findings based solely on *P*-values potentially less clinically relevant.

CONCLUSION

Through a two-step cluster analysis, this nationally representative sample of US ED visits identified groups of homeless patients based on discrete comorbid and ED utilization patterns. Significant comorbidity was found in each of the nine groups especially within the major depressive disorder, COPD, infectious disease, and injury and accidents clusters. Most notably, substance use disorder was ubiquitous among the cases examined, making it the most prevalent chronic condition within our study sample. The proposed screening algorithm may provide a collaborative approach to comprehensive, ED health planning focused on the equitable delivery of high-quality care to all homeless individuals while mitigating repeat hospital admissions.

Address for Correspondence: Jan Talley, PhD, MA, MSW, Kansas City University, Department of Behavioral Health, 1750 Independence Avenue, Kansas City, Missouri 64106. Email: jtalley@kansascity.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. Wright NMJ, Tompkins CNE. How can health care systems effectively deal with the major health care needs of homeless people? 2018. Available at: http://www.euro.who.int/Document/E85482.pdf. Accessed June 4, 2021.
2. United States Interagency Council on Homelessness. Home, Together: the federal strategic plan to prevent and end homelessness, 2018. Available at: https://www.usich.gov/resources/uploads/asset_ library/Home-Together-Federal-Strategic-Plan-to-Prevent-and-EndHomelessness.pdf. Accessed June 3, 2021.
3. Henry M, Mahathey A, Morrill T, et al. The 2018 Annual Homelessness Assessment Report (AHAR) to Congress, Part 1: Point-in-Time Estimates of Homelessness. 2017. Available at: https://www.wpr.org/sites/default/files/2018-ahar-part-1-compressed.pdf. Accessed June 3, 2021.
4. Henry M, Shivji A, de Sousa T, et al. The 2015 Annual Homelessness Assessment Report (AHAR) to Congress: Part 1, Point-in-Time Estimates of Homelessness. 2015. Available at: https://www.huduser.gov/portal/sites/default/files/pdf/2015-AHAR-Part-1.pdf. Accessed June 3, 2021.
5. Blonigen DM, Manfredi L, Heinz A, et al. Reducing frequent utilization of psychiatric emergency services among veterans while maintaining quality of care. *Psych Serv*. 2018;69(4):438-47.
6. Herman DB, Conover S, Gorroochurn P, et al. Randomized trial of critical time intervention to prevent homelessness after hospital discharge. *Psych Serv*, 2011;62(7):713-9.
7. Shinn M, Samuels J, Fischer SN, et al. Longitudinal impact of a family critical time intervention on children in high-risk families experiencing homelessness: a randomized control trial. *Am J Com Psychol*. 2015;56(3-4):205–16.
8. Salhi BA, White MH, Pitts SR, et al. Homelessness and emergency medicine: a review of the literature. *Acad Emer Med*. 2018;25(5):577–93.
9. O'Neill J, Tabish H, Welch V, et al. Applying an equity lens to interventions: using PROGRESS ensures consideration of socially stratifying factors to illuminate inequities in health. *J Clin Epidemiol*. 2014;67(1):56-64.
10. National Health Care for the Homeless Council: Adapted Clinical Guidelines. 2020. Available at: https://nhchc.org/research/publications/. Accessed June 4, 2021.
11. Anderson ES, Hsieh D, Alter HJ. Social emergency medicine: embracing the dual role of the emergency department in acute care and population health. *Ann Emerg Med*. 2016;68(1):21-5.
12. Moore M, Conrick KM, Reddy A, et al. From their perspective: the connection between life stressors and health care service use patterns of homeless frequent users of the emergency department. *Hlth Soc Work*. 2019;44(2):113-22.
13. Schanzer B, Dominguez B, Shrout PE, et al. Homelessness, health status, and health care use. *Am J Public Health*. 2007;97(3):464-9.
14. Marmot M. Status syndrome. *Royal Statistical Society*. 2004.
15. Wilkinson RG. (2005). *The Impact of Inequality: How to Make Sick Societies Healthier*. London: Routledge: and New York: New Press.
16. Sen A. (1992). *Inequality Reexamined*. Oxford: Oxford University Press.
17. Fogel RW. (2000). *The Fourth Great Awakening and the Future of Egalitarianism*. Chicago: University of Chicago Press.
18. Bernstein E, Bernstein J, Feldman J, et al. An evidence based alcohol screening, brief intervention and referral to treatment (SBIRT) curriculum for emergency department (ED) providers improves skills and utilization. *Subst Abus*. 2007;28(4):79-92.
19. Farmer P. (1999). *Infections and Inequalities*. University of California Press.
20. Broyles LM, Binswanger IA, Jenkins JA, et al. Confronting inadvertent stigma and pejorative language in addiction scholarship: a recognition and response. *Subst Abus*. 2014;35(3):217-21.
21. Botticelli MP. Changing the language of addiction. 2017. Available at: https://obamawhitehouse.archives.gov/sites/whitehouse.gov/files/images/Memo%20-%20Changing%20Federal%20Terminology%20Regrading%20Substance%20Use%20and%20Substance%20Use%20Disorders.pdf. Accessed June 17, 2021.
22. Gawande A. (2010). *The Checklist Manifesto: How to Get Things Right*. New York City: Metropolitan Books.
23. Pronovost PJ, Needham D, Berenholtz S, et al. An intervention to reduce catheter-related bloodstream infections in the ICU. *N Engl J Med*. 2006;355(26):2725-32.
24. Haynes AB, Weiser TG, Berry WR, et al. Surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med*. 2009;360(5):491-9.
25. Szulewski A, Howes D, van Merriënboer JJG, et al. From theory to practice: the application of cognitive load theory to the practice of medicine. *Acad Med*. 2021;96(1):24-30.
26. Shimizu T, Matsumoto K, Tokuda Y. Effects of the use of differential diagnosis checklist and general de-biasing checklist on diagnostic performance in comparison to intuitive diagnosis. *Med Teach*. 2013;35(6):e1218-1229.
27. Delanaye P, Mariat C. The applicability of eGFR equations to different populations. *Nat Rev Nephrol*. 2013;9(9):513-22.
28. Gottlieb LM, Tirozzi KJ, Manchanda R, et al. Moving electronic

medical records upstream: incorporating social determinants of health. *Am J Prev Med*. 2015;48(2):215-8.

29. Agency for Healthcare Research and Quality. Overview of the Nationwide Emergency Department Sample (NEDS). Available at: https://www.hcup-us.ahrq.gov/nedsoverview.jsp. Accessed June 29, 2021.
30. Clinical Classifications Software (CCS) for ICD-10-PCS (beta version). Healthcare Cost and Utilization Project (HCUP). 2019. Available at: www.hcup-us.ahrq.gov/toolssoftware/ccs10/ccs10.jsp. Accessed June 4, 2021.
31. 2018 National Healthcare Quality and Disparities Report. Rockville, MD: Agency for Healthcare Research and Quality; September 2019. AHRQ Pub. No. 19-0070-EF.2018 National Healthcare Quality and Disparities Report | Agency for Healthcare Research and Quality.
32. Bell N, Wilkerson R, Mayfield-Smith K, et al. Community social determinants and health outcomes drive availability of patient-centered medical homes. *Health Place*. 2021;67:102439.
33. Sun R, Karaca Z, Wong HS. Characteristics of Homeless Individuals Using Emergency Department Services in 2014. 2017. Available at: https://www.hcup-us.ahrq.gov/reports/statbriefs/sb229-Homeless-EDVisits-2014.pdf. Accessed July 16, 2021.
34. Salhi BA, White MH, Pitts SR, et al. Homelessness and emergency medicine: a review of the literature. *Acad Emer Med*. 2018;25(5):577-93.
35. Mitchell MS, León CLK, Byrne TH, et al. Cost of health care utilization among homeless frequent emergency department users. *Psychol Serv*. 2017;14(2):193-202.
36. 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.
37. Doran KM, Ragins KT, Iacomacci AL, et al. The revolving hospital door: hospital readmissions among patients who are homeless. *Med Care*. 2013;51(9):767-73.
38. Fazel S, Geddes JR, Kushel M. The health of homeless people in high-income countries: descriptive epidemiology, health consequences, and clinical and policy recommendations. *Lancet*. 2014;384(9953):1529-40.
39. Sadowski LS, Kee RA, Vander Weele 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.
40. Rinke ML, Dietrich E, Kodeck T, et al. Operation care: a pilot case management intervention for frequent emergency medical system users. *Am J Em Med*. 2012;30(2):352–7.
41. Boudreaux JG, Crapanzano KA, Jones GN, et al. Using mental health outreach teams in the emergency department to improve engagement in treatment. *Community Ment Health J*. 2016;52(8):1009-14.
42. Jones AL, Hausmann LRM, Kertesz SG, et al. Providing positive primary care experiences for homeless veterans through tailored medical homes: the Veterans Health Administration's homeless patient aligned care teams. *Med Care*. 2019;57(4):270-8.
43. Sarrazin MS and Rosenthal GE. Finding pure and simple truths with administrative data. *JAMA*. 2012;307(13):1433-5.
44. National Human Genome Research Institute. 15 ways genomics influences our world: social context. 2019. Available at: https://www.genome.gov/dna-day/15-ways/social-context. Accessed June 29, 2021.
45. Norton JM, Moxey-Mims MM, Eggers PW, et al. Social determinants of racial disparities in CKD. *J Am Soc Nephrol*. 2016;27(9):2576-95.
46. Institute of Medicine (US) Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care. (2003). Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care. Smedley BD, Stith AY, Nelson AR, editors. Washington DC: National Academies Press (US).
47. McNeely J, Wu LT, Subramaniam G, et al. Performance of the tobacco, alcohol, prescription medication, and other substance use (taps) tool for substance use screening in primary care patients. *Ann Intern Med*. 2016;165(10):690-9.
48. Bull P. Rating scales and safety measurements in bipolar disorder and schizophrenia–a reference guide. *Psychopharm Bull*. 2017;47(3):77-109.
49. Horowitz LM, Snyder DJ, Boudreaux ED, et al. Validation of the Ask Suicide-Screening Questions for adult medical inpatients: A brief tool for all ages. *Psychosom*. 2020;61(6):713-22.
50. Matza LS, Morlock R, Sexton C, et al. Identifying HAM-A cutoffs for mild, moderate, and severe generalized anxiety disorder. *Int J Methods Psychiatr Res*. 2010;19(4):223-32.
51. Differentiating moderate and severe depression using the Montgomery–Åsberg depression rating scale (MADRS), *J Aff Dis*. 2003;77(3):255-60.
52. Goertz YMJ, Looijmans M, Prins JB, et al. Fatigue in patients with chronic pulmonary obstructive disease: protocol of the Dutch multicentre, longitudinal, observational FAntasTIGUE study. *BMJ Open*. 2018;8(4):e021745.
53. Matrix Outcomes Models. Family Development Matrix. Available at: https://matrixoutcomesmodel.com/famdevmatrix.php#. Accessed October 1, 2021.
54. Posner K, Brown GK, Stanley B, et al. The Columbia-Suicide Severity Rating Scale: initial validity and internal consistency findings from three multisite studies with adolescents and adults. *Am J Psy*. 2011;168(12):1266–77.
55. Brown M, Cummings C, Lyons J, et al. Reliability and validity of the Vulnerability Index-Service Prioritization Assistance Tool (VI-SPDAT) in real-world implementation. *J Soc Dis Homeless*. 2018;27(2):110-7.
56. Emsley R, Rabinowitz J, Torreman M; RIS-INT-35 Early Psychosis Global Working Group. The factor structure for the Positive and Negative Syndrome Scale (PANSS) in recent-onset psychosis. *Schizophr Res*. 2003;61(1):47-57.
57. Pretzel E. Risk assessment tool: HIV/STD/Hepatitis-Minnesota Dept. of Health. MN Department of Health. 2016. Available at: https://health.state.mn.us/diseases/stds/riskassess/riskassess.pdf. Accessed June 4, 2021.

Novel Use of Video Logs to Deliver Educational Interventions to Black Women for Disease Prevention

Mandy J. Hill, DrPH, MPH*
Sandra Coker, MD†

*McGovern Medical School and University of Texas Health Science Center at Houston, Department of Emergency Medicine, Houston, Texas
†The University of Chicago Pritzker College of Medicine, Department of Emergency Medicine, Chicago, Illinois

Section Editor: John Ashurst, DO
Submission history: Submitted July 1, 2021; Revision received December 6, 2021; Accepted December 14, 2021
Electronically published February 28, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.12.54012

Introduction: Cisgender Black women comprise 67% of new human immunodeficiency virus (HIV) diagnoses among women in the South and are 11 times more likely to become HIV positive than White women in Texas. Optimal progress toward ending the HIV epidemic requires strategies that will interrupt transmission pathways in hotspot locations like Harris County, TX. Researchers are calling for public health interventions that can prevent HIV and sexually transmitted infections (STI) transmission; thus, we launched the first video log (vlog)-based, pilot HIV prevention intervention.

Methods: In a prospective. randomized controlled trial of two educational intervention strategies delivered as vlogs eligible participants were randomized to either 1) an interactive gaming, education-based strategy, or 2) a storytelling, education-based strategy. Eligible participants were cisgender Black women being seen in the emergency department (ED) for a non-emergent condition who reported recent condomless heterosexual sex, were ages 18-45, and had social media access. Enrolled women completed a screening assessment, informed consent, randomization, and 10-item pre-and-post assessments with true/false statements before and after viewing a brief vlog on a tablet device to identify changes in knowledge before and after being educated on HIV/STI transmission.

Results: Twenty-six women were randomized to the Taboo group, an interactive gaming, education-based strategy, (14 [53.8%]), or to storytelling, an education-based strategy using non-fictional and fictional case scenarios (12 [46.2%]). Taboo participants self-identified as African-American (12 [85.7%]), Black (1 [7.1%]) or "other" (1 [7.1%]), were younger (28.6% were ≥ 30 years), single (57.1%), reported a previous STI (8 [57.1%]), and were likely employed (57.2%). Storytelling participants self-identified as African-American (7 [58.3%]) or Black (5 [41.7%]), were older (49.9% were ≥ 30 years), in a relationship but not married (50%), and half were unemployed. Highest level of education and monthly income varied. The storytelling strategy increased knowledge in two areas and the Taboo strategy increased knowledge in one. No intervention effect was identified in three areas, and a significant decrease in knowledge ($P < .0001$) was discerned in eight areas for Taboo and six areas for storytelling.

Conclusion: Further research is necessary to confirm whether delivery of HIV prevention interventions with vlogs is a useful approach for HIV-vulnerable populations. Findings suggest that vlogs are a feasible approach to brief behavioral interventions during an ED visit. [West J Emerg Med. 2022;23(2)211–221.]

INTRODUCTION

New human immunodeficiency virus (HIV) and sexually transmitted infections (STI) are major public health problems for cisgender Black women who account for 67% of new HIV diagnoses among women in the South and STIs at a much higher rate than other women.[1-3] The emergency department

(ED) is a usual source of care for many Black women who are more likely to use the ED for primary care than others.[4,5] The ED visit provides an opportunity to engage Black women in HIV prevention. Prevention interventions for HIV have leveraged technology to facilitate education to vulnerable populations. Wingood et al led randomized controlled trials (RCT) of behavioral interventions with computer-delivered interventions for Black women to motivate behavior change with individuals and groups.[6,7,8] These interventions demonstrated efficacy with Black women; however, we need innovation to translate intervention efficacy through web-based delivery. Bond et al (2019) led an HIV prevention intervention for Black women using electronic health (eHealth) videos to offer education through culturally centered, entertainment-education health messages to increase awareness of HIV prevention methods.[9]

Our goal was to add innovation to eHealth videos with video logs (vlog). Within the last five years, researchers began to explore the utility of vlogs as a means of engaging patients,[10] testing social network interventions, and promoting healthy behavior changes.[11] Vlogs are brief videos that are developed by users and shared online through social media platforms.[11,12] Vlogs can connect peers to one another through observation of others' behavior.[11,13] Evidence affirms vlogs as a primary source of information for many Black women. Using vlogs to deliver interventions is still novel, and to our knowledge has only been used for health promotion in one other study (to increase physical activity).[11] Adapting vlogs for health education through vehicles that Black women are already using for information is a necessary addition to HIV prevention science.

This "Debunking Myths" pilot study is our first attempt at enhancing the sexual health knowledge of Black women during an ED visit. We chose myths regarding transmission pathways that were discovered through a thematic content analysis of interview transcripts of Black women who described their sexual experiences, norms, and practices.[14-16] Due to the prevalence of myths conveyed during the interviews, we designed this pilot study that uses vlogging to educate Black women on HIV/STI transmission to protect their own sexual health. The goal was for vlogs to resonate with Black women and inform healthy sexual decision-making. We hypothesized that storytelling would be more effective because it was more culturally relevant for Black women.

Population Health Research Capsule

What do we already know about this issue?
Cisgender Black women are at risk for human imunodeficiency virus (HIV) and sexually transmitted infections (STI), which warrants new prevention strategies capable of disrupting transmission patterns.

What was the research question?
Would video logs (vlog) delivered as storytelling be more effective at increasing knowledge than a question-and-answer model?

What was the major finding of the study?
Although innovative, the vlog approach did not increase knowledge on HIV and STI transmission as we hypothesized.

How does this improve population health?
Vlogging can connect with diverse audiences in a way that aligns with societal and community-based communication norms to motivate behavior change.

METHODS

Study Design

This was a prospective, comparative effectiveness RCT whereby eligible participants were recruited during an ED visit at two hospital sites. Enrolled participants were randomized (2019-2021) to either 1) an interactive gaming, education-based strategy, or 2) a storytelling, education-based strategy. Both strategies displayed a vlog on a tablet device. The primary outcome was an increase in knowledge regarding how HIV and STIs are transmitted. This study was reviewed and approved by the UTHealth Center for the Protection of Human Subjects (HSC-MS-19-0488).

Enrollment Process

Cisgender Black women were screened during an ED visit for a non-emergent condition (an acuity level of three or higher on the Emergency Severity Index scale). We recruited those who met the inclusion criteria based on the electronic health record (EHR) screening at two participating hospitals, a public hospital with a Level III trauma designation (volume: 90,000 ED visits/year) and a private hospital with a Level I trauma designation (volume: 70,0000 ED visits/year) **(Table 1).**

The entire research process, including in-person recruitment, eligibility assessment, enrollment and informed consent, randomization, pre-test, watching the vlog, and the post-test took place within 20 minutes for each participant enrolled. The Taboo vlog[17] was eight minutes and 46 seconds long. The storytelling vlog was 11 minutes and 11 seconds long. Research participants viewed the vlog during wait times of an ED visit, after they were placed in a patient room following triage and prior to discharge, transfer, or escalation of care beyond the ED.

Randomization

After we obtained consent for study participation, each woman was assigned a study identification number that linked her to study data. When a new participant was enrolled and pre-screened, the randomization button in REDCap hosted at

Table 1. Eligibility criteria of cisgender Black women.

Criteria	Description
Inclusion criteria	• Cisgender women • Race: Identified as Black or African American in the EHR • Sexual orientation: Women who have sex with cisgender men • Age: 18-45 years • Reported sexual activity in the prior three months • Presented to the ED with a non-emergent condition • Had basic understanding of how to answer survey questions on a tablet device • Had visual and comprehension capabilities
Exclusion criteria	• Cisgender Black women <18 and >45 years of age • Sexual orientation: sex with cisgender women • Had a high acuity condition • Had no technical competency on how to use a tablet device • Had limited visual and comprehension capabilities

UTHealth Science Center at Houston was selected to assign the participant to a study arm.[18,19] Randomized assignments were placed in an Excel[20] file (Microsoft Corporation, Redmond, WA) and uploaded to REDCap online software (REDCap Technologies, LLC, Fort Lauderdale, FL)[18,19] by a statistician.

Study Assessments

Participants were screened using REDCap software[18,19] accessed on a tablet device that assessed demographic, structural, environmental, and behavioral factors. Once deemed eligible and consented, participants were randomized.

Pre-test

Participants completed a pre-test using Qualtrics software (Qualtrics XM, Provo, UT).[21] The pre-test assessed baseline knowledge on HIV/STI transmission routes through presentation of 10 myths and facts as single sentences with a true/false response format.

Post-test

Following vlogs, participants completed a post-test, which was identical to the pre-test, to evaluate whether the education intervention had an effect.

Intervention Strategies

Each intervention used a distinct educational approach whereby misinformation on how HIV/STIs are transmitted was communicated first. Then, accurate information was shared in a way to correct the original misinformation.

Taboo is an interactive gaming, education-based strategy. The vlogger is dressed in casual clothes and presents information as facts followed by a surprise graphic interchange format or unexpected buzzer, which serves as a signal of misinformation. Following the sound of the buzzer, the vlogger appears with a white coat and stethoscope in the adjacent lamp shade to share accurate and factual information **(Image 1)**.

Image 1. A visual of the Taboo intervention strategy depicting communication between a healthcare physician and a Black woman.

Storytelling is an education-based strategy using non-fictional and fictional case scenarios. Storytelling involved two vloggers having a conversation in a social setting as friends **(Image 2)**. Vloggers recount scenarios in a casual manner with use of modern colloquialisms that are common to Black women. Myths regarding HIV/STI transmission were presented and refuted. This entertaining yet relatable education strategy aligned with the study aim to address a specific demographic with a culturally relevant approach.

Image 2. A visual of the storytelling intervention strategy depicting a conversation between two Black women.
Note: Image reflects actor portrayals illustrating video log communication.

Sample Size

We enrolled 26 women (14 in Taboo, 12 in storytelling). Our sample size was based on reports that 20 participants would be sufficient to determine salient beliefs.[22-24] Thus, a sample size of 26 (Figure 1) was deemed sufficient to discern changes in knowledge.

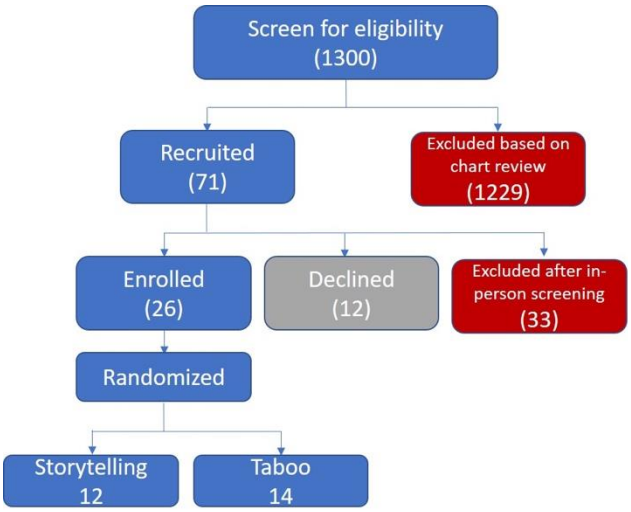


Figure 1. CONSORT* flow diagram of the participants. *Consolidated Standards of Reporting Trials.

Data Analytic Plan

We analyzed quantitative results from the assessments using SPSS statistical software (IBM Corporation, Armonk, NY).[25] The file was split by randomization group to compare the intervention effect on knowledge and discern demographic differences between participants in each group. We assessed knowledge based on responses to true/false statements using frequency analyses and Pearson's chi-squared tests with *P*-values. Incomplete data was identified and is reflected in the study findings (see Tables).

RESULTS

Demographics

Participants were asked how they self-identify by race **(Table 2)**. Taboo participants (85.7%) were more likely to self-identify as African-American than women randomized to storytelling (58.3%). One woman randomized to Taboo described her race as "other." Women randomized to Taboo were younger: 50% (7/14) were 20-24 years of age. The age differences between groups were statistically significant ($P = 0.05$). Half of participants in storytelling were single (41.7%) or in a relationship but not married (50.0%). Most women in Taboo were single (57.1%) or in a relationship, but not married (28.6%). In the storytelling cohort, the age range of the women was broader: 16.7% were 18-19 years; 25% were 25-29 years; and 33.3% were 35-40 years. Education level varied with 35.7% of participants reporting that they had completed secondary education. Most participants (57.2%) in the Taboo arm were employed either full-time or part-time. We observed variance in household income where 42.9% of participants reported a monthly income ≤ $1,000 and 35.7% reported a monthly income ≥ $2,001. Half of participants in the storytelling cohort were unemployed and reported a household income of $501-$1,500. The differences noted between groups in all categories, except for age, were not statistically significant **(Table 2)**.

Reported Behaviors

Behavioral characteristics of the women in the study sample were based on sexual experience, history of STIs, access to social media, and condomless sexual activity (Table 3). Heterosexual, condomless encounter within the prior three months was reported by 92.9% of women randomized to the Taboo study arm and 91.7% of those randomized to storytelling. Most women reported knowledge of their current HIV status as negative (78.3% in Taboo, and 91.7% in storytelling). Most women in the Taboo group (57.1%) reported a history of STI, while most women randomized to storytelling did not have a history of a STI (66.7%). All participants reported access to social media. There were no significant differences between groups regarding reported behaviors **(Table 3)**.

Assessment of Intervention's Initial Efficacy

Findings of the Taboo and storytelling interventions demonstrate that these educational strategies have preliminary efficacy at influencing perceived knowledge on how HIV/STIs are transmitted among Black women who were exposed to the intervention. The directionality of that impact revealed variance across three responses: increased knowledge; no intervention effect; or decreased knowledge (Table 4).

Increased Knowledge

The Taboo educational strategy showed preliminary effectiveness at reinforcing knowledge in area one **(Table 4)**. One participant in this study arm responded incorrectly during the true/false statement during the pre-test but responded correctly after the intervention. Conversely, the storytelling strategy increased knowledge in areas two and three **(Table 4)**. Knowledge was retained before and after the intervention among participants who responded correctly during the pre-test. Knowledge increased for one participant who responded incorrectly in area two and increased for two participants in area three. Only one participant responded incorrectly in area three during the post-test.

No Intervention Effect

The Taboo educational strategy elicited no change in knowledge before and after the intervention in areas 2–4, nor did storytelling elicit a change in knowledge (Table 4).

Decreased knowledge

There was a decrease in knowledge before and after the intervention among 11 true/false statements in both study arms.

Table 2. Demographic description of the study population (N = 26 Black women).

Study arm	Taboo (N = 14)		Storytelling (N = 12)		P-value
Categories	N	Frequency (%)	N	Frequency (%)	
Race					0.88
African American	12	85.7	7	58.3	
Black	1	7.1	5	41.7	
Other*	1	7.1			
Gender at birth					
Female	14	100	12	100	
Age					0.05
18-19 years	0	0	5	16.7	
20-24 years	7	50.0	1	8.3	
25-29 years	3	21.4	3	25.0	
30-34 years	2	14.3	1	8.3	
35-40 years	0	0	4	33.3	
40-45 years	2	14.3	1	8.3	
Relationship status					0.70
Single	8	57.1	5	41.7	
In a relationship (not married)	2	14.3	4	33.3	
Living with partner (not married)	2	14.3	2	16.7	
Married	1	7.1	1	8.3	
Separated	1	7.1	0	0	
Highest level of education completed					0.74
Some secondary	3	21.4	2	16.7	
Completed secondary	5	35.7	4	33.3	
Some university	3	21.4	5	41.7	
Completed university	2	14.3	1	8.3	
Graduate/professional school	1	7.1	0	0	
Current employment status					0.66
Full-time (30-40 hours/week)	4	28.6	4	33.3	
Part-time (<30 hours/week)	4	28.6	2	16.7	
Occasional	1	7.1	0		
Unemployed	5	35.7	6	50.0	
Current monthly household income					0.36
< $500	2	14.3	4	33.3	
$501-$1,000	4	28.6	3	25.0	
$1,001 - $1,500	1	7.1	3	25.0	
$1,501-$2,000	2	14.3	0	0	
$2,001 - $2,500	1	7.1	1	8.3	
≥ $3,001 and over	4	28.6	1	8.3	

In contrast to the increase in knowledge described above in Taboo, knowledge regarding area 1 decreased before and after the intervention for two participants who were randomized to the storytelling study arm. There was no change in knowledge among 10 participants who responded correctly prior to storytelling. The decrease in knowledge in the Taboo cohort was significant (P < .0001) in areas 5–12 (Table 4). A significant decrease in knowledge regarding the ability to prevent HIV transmission with appropriate medications among people who are HIV positive was noted (*P* =.006). Although not significant,

Table 3. Description of reported behaviors among the study cohort.

Study Arm	Taboo		Storytelling		P-value
Categories	N= 14	%	N= 12	%	
Heterosexual encounter in the prior 3 months					0.91
Yes	13	92.9	11	91.7	
No	1	7.1	1	8.3	
Missing					
Condomless sex in the prior 3 months					0.91
Yes	13	92.9	11	91.7	
Missing	1	7.1	1	8.3	
Knowledge of current HIV status					0.39
Yes	11	78.3	11	91.7	
No	3	21.4	1	8.3	
Missing					
If yes, what is your current HIV status?					
Negative	10	71.4	11	91.7	
Positive	1	7.1	0	0	
Missing	3	21.4	1	8.3	
History of an STI					0.23
Yes	8	57.1	4	33.3	
No	6	42.9	8	66.7	
Access to social media					NC
Yes	14	100	12	100	
No	0	0	0	0	

HIV, human immunodeficiency virus; *STI,* sexually transmitted infection; *NC,* not computed due to lack of variance in responses across groups.

a decrease in knowledge before and after the intervention was also identified in areas 13 and 14 (Table 4).

Among 12 participants randomized to the storytelling cohort, the decrease in knowledge before and after the intervention met a *P*-value of .00 in six areas. Those six areas match areas 7–12 described above in reference to Taboo. The decrease in knowledge in area 5 had a *P*-value of .001 and a *P*-value of .004 in area 6 (Table 4).

The findings summarized in the table suggest that both interventions had a comparable effect on decreasing HIV/STI knowledge of participants despite any demographic differences noted. Similarly, areas where a decrease in knowledge was noted (but without significance) applied to both interventions relative to knowledge in area 13 and 14. However, significance in the change of knowledge before and after the Taboo educational intervention regarding area 15 was not found in storytelling ($P = .02$).

DISCUSSION

Study findings contribute to the growing body of literature affirming the feasibility of integrating brief interventions within an ED visit.[4] The ED is an ideal clinical environment for brief interventions that promote sexual health because it offers flexibility during wait times for nonemergent conditions to engage at-risk populations and link patients to primary prevention strategies that promote health.[14,15,26-34] We pilot-tested an intervention approach in the ED using vlogging to deliver a brief educational strategy to Black women aimed at increasing their knowledge of how HIV/STIs are transmitted. Pilot study findings support a future prevention intervention aimed at promoting sexual health. To our knowledge, this is the first study to pilot-test vlogging as an educational intervention strategy for HIV/STI prevention.

Changes in knowledge by vlog educational strategy varied. Storytelling was more effective at increasing knowledge than Taboo. Similarly, a study among Black youth in Nigeria found that an educational digital storytelling intervention (EDSI) increased their perception and knowledge of HIV risk.[34] In our study, women randomized to the storytelling cohort learned or experienced reinforcement of their current knowledge on HIV/STI transmission in relation to bodily fluids, specifically semen and urine. Women randomized to the Taboo cohort learned or experienced reinforcement of their current knowledge that birth control cannot prevent STIs. When knowledge increased in one intervention, there was either a knowledge decrease or no effect in the comparable strategy.

Table 4. An evaluation of changes in knowledge between the pre- and post-intervention assessments.

Intervention strategy	Areas	Taboo (N = 14)					Storytelling (N = 12)				
True (T) / false (F) statement (correct response)			Pre-test	Post-test	X^2 test	P-value	2-sided	Pre test	Post test	X^2 test	P-value
			Knowledge increased								
If I am taking birth control, then I cannot get an STI. (F)	1	True	1	0	1.04	.31	True	-	-	-	-
		False	13	14			False	-	-	-	-
If my partner does not cum inside me, then I cannot get an STI. (F)	2	True	-	-	-	-	True	1	0	NC	
		False	-	-	-	-	False	11	12		
There is no risk of getting an STI if you urinate after having sex. (F)	3	True	-	-	-	-	True	3	1	1.20	.27
		False	-	-	-	-	False	9	11		
			No intervention effect								
If my partner does not cum inside me, then I cannot get an STI. (F)	2	True	14	14	NC		True	-	-	-	-
		False	0	0			False	-	-	-	-
There is no risk of getting an STI if you urinate after having sex. (F)	3	True	1	1	.00	1.000	True	-	-	-	-
		False	13	13			False	-	-	-	-
If I have only had sex with one person, then I cannot have an STI. (F)	4	True	0	0	NC		True	0	0	NC	
		False	14	14			False	12	12		
			Knowledge decreased								
If I am taking birth control, then I cannot get an STI. (F)	1	True	-	-	-	-	True	0	2	2.18	.14
		False	-	-	-	-	False	12	10		
If someone has HIV or an STI, I would be able to tell. (F)	5	True	1	13	20.57	.000	True	1	9		
		False	13	1			False	11	3	10.97	.001
The risk of getting a new STI is higher if I already have an STI. (T)	6	True	9	0	13.26	.000	True	9	2	8.22	.004
		False	5	14			False	3	10		
HIV and STIs can be spread through shaking hands, touching doorknobs, and sitting on toilet seats. (F)	7	True	3	13	14.58	.000	True	1	11	14.06	.000
		False	11	1			False	11	1		
Chlamydia and gonorrhea are two STI that can be treated and cured using medication. (T)	8	True	13	0	24.27	.000	True	12	1	20.31	.000
		False	1	14			False	0	11		
If my sexual partner and I both have HIV, then we do not need to use condoms. (F)	9	True	3	14	18.12	.000	True	1	11	20.33	.000
		False	11	0			False	11	0		
It is possible to have an STI without feeling sick. (T)	10	True	13	2	17.37	.000	True	12	3	14.40	.000
		False	1	12			False	0	9		

STI, sexually transmitted infection; HIV, human immunodeficiency virus; NC, not computed because the question is a constant.

Table 4. Continued.

Intervention strategy	Areas	Taboo (N = 14)					Storytelling (N = 12)				
True (T) / false (F) statement (correct response)			Pre-test	Post-test	X^2 test	P-value	2-sided	Pre test	Post test	X^2 test	P-value
Baby oil and Vaseline are good to use with a latex condom as lube. (F)	11	True	2	14	21.00	.000	True	2	12	17.14	.000
		False	12	0			False	10	0		
Condoms should be used with anal sex. (T)	12	True	12	1	19.58	.000	True	12	1	20.31	.000
		False	1	13			False	0	11		
Every STI has a cure. (F)	13	True	1	4	2.19	.139	True	1	3	1.20	.273
		False	13	10			False	11	9		
Although there is no cure for HIV, it is possible to live a long, healthy life with the help of proper medications. (T)	14	True	14	13	1.04	.309	True	12	11	1.04	.307
		False	0	1			False	0	1		
If I am HIV positive, I cannot spread HIV to my sexual partner if I am taking the right medicine. (T)	15	True	6	0	7.64	.006	True	4	0	4.80	.028
		False	8	14			False	8	12		

STI, sexually transmitted infection; HIV, human immunodeficiency virus.

The variance in vlogs' efficacy in increasing HIV/STI knowledge of transmission routes compared to other education strategies could have been influenced by differences in study design. Computer-based interventions and peer education interventions are generally found to be effective at improving HIV-related knowledge.[36] All studies included in a meta-analysis with a peer education component showed a significant increase in knowledge of HIV/STI transmission in the intervention group.[36-39] The EDSI used a RCT design that involved 16 intervention sessions with an eight-week follow-up period.[34] Sakha et al (2013) conducted a quasi-experimental study using a multimodal intervention strategy and assessed intervention effects over two months.[40] This strategy was effective at increasing general knowledge about HIV/STIs among the 80 women enrolled (P <0.001). As in our study, Sakha et al found that their health education intervention increased participants' knowledge in different aspects.[40] Another multimodal strategy that was used as an educational intervention and included a one-hour educational session demonstrated a significant increase in knowledge (28 vs 21; P <.001).[41] Our "Debunking Myths" study also used a RCT of two interventions with no control group and took place within one brief session; thus, temporality of intervention effect could not be assessed.

There were also differences in baseline knowledge among the studies. Findings of the pre-test with the EDSI revealed that participants had low HIV knowledge.[35] Conversely, the pre-test in the "Debunking Myths" study revealed that participants had a high level of HIV knowledge during the pre-test. There was a significant decrease in knowledge among participants between the pre- and post-test. This finding contradicts previous research[42] illustrating the effectiveness of peer education and storytelling strategies at increasing HIV knowledge.

Taboo participants were confident and steadfast in their HIV/STI knowledge before and after the intervention regarding knowledge that ejaculation was not required for STI transmission or urination did not prevent STI transmission. Storytelling was effective at increasing knowledge in these areas. Neither Taboo nor storytelling had an effect on participants' knowledge that their own monogamy was not effective at preventing STI transmission. This sustained knowledge suggests that the Black women enrolled in the study were aware that they were at risk for HIV/STIs despite their own monogamy. This awareness is a very important finding as lack of sexual risk awareness among Black women has been a consistent finding in the literature.[43-47] Within this sample, some Black women had an accurate perception of their risk for contracting HIV/STI risks. Neither vlog intervention strategy, Taboo or storytelling, had an impact on their confidence in that knowledge.

We hypothesized that storytelling would be superior to Taboo at increasing knowledge, but we did not expect that knowledge would decrease. Although most participants demonstrated significant HIV/STI knowledge during the pre-test, after reviewing the vlog they changed their responses. This change indicates that the vlog intervention either decreased their knowledge or decreased their confidence in their initial response prior to vlog exposure. While the humor and cultural competency of the vlog strategy was

well received by many participants, as evidenced by their laughter and verbal engagement while viewing the vlog, the casual communication style could have diluted the potential for intervention efficacy. Findings did not offer compelling evidence that vlogs increased knowledge of HIV/STIs or that they could debunk myths regarding how HIV and STIs are transmitted. Additional research is needed to identify best approaches to leverage vlogs as a health communication medium to effectively increase knowledge on HIV/STI prevention among HIV/STI vulnerable populations.

LIMITATIONS

The small sample size made it challenging to discern significant differences between the two groups before and after the intervention. This is the first time to our knowledge that a vlog was used to offer education on HIV/STI prevention, and the communication strategy we used may have prioritized cultural competency over message clarity. Additionally, there was a significant change in our staff, requiring re-training and interruptions with enrollment. We paused enrollment for 10 months during the COVID-19 pandemic to minimize risk to the research staff and the patient population. As the vast majority of research on HIV prevention educational strategies is conducted outside the US, those findings may be less applicable due to differences in culture and/or communication norms.

We should also point out that although the randomization was established by a statistician and set up with the randomization model within REDCap,[18,19] the randomization did not appear adequate given the differences in demographics between groups. Given the unbalanced sample between groups, selection bias may have occurred and led to difficulty with reproducibility of the findings in a second iteration of the study. To quantify the possible impact of this potential for selection bias, we conducted a *P*-value to discern whether the demographic differences between groups were statistically significant. We learned that the only significant difference between groups related to age. All other differences were statistically insignificant. Lastly, the primary focus of the vlog was to deliver the health information in an engaging manner that would be well received. More attention should have been focused on delivering health education in a way that was clear and readily comprehensible.

Future Research

As of April 2019, YouTube ranks as the social network site with the second highest internet traffic volume worldwide.[48-50] Black millennials reported daily YouTube use.[50] Gabarron and Wynn (2016) put forth a call to action, encouraging future researchers to conduct more in-depth studies using social media to promote sexual education to create evidence supporting the efficacy of this medium.[51] There is potential for using vlogs for peer education, which has been established as one of the most effective intervention strategies,[36] through a YouTube channel as an avenue to refute common misconceptions about the transmission of HIV/STIs. Importantly, HIV education interventions tend to increase opportunities for subsequent behavior changes that promote health and prevention of disease transmission when implemented together with behavioral change strategies.[36,52] Given those findings, it is pertinent to develop and implement research that connects vlogs to strategies that motivate changes in behavior. Future research using vlogs may benefit from a larger sample size and additional adjusted analyses to contribute findings capable of reproducibility. Leveraging social media influences as behavioral scientists develop interventions is vital, now and in the future.

CONCLUSION

Leveraging vlogs to test innovative ways of providing sexual health education in a culturally competent manner for Black women has not been readily adopted within clinical or public health practice. We used actors who reflected the target audience in terms of race, gender, and colloquialism as the communication method in an effort to enhance cultural relevance with the intervention's content. This model can be built upon to design and implement innovative intervention strategies that connect with the audience in a way that aligns with societal and community-based communication norms.

This research was presented at the following conferences:
2018 The National Medical Association Annual Meeting, Orlando, FL
2019 The 12th Health Disparities Conference, New Orleans, LA
2019 The College on Problems of Drug and Alcohol Dependence Annual Meeting, San Antonio, TX
2019 The 11th International Women's and Children's Health and Gender (InWomen's) Group Conference, San Antonio, TX
2020 The Black Maternal Health Summit, Houston, TX
2020 The National Conference for HIV, HCV, STI, and LGBTQ Health, Virtual.
2021 Biomedical HIV Prevention Summit, Virtual
2021 Seminar Series on Health Disparities at the University of Houston College of Pharmacy
2021 The Annual Biomedical Research Conference for Minority Students (ABRCMS)
2021 The National Sexual Health Conference

Address for Correspondence: Mandy J. Hill, DrPH, McGovern Medical School, Department of Emergency Medicine, 6431 Fannin JJL 475G, Houston, TX 77030. Email: mandy.j.hill@uth.tmc.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. Centers for Disease Control and Prevention. HIV and African American women. 2015. Available at: https://www.cdc.gov/healthcommunication/toolstemplates/entertainmented/tips/hivwomen.html. Accessed June 9, 2017.
2. Coker S, Hill M, Stotts A. Leveraging the emergency department visit to debunk myths on HIV risks among substance-using African American women. The College on Problems of Drug and Alcohol Dependence Annual Meeting; 2019; San Antonio, TX.
3. Prather C, Fuller TR, Jeffries WLt, et al. Racism, African American women, and their sexual and reproductive health: a review of historical and contemporary evidence and implications for health equity. *Health Equity.* 2018;2(1):249-59.
4. Hill M, Flash C, Heads A, et al. PrEP Education and awareness building through an intervention for African-Americans reporting both condomless sex and substance use during an emergency department visit. *J AIDS Clin Res Sex Transm Dis.* 2020;7(028):100028.
5. University of Texas Health Science Center at Houston McGovern Medical School. Hospital Profiles. 2016. Available at: https://med.uth.edu/emergencymedicine/education/residency/facilities. Accessed March 24, 2016.
6. Centers for Disease Control and Prevention. Compendium of Evidence-Based HIV Prevention Interventions. 2008. Available at: https://www.cdc.gov/hiv/research/interventionresearch/compendium/index.html. Accessed April 8, 2009.
7. Wingood GM, Card JJ, Er D, et al. Preliminary efficacy of a computer-based HIV intervention for African-American women. *Psychol Health.* 2011;26(2):223-34.
8. Card JJ, Kuhn T, Solomon J, et al. Translating an effective group-based HIV prevention program to a program delivered primarily by a computer: methods and outcomes. *AIDS Educ Prev.* 2011;23(2):159-74.
9. Bond KT, Ramos SR. Utilization of an animated electronic health video to increase knowledge of post- and pre-exposure prophylaxis for HIV among African American women: nationwide cross-sectional survey. *JMIR Form Res.* 2019;3(2):e9995.
10. Lee JL, Frey M, Frey P, et al. Seeing is engaging: vlogs as a tool for patient engagement. *Patient.* 2017;10(3):267-70.
11. Van Woudenberg TJ, Bevelander KE, Burk WJ, et al. Testing a social network intervention using vlogs to promote physical activity among adolescents: a randomized controlled trial. *Front Psychol.* 2019;10:2913.
12. Gao W, Tian Y, Huang T, et al. Vlogging: a survey of videoblogging technology on the web. *ACM Comput Surv.* 2010;42:1-57.
13. Montgomery SC, Donnelly M, Bhatnagar P, et al. Peer social network processes and adolescent health behaviors: a systematic review. *Prev Med.* 2020;130:105900.
14. Hill M, Andrews S. Evolution of the sexual script: insight into sexual decision making among young African American women. *J Gen Emerg Med.* 2017;2(4):1-15.
15. Hill M, Granado M, Villarreal Y, et al. Predictors of sexual scripts among young, sexually-active, substance-using African American women. *J AIDS Clin Res.* 2017;8(1):655.
16. Hill M, Andrews S, Granado M, et al. 'Just': An indicator of minimized value of the sexual act. *HIV AIDS Res J.* 2018;1(2):1-9.
17. Hasbro, Inc. Taboo board game. Pawtucket, RI.
18. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: building an international community of software platform partners. *J Biomed Inform.* 2019;95:103208.
19. 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.
20. Microsoft Corporation. Microsoft Excel. 2018. Available at: https://office.microsoft.com/excel. Accessed January 26,2021.
21. *Qualtrics* [computer program]. Provo, Utah, USA2020.
22. Fishbein M, Ajzen I. (2010) *Predicting and Changing Behavior: The Reasoned Action Approach.* New York:Psychology Press.
23. Yzer M. (2012). The integrated model of behavioral prediction as a tool for designing health messages. In: Cho H, ed. *Health Communication Message Design: Theory and Practice.* New York:Sage Publications.
24. Glanz K, Rimer BK, and Viswanath K. (2008). *Health Behavior and Health Education: Theory, Research, and Practice.* 4th ed. San Francisco:Jossey Bass.
25. IBM Corp. (2017). *IBM SPSS Statistics for Windows*. Armonk, NY:IBM Corp. Retrieved from https://hadoop.apache.org.
26. Hill M, Grimes R. A pilot study assessing whether African American women visiting the emergency department give different answers than an anonymous, internet-based population. *Emer Med Health Care.* 2014;5.
27. Hill M, Granado M, Peters R, et al. A pilot study on the use of a smartphone application to encourage emergency department patients to access preventive services: human papillomavirus vaccine as an example. *Emergency Medicine and Health Care.* 2013;1:4.
28. Hill M, Hu N, Granado M, et al. Review of sexual risk with HIV negative women tested in an emergency department. *Am J Health Stud.* 2014;29(4):279-86.
29. Hill M, Granado M, Montealegre J. Examining predictors of willingness to receive the catch-up HPV vaccine among age-eligible African American Women. *EC Anaesthesia.* 2015;2(3):113-22.
30. Hill M, Hudson T, Gilmore-Thomas A, et al. Linking patients with substance misuse to an outpatient substance use treatment program from the emergency department visit. The College on Problems of Drug Dependence, Inc. Annual Meeting; 2020; Virtual.
31. McGinnes RA, Hutton JE, Weiland TJ, et al. Review article: effectiveness of ultra-brief interventions in the emergency department to reduce alcohol consumption: a systematic review. *Emerg Med Australas.* 2016;28(6):629-40.
32. Balbi AM, Gak AE, Kim ES, et al. Brief motivational interviewing for substance use by medical students is effective in the emergency department. *J Emerg Med.* 2019;57(1):114-7.
33. Imtiaz S, Roerecke M, Kurdyak P, et al. Brief interventions for

cannabis use in healthcare settings: systematic review and meta-analyses of randomized trials. *J Addict Med.* 2020;14(1):78-88.

34. Elzerbi C, Donoghue K, Boniface S, et al. Variance in the efficacy of brief interventions to reduce hazardous and harmful alcohol consumption between injury and noninjury patients in emergency departments: a systematic review and meta-analysis of randomized controlled trials. *Ann Emerg Med.* 2017;70(5):714-23.e713.
35. Ofoegbu TO, Otu MS, Christopher I, et al. Impact of an educational digital storytelling intervention on HIV risk perception among Nigerian adolescents. *J Int Med Res.* 2020;48(1):300060519854635.
36. Faust L, Yaya S. The effect of HIV educational interventions on HIV-related knowledge, condom use, and HIV incidence in sub-Saharan Africa: a systematic review and meta-analysis. *BMC Public Health.* 2018;18(1):1254.
37. Osagbemi MO, Joseph B, Adepetu AA, et al. Culture and HIV/AIDS in Africa: promoting reproductive health in light of spouse-sharing practice among the Okun people, Nigeria. *World Health Popul.* 2007;9(2):14-25.
38. Adeomi AA, Adeoye OA, Asekun-Olarinmoye EO, et al. Evaluation of the effectiveness of peer education in improving HIV knowledge, attitude, and sexual behaviours among in-school adolescents in Osun State, Nigeria. *AIDS Res Treat.* 2014;2014:131756.
39. Abu-Saeed MB, Abu-Saeed K. Attitudinal changes using peer education training in the prevention of HIV/AIDS: a case study of youths in North Central Nigeria. *Adv Pharm Bull.* 2013;3(1):45-50.
40. Sakha MA, Kazerooni PA, Lari MA, et al. Effect of an educational intervention on knowledge, attitudes and preventive behaviours related to HIV and sexually transmitted infections in female sex workers in southern Iran: a quasi-experimental study. *Int J STD AIDS.* 2013;24(9):727-35.
41. Khawcharoenporn T, Srirach C, Chunloy K. Educational interventions improved knowledge, attitude, and practice to prevent HIV infection among HIV-negative heterosexual partners of HIV-infected persons. *J Int Assoc Provid AIDS Care.* 2020.
42. Smith JA, Sharma M, Levin C, et al. Cost-effectiveness of community-based strategies to strengthen the continuum of HIV care in rural South Africa: a health economic modelling analysis. *Lancet HIV.* 2015;2(4):e159-68.
43. Hill LM, Lightfoot AF, Riggins L, et al. Awareness of and attitudes toward pre-exposure prophylaxis among African American women living in low-income neighborhoods in a Southeastern city. *AIDS Care.* 2021;33(2):239-43.
44. Napper LE, Fisher DG, Reynolds GL. Development of the perceived risk of HIV scale. *AIDS Behav.* 2012;16(4):1075-83.
45. Nunn A, Zaller N, Cornwall A, et al. Low perceived risk and high HIV prevalence among a predominantly African American population participating in Philadelphia's Rapid HIV testing program. *AIDS Patient Care STDS.* 2011;25(4):229-35.
46. Nydegger LA, Dickson-Gomez J, Ko Ko T. A longitudinal, qualitative exploration of perceived HIV risk, healthcare experiences, and social support as facilitators and barriers to PrEP adoption among Black women. *AIDS Behav.* 2020.
47. Hill M, Granado M, Stotts A. Theoretical implications of gender, power, and sexual scripts for hiv prevention programs aimed at young, substance-using African-American women. *J Racial Ethn Health Disparities.* 2017;4(6):1175-80.
48. Statista Research Department. Most popular social networks worldwide as of July 2021, ranked by number of active users (in millions). 2021. Available at: https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/. Accessed August 18, 2021.
49. Statista Research Department. Percentage of U.S. internet users who use YouTube as of 3rd quarter 2020, by age group. 2021. Available at: https://www.statista.com/statistics/296227/us-youtube-reach-age-gender/ Accessed August 18, 2021.
50. Statista Research Department. Percentage of millennials in the United States who use YouTube at least once a day as of June 2015, by ethnicity. 2016. Available at: https://www.statista.com/statistics/610624/us-millennials-using-youtube-by-ethnicity/. Accessed August 18, 2021.
51. Gabarron E, Wynn R. Use of social media for sexual health promotion: a scoping review. *Glob Health Action.* 2016;9:32193.
52. Wamoyi J, Mshana G, Mongi A, et al. A review of interventions addressing structural drivers of adolescents' sexual and reproductive health vulnerability in sub-Saharan Africa: implications for sexual health programming. *Reprod Health.* 2014;11:88.

Prehospital Translation of Chest Pain Tools (RESCUE Study): Completion Rate and Inter-rater Reliability

Anna C. Snavely, PhD*†
Simon A. Mahler, MD, MS*‡
Nella W. Hendley, MD, MA*
Nicklaus P. Ashburn, MD*
Brian Hehl, MHS§
Jordan Vorrie, DO§
Matthew Wells, MD§
R. Darrel Nelson, MD*
Chadwick D. Miller, MD, MS*
Jason P. Stopyra, MD, MS*

*Wake Forest School of Medicine, Department of Emergency Medicine, Winston-Salem, North Carolina
†Wake Forest School of Medicine, Department of Biostatistics and Data Science, Winston- Salem, North Carolina
‡Wake Forest School of Medicine, Departments of Implementation Science and Epidemiology and Prevention, Winston-Salem, North Carolina
§Cape Fear Valley Health, Department of Emergency Medicine, Fayetteville, North Carolina

Section Editor: Julian Mapp, MD, MBA, MPH
Submission history: Submitted March 2, 2021; Revision received July 19, 2021; Accepted September 20, 2021
Electronically published January 18, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.9.52325

Introduction: Chest pain is a common reason for ambulance transport. Acute coronary syndrome (ACS) and pulmonary embolism (PE) risk assessments, such as history, electrocardiogram, age, risk factors (HEAR); Emergency Department Assessment of Chest Pain Score (EDACS); Pulmonary Embolism Rule-out Criteria (PERC); and revised Geneva score, are well validated for emergency department (ED) use but have not been translated to the prehospital setting. The objectives of this study were to evaluate the 1) prehospital completion rate and 2) inter-rater reliability of chest pain risk assessments.

Methods: We conducted a prospective observational cohort study in two emergency medical services (EMS) agencies (April 18, 2018 – January 2, 2019). Adults with acute, non-traumatic chest pain without ST-elevation myocardial infarction or unstable vital signs were accrued. Paramedics were trained to use the HEAR, EDACS, PERC, and revised Geneva score assessments. A subset of patients (a priori goal of N = 250) also had the four risk assessments completed by their treating clinicians in the ED, who were blinded to the EMS risk assessments. Outcomes were 1) risk assessments completion rate and 2) inter-rater reliability between EMS and ED assessments. An a priori goal for completion rate was set as >75%. We computed kappa with corresponding 95% confidence intervals (CI) for each risk assessment as a measure of inter-rater reliability. Acceptable agreement was defined a priori as kappa ≥ 0.60.

Results: During the study period, 837 patients with acute chest pain were accrued. The median age was 54 years, interquartile range 43-66, with 53% female and 51% Black. Completion rates for each risk assessment were above goal: the HEAR score was completed on 95.1% (796/837), EDACS on 92.0% (770/837), PERC on 89.4% (748/837), and revised Geneva score on 90.7% (759/837) of patients. We assessed agreement in a subgroup of 260 patients. The HEAR score had a kappa of 0.51 (95% CI, 0.41-0.61); EDACS was 0.60 (95% CI, 0.49-0.72); PERC was 0.71 (95% CI, 0.61-0.81); and revised Geneva score was 0.51 (95% CI, 0.39-0.62).

Conclusion: The completion rate of risk assessments for ACS and PE was high for prehospital field personnel. The PERC and EDACS both demonstrated acceptable agreement between paramedics and clinicians in the ED, although assessments with better agreement are likely needed. [West J Emerg Med. 2022;23(2)222–228.]

INTRODUCTION

Chest pain is the second most common reason patients come to the emergency department (ED) and accounts for 7-9 million patient visits to EDs in the United States every year.[1,2] Many of these patients are transported by emergency medical services (EMS) and represent about 6-16% of prehospital patient encounters.[3-7] Chest pain can signal life-threatening pathologies such as acute coronary syndrome (ACS) or pulmonary embolism (PE), or low-risk causes that do not need immediate intervention. Risk scores and care algorithms, such as the HEART pathway (history, electrocardiogram, age, risk factors, and troponin), are well-validated and commonly used in the ED to risk-stratify patients with chest pain.[8-11] Although prehospital personnel have experience using algorithms as part of the evaluation of patients with trauma and strokes, chest pain risk-stratification tools have yet to be adopted in the prehospital setting.[12-15]

In a recent study, a modified prehospital HEART pathway used by paramedics demonstrated high negative and positive predictive value for adverse cardiac events. In that study, paramedics had access to point-of-care troponin measurement in the field and incorporated those results into their risk assessments.[16] Currently, however, EMS use of point-of-care troponin in the US is limited to research studies.[16,17] Thus, prehospital chest pain risk-stratification tools that do not require troponin measurement are needed. In addition, prehospital chest pain risk-stratification has been limited thus far to concern for acute coronary syndrome (ACS) and has ignored other life-threatening causes such as pulmonary embolism (PE).

Several candidate-risk assessments for both ACS and PE that do not require troponin results exist but have yet to be validated or compared in the prehospital setting. The HEAR (history, electrocardiogram, age, risk factors) score is an abridged version of the HEART pathway that is used to establish risk of major adverse cardiac events in patients with chest pain prior to or without troponin measurement. The ED Assessment of Chest Pain Score (EDACS) is another internationally validated tool for ACS that does not require troponin measurement.[9] For the assessment of PE risk, the revised Geneva score risk-stratifies patients using risk factors, symptoms, and clinical signs to categorize patients as low, intermediate, and high probability.[11] Pulmonary Embolism Rule-out Criteria (PERC) use eight variables to rule out PE in patients with a low pretest probability for PE.[10]

These chest pain risk-stratification tools have improved patient care in the ED, and their use could do the same in the prehospital setting by helping inform treatment and destination protocols. Furthermore, if very low-risk patients could be identified in the prehospital setting, these patients could avoid unnecessary transport to the ED. However, it is currently unclear which of these risk assessments, if any, are well suited for prehospital adoption. Therefore, the objectives of this study were to 1) evaluate the paramedic completion rate of each risk assessment and 2) evaluate the inter-rater reliability of the risk assessments between paramedics and clinicians in the ED.

Population Health Research Capsule

What do we already know about this issue?
Chest pain is a common, high-stakes reason to call 911, but risk stratification tools have yet to be adopted in the prehospital setting.

What was the research question?
What is the completion rate and inter-rater reliability of chest pain risk assessments between paramedics and clinicians in the emergency department?

What was the major finding of the study?
While the completion rate of chest pain risk assessments was high, assessments with better agreement are likely needed.

How does this improve population health?
The incorporation of objective risk-stratification tools is feasible and may impact patient safety and system efficiency once incorporated into patient care protocols.

METHODS

Design

This prospective, observational cohort study investigated four rapid risk-stratification tools to assess chest pain in the prehospital setting at two EMS agencies. The study was conducted over 8.5 months (April 18, 2018 – January 2, 2019). Participants were prospectively accrued under a waiver of informed consent. The study was approved by the institutional review board and registered with clinicaltrials.gov (NCT03494556). We used the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) statement as a guide for reporting this observational study.

Setting

The study was conducted by paramedics of two county EMS agencies in North Carolina with annual call volumes of approximately 75,000 and 14,000. These county-based agencies run paramedic/emergency medical technician crews and transport a majority of their patients to a single, tertiary medical center that provides regional coronary intervention capabilities. The agencies had prior experience with EMS process improvement projects and were partnered with a large, tertiary medical center. The individual EMS agencies shared a similar electronic health record (EHR) platform and quality assurance staff. Access to this system as well as to the medical system inpatient and outpatient EHR were readily available to EMS managerial staff for data collection.

Population

Patients included in this study were at least 21 years old with acute, non-traumatic chest pain without ST-elevation myocardial infarction (STEMI) who were transported by ground EMS to a local ED. We excluded interfacility transports and patients with unstable vital signs (systolic blood pressure <90 millimeters mercury, heart rate >120 or <40, oxygen saturation <90% on room air or normal home oxygen flow rate).

Risk Assessments

A total of 166 paramedics were trained to calculate the HEAR, EDACS, revised Geneva score, and PERC risk assessments. The HEAR and EDACS scores were chosen for their effectiveness and widespread use throughout US EDs. The PERC and revised Geneva score were selected because they are objective, simple, and do not require the paramedic to make diagnostic decisions, which would be outside their scope of practice. Paramedic training sessions included a two-hour, in-person orientation that reviewed ACS and PE pathophysiology, risk factors, and classic presentation characteristics. This was followed by inclusion and exclusion criteria and a description of the HEAR, EDACS, revised Geneva score, and PERC risk assessments and how they are used. The last part of the orientation was the application of assessments in multiple case- study simulations. The opportunity to review self-learning modules was made available to the paramedics throughout the study period. Training was completed one week prior to the start of recruitment. To complete risk assessments, paramedics used a standardized, one-page double-sided, data collection template with the risk assessments listed in the following order: HEAR score; EDACS score; revised Geneva score; and PERC risk assessment (Appendix 1). Prehospital risk assessments were not used to alter patient treatment or destination decisions. For a subset of patients (convenience sample), the emergency clinician also completed the four risk-stratification tools on a separate, but identical, standardized data collection form. Clinicians in the ED were blinded to EMS risk assessments. A sample size of 250 was chosen for the assessment of inter-rater reliability between EMS and ED assessments.

Outcome Measures

The primary outcome was risk-assessment completion rate in all patients enrolled, and the secondary outcome was inter-rater reliability between EMS and ED assessments in the subset of patients where both assessments were collected. Based on prior experiences, EMS administrators set a goal to complete decision tools in >75% of eligible patients. Prehospital stroke scale assessments have been in use for many years and have completion rates of approximately 95%; thus, 75% was a reasonable estimate.[18] However, while paramedics were encouraged to complete the decision aids, they were not informed of the 75% completion goal. Intermittent correspondence and in-person reminders were communicated to field personnel during the study period to encourage risk-assessment completion. To evaluate agreement between the paramedic and ED assessments, we calculated risk assessments based on the final scores recorded by the paramedic and the clinician in the ED for HEAR, EDACS and revised Geneva score. For PERC, the recorded risk assessment was used since there was no final score.

Statistical Analyses

This study was designed to obtain precise estimates of completion rates (primary) and inter-rater reliability (secondary). With a total sample size of 800, the maximum half-width of an exact 95% confidence interval (CI) for completion rate was 0.035. In other words, each completion rate could be estimated +/- 3.5%. For a planned sample size of 250 with both EMS and ED assessments, and for an expected kappa ≥ 0.6, the maximum half-width of the 95% CI was 0.1 (ie, kappa could be estimated +/- 0.1). We estimated completion rates for each tool using the total number enrolled as the denominator and the number with a complete final score (HEAR, EDACS, revised Geneva) or risk assessment (PERC) as the numerator. Each tool's completion rate was reported along with an exact 95% CI. We compared completion rates between the two ACS tools (HEAR and EDACS) and between the two PE tools (revised Geneva score and PERC) using chi-square tests.

To evaluate agreement between paramedic and emergency clinician, we categorized each assessment as low risk or non-low risk. For HEAR, a score of 0-3 was considered low risk, for EDACS, a score of less than 16 was considered low risk, and for revised Geneva, a score of 0-3 was considered low risk. For PERC, a patient was considered low risk if he or she met all the rule-out criteria. We evaluated agreement using both the kappa statistic and raw agreement. Acceptable agreement between the emergency clinician and paramedic was defined a priori as kappa ≥ 0.60. Both statistics were reported along with 95% CIs. We also used raw agreement to evaluate the agreement of individual components of each tool.

RESULTS

During the study period, a total of 837 patients with acute chest pain were accrued. The median age was 54 years, interquartile range (IQR) 43-66, with 53% female and 51% Black. A final score was completed on 95.1% of patients (796/837) for HEAR, on 92.0% (770/837) for EDACS, and on 90.7% (759/837) for revised Geneva score (Figure 1). For PERC a final risk assessment was completed on 89.4% (748/837) of patients. All completion rates exceeded the benchmark of 75%. Confidence intervals for each completion rate are provided in Table 1. When comparing the two ACS tools, a final score was completed more often for HEAR than EDACS (95.1% vs 92.0%, $P = 0.01$). Revised Geneva score and PERC had similar rates of completion for the assessment of PE (89.4% vs 90.7%, $P = 0.4$).

A total of 260 patients (31.1%; 260/837) were accrued who had assessments by both EMS and clinicians in the ED. In this subgroup the median age was 54 years (IQR 44-65), with 50% male and 52% Black, similar to the total enrolled population.

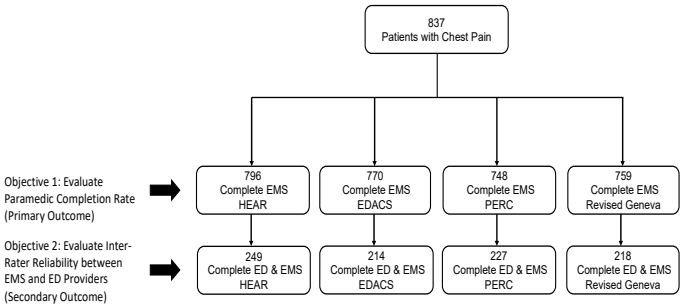


Figure 1. Study flow diagram.
ED, emergency department; *EMS,* emergency medical services; *HEAR,* history, electrocardiogram, age, risk factors; *EDACS,* Emergency Department Assessment of Chest Pain Score; *PERC,* Pulmonary Embolism Rule-Out Criteria.

Table 1. Prehospital completion rates for each chest pain risk-stratification tool (N = 837).

Risk stratification tool	Paramedic final score % complete (95% CI)
HEAR	95.1% (93.4-96.5%)
EDACS	92.0% (89.9-93.7%)
PERC	89.4% (87.1-91.4%)
Revised Geneva Score	90.7% (88.5-92.6%)

HEAR, history, electrocardiogram, age, risk factors; *EDACS,* emergency department assessment of chest pain score; *PERC,* pulmonary embolism rule-out criteria; *CI,* confidence interval.

Based on kappa, agreement between the paramedic and the emergency clinician was acceptable for EDACS (0.60; 95% CI, 0.49-0.72) and PERC (0.71; 95% CI, 0.61-0.81). However, agreement for HEAR (0.51; 95% CI, 0.41-0.61) and the revised Geneva score (0.51; 95% CI, 0.39-0.62) fell below the a priori definition of acceptability (0.6). Raw agreement was above 75% for all tools (Table 2). Cross-classification tables for EMS and ED assessments for each risk stratification tool are presented in Appendix 2. Raw agreement for each component of each ACS tool is presented in Table 3, and results for the PE tools are presented in Table 4.

DISCUSSION

This study demonstrates that paramedics achieve high completion rates for chest pain risk-stratification tools, which suggests that implementation of these tools in the prehospital setting is highly feasible. Completion rates for HEAR, EDACS, revised Geneva score, and PERC risk assessments were all significantly higher than the 75% benchmark set a priori. The final score was completed more often for HEAR than EDACS, but this may have been the result of HEAR being the first risk-stratification tool on the data collection template. The HEAR score template used in this study is the longest score and built to improve objectivity, but this may have negatively impacted completion rate of the other scores. Completion rates of over 90% have been published within large ED cohorts.[8] While completion rates over 75% are good, this rate would also likely increase once the risk score was included in protocol and directed clinical decision-making. In addition, the use of objective risk-stratification tools would further increase once standard treatment protocols change, quality improvement processes are initiated, and the paradigm of chest pain evaluation is shifted to rely on the use of risk-stratification tools.

In terms of agreement between EMS and clinicians in the ED, there was higher inter-rater reliability for EDACS and PERC (both meeting the bar of kappa ≥ 0.6), but agreement was less than acceptable for the HEAR and revised Geneva

Table 2. Comparing emergency medical services (EMS) and emergency department assessments.

Risk stratification tool	Kappa (95% CI)	Raw agreement (95% CI)
HEAR (N = 249)	0.51 (0.41-0.61)	75.9% (70.1-81.1%)
EDACS (N = 214)	0.60 (0.49-0.72)	83.6% (78.0-88.4%)
Revised Geneva score (N = 218)	0.51 (0.39-0.62)	77.1% (70.9-82.5%)
PERC (N = 227)	0.71 (0.61-0.81)	87.7% (82.7-91.6%)

HEAR, history, electrocardiogram, age, risk factors; *EDACS,* Emergency Department Assessment of Chest Pain Score; *PERC,* Pulmonary Embolism Rule-Out Criteria; *CI,* confidence interval.

Table 3. Raw agreement for components of the acute coronary syndrome tools.

Component	Raw agreement (95% CI)
HEAR	
History	49.6% (43.2-56.0%)
ECG	53.1% (46.6-59.6%)
Age	90.3% (85.7-93.7%)
Risk factors	61.6% (55.2-67.8%)
EDACS	
Age	93.4% (89.2-96.4%)
Gender	92.6% (88.1-95.8%)
Age 18-50 and known CAD or 3+ risk factors	69.5% (62.8-75.7%)
Diaphoresis	82.4% (76.5-87.3%)
Pain radiates to arm or shoulder	75.7% (69.3-81.4%)
Pain occurred or worsened with inspiration	78.5% (72.3-83.8%)
Pain is reproduced by palpation	80.5% (74.5-85.6%)

HEAR, history, electrocardiogram, age, risk factors; *ECG,* electrocardiogram; *EDACS,* Emergency Department Assessment of Chest Pain Score; *CAD,* coronary artery disease; *CI,* confidence interval.

Table 4. Raw agreement for components of the pulmonary embolism tools.

Component	Raw agreement (95% CI)
PERC	
Age ≥ 50	95.6% (92.0-97.8%)
Heart rate ≥ 100 at any time	82.6% (77.0-87.3%)
Pulse oximetry on room air < 95% with good waveform	92.0% (87.6-95.2%)
Unilateral leg swelling	98.2% (95.5-99.5%)
Hemoptysis	98.7% (96.1-99.7%)
Recent surgery or trauma	99.1% (96.8-99.9%)
Prior PE or DVT	97.3% (94.2-99.0%)
Estrogen use	99.6% (97.5-100%)
Revised Geneva score	
Age > 65	94.5% (90.6-97.1%)
Previous PE or DVT	95.0% (91.2-97.5%)
Surgery under general anesthesia or lower limb fracture in the past month	97.7% (94.7-99.3%)
Cancer condition: current or considered cured within 1 year	97.3% (94.1-99.0%)
Unilateral lower limb pain	99.1% (96.7-99.9%)
Hemoptysis	98.2% (95.4-99.5%)
Heart rate	69.1% (62.5-75.2%)
Tenderness of lower limb deep-venous palpation AND unilateral edema	99.5% (97.4-100%)

PERC, Pulmonary Embolism Rule-out Criteria; *PE,* pulmonary embolism; *DVT,* deep venous thrombosis; *CI,* confidence interval.

scores. When looking more closely at the ACS tools, agreement was fairly low for the history, ECG and risk factors components of the HEAR tool. The EDACS component that evaluates age in conjunction with either CAD or ≥ 3 risk factors showed low agreement as well. These components were all compound assessments, which likely negatively impacted agreement. Thus, it stands to reason that a tool that uses more single-answer assessments would provide improved agreement between healthcare personnel.

When developing or testing a risk-stratification tool, replicability is important. Training is frequently blamed when poor agreement is found, and this may be the case for ECG assessment within the HEAR score where agreement was only 53.1%. Interpretation of ECG is critical when evaluating patients for possible ACS. When paramedics completed the "E" part of the HEAR score, 64% gave a score of 0 (normal), whereas only 30% of clinicians in the ED gave a score of 0, suggesting that paramedics may be missing important ECG findings. This may be a result of a paramedic's lack of experience differentiating acute ischemia from both non-specific and normal ECG tracings. Historically, paramedics receive rather focused training on the identification of STEMI, and there is very little emphasis on detecting more subtle ECG findings. The ability to use the HEAR score would be improved with additional training on ischemic and non-specific ECG findings. Alternatively, simplifying interpretations of ECGs into three categories – STEMI, abnormal but not a STEMI, and totally normal – could lead to improved inter-rater agreement.

For the two PE assessment tools, agreement was very strong for all of the components with the exception of heart rate. Agreement was higher for PERC where assessment of heart rate is yes/no (heart rate ≥ 100 at any time) than for the revised Geneva score where heart rate falls into three categories (<75, 75-94, > 95). This finding further supports the conclusion that single questions have better agreement when compared to compound or multiple category parts.

This study is an important first step in evaluating the prehospital use of objective, chest pain risk- stratification tools. The paradigm shift is dependent on completeness rates and agreement. They are important metrics to predict the ability to implement decision-aid use into clinical processes. Agreement between different categories of healthcare personnel has historically been poor.[19,20] Our data is consistent with these findings. However, this should not limit the use of the tools but rather challenge us to adapt training or the tools themselves to improve agreement.

LIMITATIONS

This study has several limitations. First, it is a prospective study that used a convenience sample for both the overall population enrolled and the subset with both ED and EMS assessments, which may have resulted in a selection bias. Information was not available on EMS calls where patients were not accrued to the study. The design included two EMS services that transported patients to a single medical center. Thus, the results of this study may not be generalizable to chest pain in other EMS systems or patients presenting to other institutions. It should be noted that our study design included two risk tools for ACS and two for PE. This was "double work" for our paramedics and likely negatively impacted completeness. The time to complete the assessments was not collected. A more pragmatic study would have selected one tool for ACS and one for PE and allowed them to inform clinical decisions.

Additionally, the order in which the tools were included in the data collection template completed by paramedics may have impacted completion rates. Agreement was compared between the paramedic and the emergency clinician, but no formal risk assessment training was provided for the clinicians. They likely were not experts in the use of these risk-assessment tools as there was no uniform tool or protocol to establish their use prior to this study. The assessments completed in the ED were assumed to be the most accurate as there was no gold standard exam for comparison, which impacts reliability and validity of paramedic assessments. Finally, the assessments performed by EMS and

emergency clinicians were not done simultaneously. Patients frequently will provide different answers when questions are asked in different ways by different people at different times.

CONCLUSION

High rates of completion of chest pain risk-stratification tools among paramedics in their usual patient care workflow suggest that decision-aid implementation is highly feasible. This is the first step in a paradigm shift in prehospital healthcare to empower objective decision-making in the care of patients with chest pain. The PERC and EDACS risk scores both had acceptable agreement between paramedics and clinicians in the ED based on the a priori definition of kappa ≥ 0.6. However, there is certainly room for improvement in agreement. Improvement may be achieved by modification of existing tools or a new prehospital tool that incorporates binary objective measures in the evaluation of both ACS and PE, as agreement was much better for simple objective criteria as compared to compound or subjective criteria. Further study is needed to evaluate the performance of these risk stratification tools and how they impact patient safety and system efficiency once incorporated into patient care protocols.

Address for Correspondence: Anna C. Snavely, PhD, Wake Forest School of Medicine, Department of Emergency Medicine, Medical Center Boulevard, Winston-Salem, North Carolina 27157. Email: asnavely@wakehealth.edu.

Conflicts of Interest: By the WestJEM 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. The abstract from this analysis was accepted for presentation at the Society of Academic Emergency Medicine Annual Meeting in 2020. This study was funded by the Wake Forest Clinical and Translational Science Institute (CTSI) through a pilot grant. The CTSI is funded through a Clinical and Translational Science Award (CTSA) from the National Institutes of Health (UL1TR001420). Dr. Mahler receives research funding from Roche Diagnostics, Abbott Laboratories, Siemens, Ortho Clinical Diagnostics, Creavo Medical Technologies, PCORI, AHRQ, NHLBI (1 R01 HL118263-01), and HRSA (H2ARH39976-01-00). He has provided paid consulting to Roche Diagnostics and Amgen and is the Chief Medical Officer for Impathiq Inc. Dr. Miller receives research funding / support from Siemens, Abbott Point of Care, and 1 R01 HL118263. Dr. Stopyra receives research funding from NCATS/ NIH (KL2TR001421), HRSA (H2ARH39976-01-00), NHLBI (U01HL123027), Roche Diagnostics and Abbott Point of Care. He has provided paid consulting to Roche Diagnostics. Dr. Snavely receives funding from Abbott Laboratories, NHLBI (1 R01 HL118263-01), and HRSA (H2ARH39976-01-00). The authors declare no conflicts of interest.

REFERENCES

1. Owens PL, Barrett ML, Gibson TB, et al. Emergency department care in the United States: a profile of national data sources. *Ann Emerg Med*. 2010;56(2):150-65.
2. P Rui KK. National Hospital Ambulatory Medical Care Survey: 2017 emergency department summary tables. 2017. Available at: https://www.cdc.gov/nchs/data/nhamcs/web_tables/2017_ed_web_tables-508.pdf. Accessed January 15, 2021.
3. Pedersen CK, Stengaard C, Friesgaard K, et al. Chest pain in the ambulance; prevalence, causes and outcome: a retrospective cohort study. *Scand J of Trauma Resusc Emerg Med*. 2019;27(1):84.
4. Galinski M, Saget D, Ruscev M, et al. Chest pain in an out-of-hospital emergency setting: no relationship between pain severity and diagnosis of acute myocardial infarction. *Pain Pract*. 2015;15(4):343-7.
5. Pittet V, Burnand B, Yersin B, et al. Trends of pre-hospital emergency medical services activity over 10 years: a population-based registry analysis. *BMC Health Serv Res*. 2014;14(1):380.
6. Bjornsen LP, Naess-Pleym LE, Dale J, et al. Description of chest pain patients in a Norwegian emergency department. *Scand Cardiovasc J*. 2019;53(1):28-34.
7. Frisch A, Heidle KJ, Frisch SO, et al. Factors associated with advanced cardiac care in prehospital chest pain patients. *Am J Emerg Med*. 2018;36(7):1182-7.
8. Mahler SA, Lenoir KM, Wells BJ, et al. Safely identifying emergency department patients with acute chest pain for early discharge. *Circulation*. 2018;138(22):2456-68.
9. Than M, Flaws D, Sanders S, et al. Development and validation of the emergency department assessment of chest pain score and 2 h accelerated diagnostic protocol. *Emerg Med Australas*. 2014;26(1):34-44.
10. Kline JA, Mitchell AM, Kabrhel C, et al. Clinical criteria to prevent unnecessary diagnostic testing in emergency department patients with suspected pulmonary embolism. *J Thromb Haemost*. 2004;2(8):1247-55.
11. Le Gal G, Righini M, Roy PM, et al. Prediction of pulmonary embolism in the emergency department: the revised Geneva score. *Ann Intern Med*. 2006;144(3):165-71.
12. Katz BS, McMullan JT, Sucharew H, et al. Design andvalidation of a prehospital scale to predict stroke severity. *Stroke*. 2015;46(6):1508-12.
13. 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.
14. Bouzat P, Legrand R, Gillois P, et al. Prediction of intra-hospital mortality after severe trauma: which pre-hospital score is the most accurate? *Injury*. 2016;47(1):14-8.
15. Lima FO, Silva GS, Furie KL, et al. Field assessment stroke triage for emergency destination. *Stroke*. 2016;47(8):1997-2002.
16. Stopyra JP, Snavely AC, Smith LM, et al. Prehospital use of a modified HEART pathway and point-of-care troponin to predict

cardiovascular events. *PLoS One*. 2020;15(10):e0239460.

17. Stopyra JP, Snavely AC, Scheidler JF, et al. Point-of-care troponin testing during ambulance transport to detect acute myocardial infarction. *Prehosp Emerg Care*. 2020;24(6):751-9.
18. De Luca A, Giorgi Rossi P, Villa GF, et al. The use of Cincinnati Prehospital Stroke Scale during telephone dispatch interview increases the accuracy in identifying stroke and transient ischemic attack symptoms. *BMC Health Serv Res*. 2013;13:513.
19. Mahler SA, Riley RF, Hiestand BC, et al. The HEART pathway randomized trial: identifying emergency department patients with acute chest pain for early discharge. *Circ Cardiovasc Qual Outcomes*. 2015;8(2):195-203.
20. Wu WK, Yiadom MY, Collins SP, et al. Documentation of HEART score discordance between emergency physician and cardiologist evaluations of ED patients with chest pain. *Am J Emerg Med*. 2017;35(1):132-5.

Dispatcher Self-assessment and Attitude Toward Video Assistance as a New Tool in Simulated Cardiopulmonary Resuscitation

Hannes Ecker, MD*
Sabine Wingen, PhD*†
Anna Hagemeier, MSc‡
Christopher Plata, MD*§
Bernd W. Böttiger, MD*
Wolfgang A. Wetsch, MD*

*University of Cologne, Medical Faculty and University Hospital Cologne, Department of Anaesthesiology and Intensive Care Medicine, Cologne, Germany
†FOM University of Applied Sciences, Cologne, Germany
‡University of Cologne, Medical Faculty and University Hospital Cologne, Institute of Medical Statistics and Computational Biology, Cologne, Germany
§University Hospital RWTH Aachen, Department of Emergency Medicine, Aachen, Germany

Section Editor: Sam S. Torbati, MD
Submission history: Submitted May 4, 2021; Revision received December 13, 2021; Accepted December 11, 2021
Electronically published February 28, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.12.53027

Introduction: Video-assisted cardiopulmonary resuscitation (V-CPR) describes an advanced telephone-assisted CPR (T-CPR), in which emergency medical service (EMS) dispatchers view a live video steam of the resuscitation. Dispatchers ' general attitudes toward and self-assessment in V-CPR have not been previously investigated.

Material and Methods: We conducted this quantitative analysis along with a pilot study on V-CPR. After conducting V-CPR with laypersons in a simulation, EMS dispatchers were given questionnaires with 21 items concerning their personal attitude toward V-CPR and their self-assessment in providing instructions. The actual CPR performance achieved was recorded and compared to the dispatchers' self-assessments.

Results: Dispatchers completed 49 questionnaires, and the data is presented descriptively. Over 80% strongly agreed that V-CPR was helpful in guiding and that their feedback improved CPR quality. Fifty-one percent agreed that video images supported them in making a diagnosis, while 44.9% disagreed. A vast majority (80-90% each) strongly agreed that V-CPR helped them recognize CPR issues such as compression point, compression rate, and deterioration. In contrast, data for improved compression depth and release were weaker. Thirty percent found V-CPR to be more stressful or exhausting than T-CPR. A majority stated they would prefer V-CPR as an addition to T-CPR in the future. There was a huge gap between dispatchers' own view of CPR effort and measured CPR quality.

Conclusion: Dispatchers generally embrace V-CPR and praise the abilities it provides. Our results indicate that the use of V-CPR did not automatically result in an overall improvement in guideline-compliant CPR quality. [West J Emerg Med. 2022;23(2)229–234.]

INTRODUCTION

Telephone assistance by emergency medical service (EMS) dispatchers during cardiopulmonary resuscitation (CPR) has proven to improve patient outcome and is strongly endorsed by international guidelines.[1] Dispatchers are trained in providing telephone-assisted CPR (T-CPR) when cardiac arrest is suspected or recognized. The dispatcher then follows a structured protocol and gives the caller systematic instructions on how to perform CPR. However, this widely implemented routine is limited by several factors. For example, the callers' depiction of the situation may not be accurate due to personal limitations as well as to the potentially stressful emergency situation. Even if the dispatchers' instructions are presumed to be followed, they

remain unaware of whether the CPR is being performed correctly or sufficiently.

To overcome this uncertainty and improve patient outcome in cardiac arrest, novel technologies now enable the dispatcher to see a live video stream from the caller's smartphone of the actual CPR effort. This facilitates video-assisted CPR (V-CPR). Research on the effectiveness of V-CPR has been focused primarily on resuscitation quality and recognition of typical mistakes.[2] However, studies have yet to evaluate EMS dispatchers' attitudes about this technology.[3-9] In this study, we evaluated the dispatchers' attitudes toward V-CPR using a post-interventional questionnaire after a simulated V-CPR situation, to get their quantitative assessment of this technology.

Population Health Research Capsule

What do we already know about this issue?
Telephone assistance by Emergency Medical Services (EMS) dispatchers during CPR improves patient outcomes. Video-assisted CPR (V-CPR) could be a consistent further development of the current Telephone-CPR (T-CPR).

What was the research question?
We evaluated dispatchers' attitude toward V-CPR using a post–interventional questionnaire after a simulated V-CPR situation.

What was the major finding of the study?
Although dispatchers embrace the abilities of V-CPR, there is a discrepancy between the assessment and actual quality of CPR.

How does this improve population health?
While V-CPR has the potential to strongly improve resuscitation quality, it is important to train and guide EMS dispatchers in V-CPR to sustain the best results.

METHODS

Ethics Approval

The Ethics Committee of the University of Cologne approved the study (ID 18-043; 2018-03-27; Head: Prof. Dr. Drzezga), which was conducted in accordance with CONSORT guidelines specifically under the pilot and feasibility statement.

Study Registration

The study was registered at ClinicalTrials.gov (Identifier: NCT03527771).

Study Design

This quantitative analysis was conducted in a subgroup of a pilot study on V-CPR from July- August 2018 in the facilities of the University Hospital of Cologne.[7] In our skills lab, we set up a full-scale CPR manikin (Ambu Man Advanced, Ambu A/S, Ballerup, Denmark) to simulate a patient in cardiac arrest. In a second room, an emergency dispatcher workplace was set up, including a telephone, a computer with emergency dispatcher software (iSE COBRA 4, iSE GmbH, Aachen, Germany), and four displays with full high-definition 16:9 capability. In addition, a novel software (EmergencyEye, Corevas GmbH & Co. KG, Grevenbroich, Germany) was installed on the dispatching computer, which enables a one-way video telephone connection to a smartphone. The dispatchers consisted of four experienced emergency medical dispatchers in rotation who averaged greater than 10 years of dispatching experience, and all were trained paramedics with experience in the field. There was no randomization for the dispatcher rotation, as available personnel were used according to the duty roster of the dispatchers' employer.

Fifty healthy adult volunteers with no medical background were recruited from passersby at the study location. Volunteers were blinded to the study objective. They were told that they would be confronted with a medical emergency situation and were instructed to handle it to the best of their ability. They were given a study smartphone to "call EMS if necessary." After giving written and informed consent, these participants were accompanied into the simulation room by a study assistant who was equipped with a smartphone (Samsung S7, Android 7.1.1, Samsung Group, Seoul, Korea). Participants were instructed to provide "appropriate first aid according to their own best knowledge and skills." During the CPR scenario, using the phone for an emergency call automatically established a video connection from the caller's phone to the dispatch center. The study assistant operated the phone and placed himself with the camera facing participants and manikin in a predefined position.

The dispatcher followed a standardized, structured dispatching protocol, quickly guiding the caller through the most important questions and toward the correct diagnosis. After detection of cardiac arrest, the dispatcher informed the participants that the patient was in cardiac arrest and needed resuscitation. The dispatcher then activated the video livestream and started standardized, video-guided compression-only CPR according to the 2015 European Resuscitation Council Guidelines for Resuscitation .[1] Resuscitation quality was recorded via the integrated software of the CPR manikin (see above) and analyzed afterward. All scenarios were to be terminated after eight minutes of CPR.

After each V-CPR, the dispatcher was given a questionnaire we developed, which consisted of 21 items focusing on the dispatcher's personal attitude toward V-CPR and its usefulness in providing CPR instructions. For each question, answers could be given on a four-point Likert

scale. These questionnaires were then descriptively and quantitatively analyzed. We conducted descriptive analysis using SPSS version 25 (IBM Corp., Armonk, NY). Results are presented as absolute and relative frequencies.

RESULTS

Fifty V-CPR sequences were eligible to be analyzed in this study. In one case, due to technical problems no video was transmitted, and hence no questionnaire could be completed. All remaining 49 attempts were successful and resulted in instructed V-CPR for eight minutes. In all these cases, a questionnaire was completed by the dispatcher in charge. Thus, 49 complete questionnaires were obtained for further analysis.

Average Age, Gender and Experience in EMS Dispatching and Telephone-CPR

In this study the mean age of the dispatchers was 54 years ± 6.9 years. All participating dispatchers were male, and all had more than 10 years experience as EMS dispatchers.

Evaluation of General Usefulness of Video-CPR (Items 1-4)

When asked whether the video image irritated them while instructing CPR, 95.9% of the dispatchers strongly disagreed (Item 1). Over 80% strongly agreed that V-CPR was helpful in guiding subjects in CPR (Item 2) and 75.5% strongly agreed, while the rest agreed that the video image offered a new quality in the emergency call inquiry (Item 3). Regarding the question of whether the video image helped with the emergency call inquiry, only 55.1% strongly agreed and 38.8% agreed, while 6.1% disagreed (Item 4).

Evaluation of Recognizing Certain CPR Issues (Items 5-12)

Fifty-one percent agreed that video streaming supported them in making a diagnosis, while 44.9% disagreed with that statement (Item 5). In contrast, 85.7% strongly agreed that the video showed them errors in the resuscitation effort of the subject (Item 6), while 14.3% disagreed. Regarding certain CPR issues, such as correct compression point (Items 7), rate (Item 8) and compression fatigue (Item 11), 81.6%, 93.9% and 81.6%, respectively, strongly agreed that V-CPR helped them to recognize mistakes. For CPR quality issues, such as compression depth and release (Items 9 and 10), only 59.2% and 63.3% strongly agreed, while 18.4% and 20.4 % disagreed. Still, 83% strongly agreed that they were able to see that their feedback improved the quality of the CPR effort through the video stream, while only 2% disagreed (Item 12).

Comparing V-CPR to T-CPR and General Acceptance (Item 13-21)

Over 77% of the EMS dispatchers found the image quality of the video to be sufficient, whereas 12% disagreed (Item 21). A majority of 95.9 % strongly agreed that V-CPR helped them recognize and give corrective feedback during CPR, which they would not have recognized with T-CPR only (Item 13). Additionally, 42% strongly agreed and 46% agreed that they had the impression V-CPR helped them motivate the subject more that T-CPR alone could have done (Item 14).

Interestingly, 30% agreed that they found the video-assisted method more stressful or exhausting than the telephone-assisted method, while 63% strongly disagreed (Item 20). Still, 75% strongly agreed and 24% agreed that V-CPR was helpful in guiding the subjects on CPR and resulted in better CPR quality (Item 15). In addition, 85% strongly agreed that video-assisted CPR facilitates the instruction of CPR (Item 16). Regarding their own bias, 28% admitted that they were skeptical about video technology used in CPR, while 38% and 30%, respectively, disagreed or strongly disagreed that they were skeptical before (Item 19).

Eighty-three percent disagreed that they would prefer T-CPR only in the future (Item 17). Sixty-one percent strongly agreed and 38% agreed that that they would like to see V-CPR as an aid in their dispatching work in the future (Item 18). A summary of the questionnaire and the corresponding results is shown in Table 1.

Comparison of Dispatchers' Perceptions and Measured Values of Compression Rate and Depth

As actual CPR data about compression rate and depth was stored via the onboard software of the manikin, a direct comparison to the assessment of the dispatchers was possible. Regarding the statement of item 8, "The video image let me see errors in thorax compression rate," 93.9% strongly agreed. Comparing it to the actual compression rate achieved in these cases, it became obvious that only 32.6% performed a correct mean compression rate over eight minutes, while the majority (67.4%) did not perform a correct mean compression rate recommended by the international guidelines on resuscitation (Figure 1).

Regarding item 9, "The video image let me see errors in thorax compression depth," approximately 60% strongly agreed that only 48.3% of the volunteers actually performed a mean compression depth over eight minutes according to the guidelines (Figure 2).

DISCUSSION

Video-assisted CPR is a new tool for dispatchers to guide callers in providing CPR. While some studies focusing on the impact of V-CPR on CPR quality have been conducted, there is a paucity of research regarding EMS dispatchers' attitudes to V-CPR.[2] We undertook this study to investigate in a quantitative fashion the dispatchers' acceptance of and attitudes toward V-CPR.

While the concept of V-CPR has been around for over a decade, its large-scale deployment in EMS was never achieved due to technical limitations.[2,3] However, recent progress in smartphone technology and broad bandwidth internet coverage has made its utilization possible in emergencies.[8,9] Several studies have shown its advantages

Table 1. Distribution of dispatchers' agreement/disagreement.

	Strongly agree	Agree	Disagree	Strongly disagree
Item 1: The video image irritated me when I was instructing the subjects on CPR.	0 (0.0%)	0 (0.0%)	2 (4.1%)	47 (95.9%)
Item 2: Video-assisted CPR was helpful in guiding subjects in CPR.	40 (81.6%)	9 (18.4%)	0 (0.0%)	0 (0.0%)
Item 3: The video image offers a new quality in the emergency call inquiry.	37 (75.5%)	12 (24.5%)	0 (0.0%)	0 (0.0%)
Item 4: The video image helped me with the emergency call inquiry.	27 (55.1%)	19 (38.8%)	3 (6.1%)	0 (0.0%)
Item 5: The video image supported me in making a diagnosis.	2 (4.1%)	25 (51.0%)	22 (44.9%)	0 (0.0%)
Item 6: The video showed me errors in the resuscitation effort of the subject.	42 (85.7%)	7 (14.3%)	0 (0.0%)	0 (0.0%)
Item 7: The video image let me see errors of the correct thorax compression point.	40 (81.6%)	6 (12.2%)	2 (4.1%)	1 (2.0%)
Item 8: The video image let me see errors in thorax compression rate.	46 (93.9%)	1 (2.0%)	2 (4.1%)	0 (0.0%)
Item 9: The video image let me see errors in thorax compression depth.	29 (59.2%)	9 (18.4%)	9 (18.4%)	2 (4.1%)
Item 10: The video image let me see errors in the thorax compression release.	31 (63.3%)	5 (10.2%)	10 (20.4%)	3 (6.1%)
Item 11: Through the video image I was able to see signs of fatigue / deteriorating quality in the resuscitation effort.	40 (81.6%)	7 (14.3%)	2 (4.1%)	0 (0.0%)
Item 12: Through the video stream I was able to see that my feedback helped improving the quality of the resuscitation effort.	41 (83.7%)	7 (14.3%)	1 (2.0%)	0 (0.0%)
Item 13: Through the video-assisted CPR I was able to recognize and correct errors in the CPR, which I would not have recognized with telephone-assisted CPR only.	47 (95.9%)	2 (4.1%)	0 (0.0%)	0 (0.0%)
Item 14: I had the impression that I was able to motivate the test subject better with video-assisted CPR than I could have done with telephone-assisted CPR alone.	21 (42.9%)	23 (46.9%)	5 (10.2%)	0 (0.0%)
Item 15: Video-assisted CPR was helpful in guiding the subjects on CPR and resulted in better CPR quality.	37 (75.5%)	12 (24.5%)	0 (0.0%)	0 (0.0%)
Item 16: The video-assisted CPR facilitates the instruction of the subjects for CPR.	42 (85.7%)	7 (14.3%)	0 (0.0%)	0 (0.0%)
Item 17: I still prefer telephone CPR alone in the future.	0 (0.0%)	3 (6.1%)	5 (10.2%)	41 (83.7%)
Item 18: I would like to see video-assisted CPR as an aid in my work as a dispatcher in the future.	30 (61.2%)	19 (38.8%)	0 (0.0%)	0 (0.0%)
Item 19: Were you skeptical about the video technology used in CPR?	1 (2.0%)	14 (28.6%)	19 (38.8%)	15 (30.6%)
Item 20: Did you find the video-assisted method more stressful or exhausting than the telephone-assisted method?	15 (30.6%)	1 (2.0%)	2 (4.1%)	31 (63.3%)
Item 21: Did you find the image quality of the video to be sufficient?	35 (71.4%)	8 (16.3%)	6 (12.2%)	0 (0.0%)
	< 1 year	1-5 years	5-10 years	>10 years
Item 22: Prior experience as EMS dispatchers	0 (0.0%)	0 (0.0%)	0 (0.0%)	49 (100%)

Questionnaire used for the study, with corresponding answers. Items 0-21 with the distribution of agreement – disagreement presented in absolute and relative frequencies (%).
CPR, cardiopulmonary resuscitation; *EMS*, emergency medical services.

and superiority in comparison to T-CPR, despite the sometimes ambivalent results.[3,9]

A similar study to ours was conducted in 2008 in Norway. There, dispatchers were interviewed after simulated V-CPR sessions (with a Nokia N90). The answers in those taped interviews were then coded into categories, analyzed, and descriptively presented. The authors concluded that the video element improved the dispatchers' understanding of the emergency situation and that it assisted them in their work. But in their assessment, the dispatchers also stated that the video picture could "interfere" with their normal protocol, as it sometimes could be "noisy," "chaotic," and distracting.

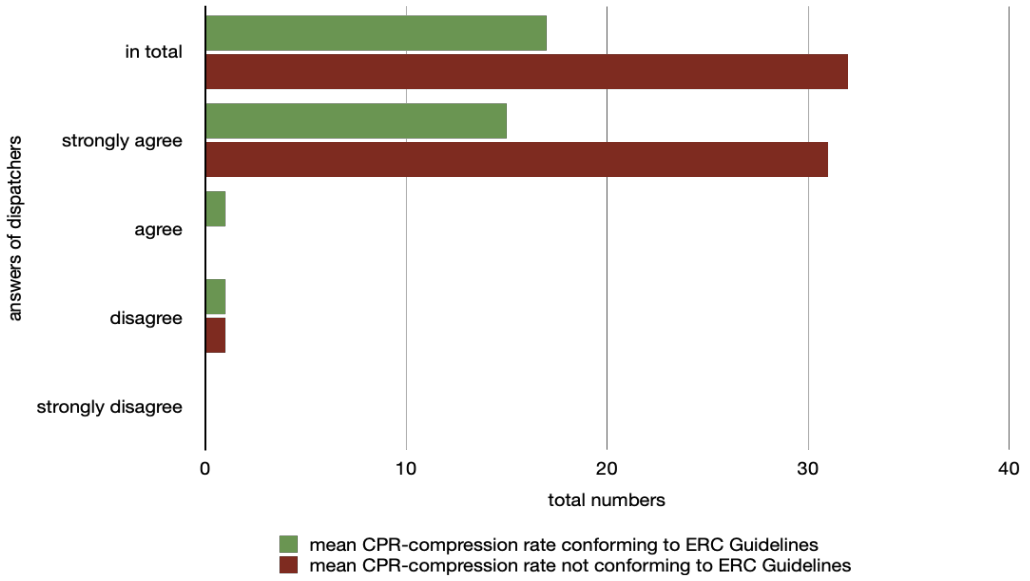


Figure 1. Agreement with Item 8 "The video image let me see errors in thorax compression rate" in comparison to mean CPR compression depth achieved.
CPR, cardiopulmonary resuscitation; *ERC,* European Resuscitation Council.

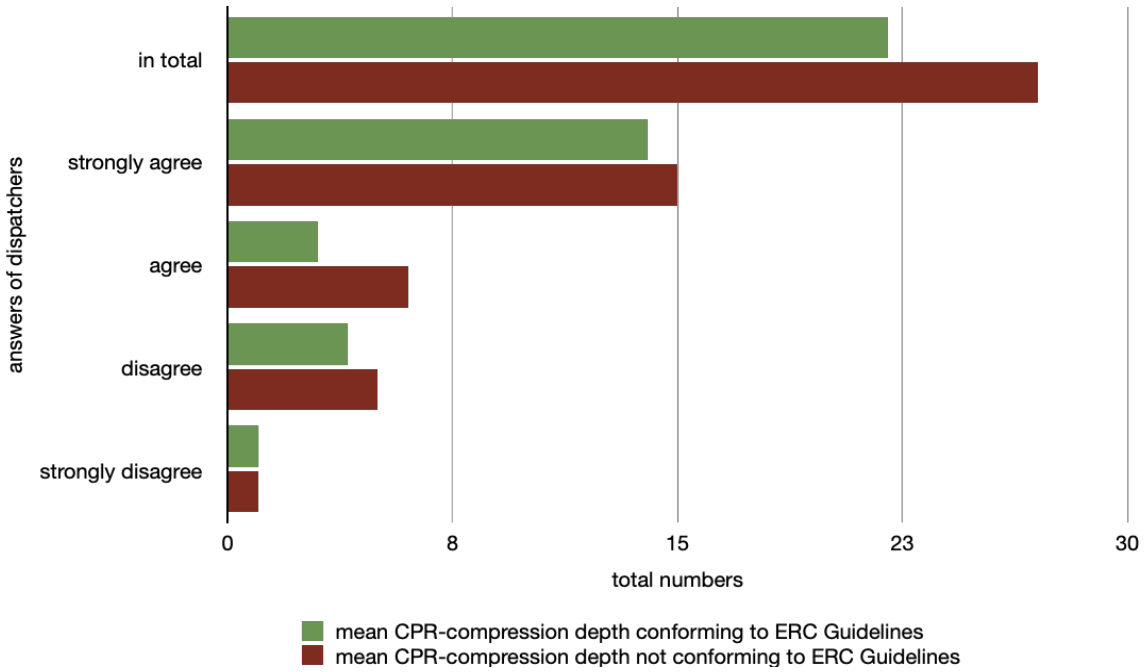


Figure 2. Agreement with Item 9 "The video image let me see errors in thorax compression depth" in comparison to mean CPR compression depth achieved.
CPR, cardiopulmonary resuscitation; *ERC,* European Resuscitation Council.

They also complained that the image quality was sometimes insufficient, as motion of the camera led to "interference."[3]

With our study, conducted over a decade later with state-of-the-art technology, we tried to systematically investigate V-CPR acceptance and usefulness from the perspectives of EMS dispatchers, who are the key players in its utilization. The overwhelming majority of the dispatchers in our study felt that V-CPR was beneficial to their work, helpful in instructing CPR, and offered a new quality in the emergency query process. However, dispatchers were nearly split in their

attitude of V-CPR helping them with their diagnosis, with a trend toward agreement.

Dispatchers in general strongly agreed that the video stream showed them errors in the resuscitation effort. Namely, dispatchers in 80-90% of the cases strongly agreed it to be helpful in the recognition of the correct compression point, frequency, and compression fatigue. In contrast, only around 60% strongly agreed that V-CPR helped them to recognize mistakes in compression depth and release. Interestingly, however, we found a huge discrepancy between the assessment of the observed CPR and the actual performed CPR – as compression rate and depth were only correctly performed in 32% and 48% of the cases, respectively, in which the dispatchers strongly agreed that V-CPR helped them in recognizing these mistakes.

The reason for this surprising discrepancy is not clear. On the one hand, this might be attributed to technical reasons, such as image quality, video frame rate, or the angle in which the scene was being filmed. Contrary to this, most dispatchers found that the video quality was sufficient to evaluate CPR, which is in strong contrast to studies from over a decade ago, in which V-CPR was deemed unfavorable due to its poor video quality.[4] Technical evolution over a decade may have had significant impact on video quality and may pose an explanation as to why this finding changed over time.

Another important reason for this contradiction might be attributed to the dispatchers' operating experience with V-CPR. Even though trained and seasoned in T-CPR, the video element represents a new aspect to their work, as dispatchers are not yet accustomed to visually evaluate a live CPR. This might be enforced by our finding that about 30% conceded and agreed that the video-assisted method was more stressful or exhausting than normal T-CPR (while 63% strongly disagreed). We conclude that these might be indicators that dispatchers need special theoretical-practical training and perhaps emotional support before using V-CPR. Still, the majority of dispatchers in our study agreed that V-CPR facilitated their task and was advantageous to T-CPR and reported that they would like to see V-CPR become part of their dispatching work in the future.

LIMITATIONS

This study investigated a small group of only male, older, and very experienced dispatchers in an artificial scenario on a CPR manikin. Further studies should be conducted on a larger scale and perhaps in a real emergency situation with all genders to increase its generalizability.

CONCLUSION

Video-assisted CPR is a novel technology that was highly embraced by EMS dispatchers in our study. Dispatchers praised the new abilities provided by it. However, our results indicate that the benefits of V-CPR are not a given, as use of V-CPR did not automatically result in an overall improvement in guideline-compliant CPR quality. Dispatchers need further training and guidance to integrate V-CPR into their workflow.

Address for Correspondence: Priv.-Doz. Dr. Med. Univ. Wolfgang A. Wetsch, University of Cologne, Faculty of Medicine, Kerpener Str. 62, 50937 Cologne, Germany. Email: wolfgang.wetsch@uk-koeln.de.

Conflicts of Interest: By the WestJEM 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. Bernd W. Böttiger has received professional fees for lectures from the following companies: Medupdate GmbH, "Forum für medizinische Fortbildung (FomF)", Baxalta Deutschland GmbH, Bayer Vital GmbH, ZOLL Medical Deutschland GmbH, C. R. Bard GmbH, GS Elektromedizinische Geräte G. Stemple GmbH, Novartis Pharma GmbH, Philips GmbH Market DACH. Wolfgang A. Wetsch has received travel expenses from C.R. Bard. All other authors have no financial relationships to declare.

REFERENCES

1. Monsieurs KG, Nolan JP, Bossaert LL, et al. European Resuscitation Council Guidelines for Resuscitation 2015: Section 1. Executive summary. *Resuscitation*. 2015;95:1-80.
2. Lin YY, Chiang WC, Hsieh MJ, et al. Quality of audio-assisted versus video-assisted dispatcher-instructed bystander cardiopulmonary resuscitation: A systematic review and meta-analysis. *Resuscitation*. 2018;123:77-85.
3. Johnsen E, Bolle SR. To see or not to see--better dispatcher-assisted CPR with video-calls? A qualitative study based on simulated trials *Resuscitation*. 2008;78(3):320-6.
4. Bolle SR, Scholl J, Gilbert M. Can video mobile phones improve CPR quality when used for dispatcher assistance during simulated cardiac arrest? *Acta Anaesthesiol Scand*. 2009;53(1):116-20.
5. Bolle SR, Johnsen E, Gilbert M. Video calls for dispatcher-assisted cardiopulmonary resuscitation can improve the confidence of lay rescuers--surveys after simulated cardiac arrest. *J Telemed Telecare*. 2011;17(2):88-92.
6. Stipulante S, Delfosse AS, Donneau AF, et al. Interactive videoconferencing versus audio telephone calls for dispatcher-assisted cardiopulmonary resuscitation using the ALERT algorithm: a randomized trial. *Eur J Emerg Med*. 2016;23(6):418-24.
7. Ecker H, Lindacher F, Adams N, Het al. Video-assisted cardiopulmonary resuscitation via smartphone improves quality of resuscitation: a randomised controlled simulation trial. *Eur J Anaesthesiol*. 2020;37(4):294-302.
8. Ecker H, Wingen S, Hamacher S, et al. Evaluation Of CPR quality via smartphone with a video livestream - a study in a metropolitan area. *Prehosp Emerg Care*. 2020;25(1):1-6.
9. Lee SY, Song KJ, Shin SD, et al. Comparison of the effects of audio-instructed and video-instructed dispatcher-assisted cardiopulmonary resuscitation on resuscitation outcomes after out-of-hospital cardiac arrest. *Resuscitation*. 2020;147:12-20.

Novel Technique for Open Surgical Tracheostomy in Small Children

Nicholas S. Simpson, MD*
Kelsey M. Spaur, MD*
Ashley M. Strobel, MD*
Evan J. Kirschner, MD†
Brian E. Driver, MD*
Robert F. Reardon, MD*

*Hennepin County Medical Center, Department of Emergency Medicine, Minneapolis, Minnesota
†Elson S. Floyd College of Medicine, Department of Emergency Medicine, Spokane, Washington

Section Editor: David Thompson, MD
Submission history: Submitted May 19, 2021; Revision received September 16, 2021; Accepted November 19, 2021
Electronically published February 23, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.11.53296
West J Emerg Med. 2022;23(2)235–237.]

Performing an emergency surgical airway on a young child is a harrowing event. Modern supraglottic devices have made the need for pediatric surgical airways exceedingly rare. Because of the rarity of pediatric surgical airways, many physicians have low confidence with performing this procedure.[1,2] The best method of performing a surgical airway in children remains unclear. The pediatric cricothyroid membrane is too small to perform a traditional cricothyrotomy; in neonates, it is five times shorter and four times narrower than that of an adult, with a mean length of 2.6 +/- 0.7 millimeters (mm) and width of 3 +/- 0.63 mm.[3,4] For this reason, cricothyrotomy is not recommended for children younger than about 8-10 years old.

Both transtracheal needle ventilation (TTNV) and open surgical tracheostomy are described as alternative options.[5] Transtracheal needle ventilation (also known as transtracheal jet ventilation) has been traditionally recommended as the initial approach in the cannot intubate, cannot oxygenate (CICO) scenario; however, this recommendation has been challenged recently because there is scant evidence to support the use of TTNV in this setting. The rationale for TTNV is that it is quicker than an open surgical technique and has less risk of damage to surrounding structures. Some literature also recommends TTNV as a bridge until otolaryngologists or other experienced clinicians arrive, but many emergency physicians do not practice in environments with these resources and need to have options for definitive management. Additionally, TTNV use in emergency situations is incredibly rare, and knowledge of actual clinical performance is limited to adult patients.

The originally described options include use of a large-bore needle with a 3.0-mm inner diameter (ID) endotracheal tube adapter connected to a bag valve device, or use of a large-bore needle with a 3-milliliter syringe attached and an 8.0-mm ID endotracheal tube adapter in the barrel of the syringe. Since then, several commercially available devices were introduced; however, few are small enough for a neonate or infant cricothyroid membrane, and few have been studied in children at all.[3] Smith et al reported two cases in which a TTNV needle and catheter were placed through an old tracheostomy fistula and scar, which is much different from using it on a child without a prior tracheostomy.[6] Depierraz et al described TTNV use in 16 children for 28 elective cases in patients with known subglottic stenosis. They carefully placed transtracheal needles and catheters using direct endoscopic guidance and concluded that the procedure is only safe when performed in this manner. Their experience included a six-week-old child weighing only 2.8 kilograms who received TTNV using an 18-gauge, 0.8-mm inner diameter, 37-mm length Teflon catheter, and who suffered barotrauma with bilateral pneumothoraces and subcutaneous emphysema requiring tracheal intubation and bilateral chest tube placement.[7]

Barotrauma, subcutaneous emphysema hampering subsequent surgical attempts, and device failure are well described complications of TTNV. The rate of significant complications is about 50% when TTNV is attempted in CICO scenarios, and it is rarely performed in these emergent situations.[7,8] A review of TTNV in the literature identified only two instances of the procedure being performed emergently in children aged 1-8 years old.[8] In addition to the lack of evidence for its utility, TTNV requires specialized equipment that may not be available in an emergency department (ED) setting. Also, there is experimental evidence, which correlates with our laboratory and clinical experience, showing that the success rate of TTNV in small children is significantly lower than surgical tracheostomy.[9]

A review by Coté et al advocates for surgical tracheostomy.[3,10] The recent movement away from TTNV

should prompt those who perform emergency airway management to consider their own skill level and ability to perform an open surgical procedure and to review the details of the procedure. The emergency open pediatric surgical tracheostomy is often taught to be similar to an elective open tracheostomy, with careful dissection of soft tissues to visualize the trachea before placing stay sutures, incising the trachea, and inserting a tracheostomy tube.[11] A review by Koers et al demonstrates the high success rate of scalpel tracheostomy, with longer procedure time being the limiting factor.[12]

Therefore, we developed a technique that was meant to be quick and successful and that we believe is the fastest way of performing an open surgical tracheostomy. This technique uses equipment that is readily available in all EDs and consists of just a few steps to a definitive airway. While teaching emergency surgical techniques in our live animal lab over the last few decades we found that the most difficult part of performing an open tracheostomy on subjects with a very small trachea (live rabbit model) was stabilizing the trachea during incision and blunt dissection of the overlying soft tissues, which is even more important in infants whose cartilage is more pliable. Therefore, we developed this technique to overcome those difficulties.

In this novel method, first, a midline vertical incision is made through the skin overlying the trachea. After using palpation to confirm tracheal location, a single 0-silk stay suture is placed in the sagittal plane in the midline through the overlying soft tissue and the trachea. Both sides of the suture are then pulled upward and held firmly by an assistant while the primary operator dissects the overlying soft tissue and exposes the trachea. Then, a horizontal incision is made in the trachea superior to the stay suture (see the Figure for anatomic details); then a bougie is inserted into the trachea, followed by an endotracheal tube.

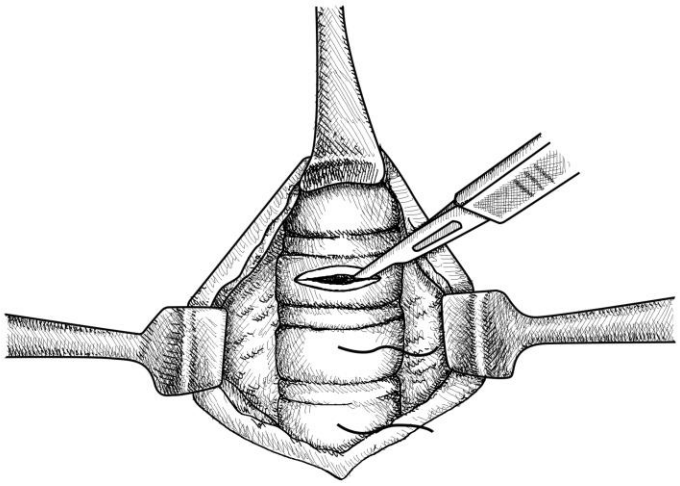


Figure. Anatomic details: The midline stay suture is placed before tracheal visualization and helps stabilize the trachea during blunt dissection. Once the trachea is seen, a horizontal incision is made superior to the stay suture.
*The retractors are included for clarity of the drawing but are not necessary during the actual procedure.

After obtaining exemption from the Institutional Review Board and approval from the animal care committee, we used a live, anesthetized rabbit model with tracheal diameters ranging from 5-6 mm, simulating the airway of a human child aged 0-4 years old, to compare this novel technique to a standard open surgical technique. While this model accurately reflects the size of an infant or young child's trachea, there may be less subcutaneous fat and bleeding than in humans. This highlights the importance of learning the novel technique as a tactile rather than visual procedure, which better prepares learners for the real-life experience. In the standard technique, a midline vertical incision is made over the trachea, followed by blunt dissection with forceps and blunt scissors until the trachea is visualized. Then two stay sutures are placed in the lateral trachea, and the trachea is incised vertically and a tracheostomy tube is placed into the trachea.

We enrolled 15 emergency medicine residents who had never performed tracheostomies on humans to randomly perform the novel or standard technique. Seven residents performed the novel technique, with success on the first attempt occurring in six of seven, with a median time of 239 seconds (s) (95% confidence interval [CI], 190-664 s). Eight residents performed the standard technique, with success on the first attempt occurring in seven of eight, with a median time of 306 s (95% CI, 230-439 s). There was an absolute difference between groups of 39 s (95% CI, -118 s to 164 s). No residents needed to switch from one technique to the other, and all rabbits were successfully cannulated after two or three attempts. In the novel technique, there were two instances where the faculty physician had to intervene in the procedure (both to help identify the trachea and place the stay suture in the correct location), and one instance of complete tracheal transection caused by the horizontal incision. Some faculty assistance is expected with critical procedures at an academic facility and highlights the necessity of practice and familiarity with the procedure when practicing independently.

This data highlights the fact that performing an open tracheostomy on a very small, live animal model is a difficult, time-consuming procedure that requires practice before attempting it in a child. Although this novel technique may be performed faster than a traditional open surgical tracheostomy it might be technically more difficult, as there was one instance of tracheal transection, which is a significant complication. Risk of this potentially life-ending complication could be reduced by using sharp scissors to vertically cut the trachea above the stay suture, rather than incising horizontally with a scalpel, a technique previously described to be successful.[9] When a small child requires an emergency surgical airway, however, time is paramount, and in many instances there is not enough time to perform a careful dissection to visualize the trachea.

The fastest, most successful, and safest method of performing a surgical airway on a small child remains unknown, and more research on this procedure is needed.

We believe that this study demonstrates the importance of stabilizing the trachea prior to dissection of the overlying soft tissue. It also demonstrates the importance of visualizing and carefully incising the trachea, which makes this procedure very different from an emergent cricothyrotomy in an adult and highlights the need to practice this specific procedure.

Address for Correspondence: Kelsey M. Spaur, MD, Hennepin County Medical Center, Department of Emergency Medicine, 730 S 8th St, Minneapolis, MN 55415. Email: kspaur6@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. Nagaro T, Yorozuya T, Sotani M, et al. Survey of patients whose lungs could not be ventilated and whose trachea could not be intubated in university hospitals in Japan. *J Anesth*. 2003;17(4):232-40.
2. Simon HK, Sullivan F. Confidence in performance of pediatric emergency medicine procedures by community emergency practitioners. *Pediatr Emerg Care*. 1996;12(5):336-9.
3. Coté CJ, Hartnick CJ. Pediatric transtracheal and cricothyrotomy airway devices for emergency use: Which are appropriate for infants and children? *Paediatr Anaesth*. 2009;19 Suppl 1:66-76.
4. Navsa N, Tossel G, Boon JM. Dimensions of the neonatal cricothyroid membrane - how feasible is a surgical cricothyroidotomy? *Paediatr Anaesth*. 2005;15(5):402-6.
5. Luten RC, Godwin SA, Mick NW. (2018). Pediatric airway techniques. In: Calvin A Brown III, John C Sakles, Nathan W Mick, ed. *The Walls Manual of Emergency Airway Management*. Wolters Kluwer; New York. 301-310.
6. Smith RB, Myers EN, Sherman H. Transtracheal ventilation in paediatric patients. *Br J Anaesth*. 1974;46(4):313-4.
7. Depierraz B, Ravussin P, Brossard E, et al. Percutaneous transtracheal jet ventilation for paediatric endoscopic laser treatment of laryngeal and subglottic lesions. *Can J Anaesth*. 1994;41(12):1200-7.
8. Duggan LV, Scott BB, Law JA. Transtracheal jet ventilation in the 'can't intubate can't oxygenate' emergency: a systematic review. *Br J Anaesth*. 2016; 117 Issue suppl_1:i28-i38.
9. Johansen K, Holm-Knudsen RJ, Charabi B, et al. Cannot ventilate-cannot intubate an infant: surgical tracheotomy or transtracheal cannula? *Paediatr Anesth*. 20(11):987-93.
10. Black AE, Flynn PER, Smith HL, et al. Development of a guideline for the management of the unanticipated difficult airway in pediatric practice. *Paediatr Anaesth*. 2015;25(4):346-62.
11. Caldicott LD, Oldroyd GJ, Bodenham AR. An evaluation of a new percutaneous tracheostomy kit. *Anaesth*. 1995;50(1):49-51.

Utility of Temporal Bone Computed Tomography in Pediatric Emergency Medicine

Sarah Benyo, BS*
Darrin V. Benn, MD, PhD†
Robert A. Saadi, MD‡
Linda Gangai, RN§
Kathryn E. Kasmire, MD, MS§
Huseyin Isildak, MD¶
Neerav Goyal, MD, MPH¶

*The Pennsylvania State University, College of Medicine, Hershey, Pennsylvania
†University of North Carolina, Department of Otolaryngology – Head and Neck Surgery, Chapel Hill, North Carolina
‡University of Arkansas for Medical Sciences, Department of Otolaryngology – Head and Neck Surgery, Little Rock, Arkansas
§Penn State Health Milton S. Hershey Medical Center, Department of Emergency Medicine, Hershey, Pennsylvania
¶The Pennsylvania State University, College of Medicine, Department of Otolaryngology – Head and Neck Surgery, Hershey, Pennsylvania

Section Editor: Paul Walsh, MD
Submission history: Submitted April 6, 2021; Revision received December 7, 2021; Accepted November 23, 2021
Electronically published February 9, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.11.52704

Objective: Temporal bone computed tomography (CT) requires a relatively high radiation dose to produce high-resolution images required to define surgical anatomy. In the acute setting, the need for this detailed evaluation of temporal bone pathology may not be required for nonsurgical management and clinical decision-making. We performed a retrospective review of the clinical characteristics and subsequent management of children who underwent CT of the temporal bone with the goal of optimizing clinical decision-making and mitigating the risks of radiation exposure in children.

Methods: We included pediatric patients (<18 years of age) with International Classification of Diseases (9th or 10th revision) diagnoses consistent with otitis externa, otitis media, mastoiditis, head trauma, temporal bone fracture, and otalgia who were treated in the emergency department and underwent temporal bone CT from January 1, 2012–December 31, 2016. We collected data regarding the patients' presenting symptoms, physical exam findings, indications for imaging, radiographic findings, disposition, and operative intervention within 30 days of imaging. Features of the suspected mastoiditis group were compared between operative and non-operative patients.

Results: Over the four-year study period there were 96 temporal bone CTs. Most studies (70%) were associated with a subsequent inpatient admission. Common indications for imaging included evaluation of acute mastoiditis (55%) or trauma (41%). Of the 53 patients with concern for mastoiditis, 27 (51%) required otologic surgery. Two patients in the trauma group required surgical intervention, both for facial nerve decompression. In patients with suspected mastoiditis, mental status changes ($P = 0.02$), auricular proptosis ($P = 0.05$), and fluctuance ($P = 0.02$) were significantly more prevalent in the operative group; however, no other findings were significantly associated with operative intervention.

Conclusion: Temporal bone CT is beneficial in guiding diagnosis and management of acute mastoiditis. We found that a majority of patients with suspected mastoiditis who underwent temporal bone CT ultimately required surgery or hospital admission. However, the potential for reduction in the use of CT still exists in this population. Fractures of the temporal bone typically do not require urgent operative intervention in the absence of complete facial nerve paralysis; thus, the utility of temporal bone CT in trauma evaluation may be limited. [West J Emerg Med. 2022;23(2)238–245.]

INTRODUCTION

Up to seven million children in the United States undergo computed tomography (CT) annually, which has been raised as a public health concern due to radiation exposure and increased lifetime cancer risk.[1,2] For this reason, multiple algorithms have been developed to reduce the radiation dose associated with CT in the pediatric population.[3,4] The "as low as reasonably achievable" (ALARA) concept addresses methods for reducing the amount of radiation in a child while maintaining reliability of the diagnostic modality. The ALARA recommendations include developing weight-based protocols, considering alternative non-radiation modalities, and discouraging repeat CT imaging.[3] Furthermore, young children may require sedation for imaging, adding additional risks, time, and cost.[5] Ultimately, the best method of harm reduction is to avoid performing CT that will not inform or alter clinical decision-making.

Temporal bone CT is used in the pediatric population to identify acute middle- and inner-ear pathologies, often in the setting of infectious or trauma evaluation.[6,7] Due to the complex bony anatomy, CT of the temporal bone requires a slice thickness of <1.0 millimeter and a high signal-to-noise ratio to minimize artifact for optimal visualization, thus requiring a higher radiation dose compared to routine head CT.[8] Reducing the radiation dose of temporal bone CT below literature-derived protocols while maintaining accurate detection of findings of middle- and inner-ear structures is an area of active research.[9]

The high resolution of temporal bone CT aids in surgical planning by identifying infectious destruction of bone or the precise location of a temporal bone fracture that may otherwise be missed on lower-resolution imaging protocols. In the setting of temporal bone fracture, operative intervention with facial nerve decompression is indicated for patients with immediate facial nerve paresis and progressive decline in electroneuronography (ENoG) functioning to less than 10% of the normal side.[10] Operative intervention is often indicated for complicated mastoiditis, with extracranial and intracranial sequelae encountered in 13-38% of mastoiditis cases.[11,12] However, the current criteria for diagnosing complicated mastoiditis are diverse, and there is a lack of consensus regarding the strategies for diagnosis and the role of CT in the pediatric population.[13]

The primary objective of our study was to characterize the use of temporal bone CT in the acute emergency setting and investigate the clinical utility of this imaging modality in diagnosis and management of acute infectious and traumatic pathology of the temporal bone in the pediatric population. Our goal was to identify patient characteristics and common indications for temporal bone CT at our institution and to determine the subsequent clinical and/or operative management for these patients. Recognizing the appropriate scenarios to order temporal bone CT may prevent unnecessary radiation exposure in children presenting with such pathologies.

Population Health Research Capsule

What do we already know about this issue?
High-resolution computed tomography (CT) may be used in pediatric infectious and traumatic temporal bone etiologies, but radiation dose is a public health concern.

What was the research question?
What is the clinical utility of temporal bone CT in pediatric acute infectious and traumatic pathologies?

What was the major finding of the study?
Temporal bone CT is beneficial for acute mastoiditis, but its utility in trauma evaluation may be limited.

How does this improve population health?
We identify areas for potential reduction in the use of temporal bone CT, which may limit unnecessary radiation exposure in the pediatric population.

MATERIALS AND METHODS

Following institutional review board approval at Penn State Hershey Medical Center, we conducted a retrospective review of pediatric emergency department (ED) visits at our institution between January 1, 2012 – December 31, 2016, for all pediatric patients who underwent CT temporal bone imaging over the specified time period. Patients with a primary *International Classification of Disease*s, 9th or 10th revision, diagnosis consistent with otitis externa, otitis media, mastoiditis, head trauma, temporal bone fracture, or otalgia were included to limit our study to the use of CT temporal bone imaging in the acute evaluation of infectious and traumatic etiologies. We collected data regarding patients' presenting signs/symptoms and admission type (inpatient vs emergency), indications for CT temporal bone imaging, radiologic findings, and operative procedures performed within 30 days of CT imaging. For patients with suspected mastoiditis, we compared the operative and non-operative groups. The chart abstractors were not blinded to the study hypothesis. Statistical significance was determined by Fisher's exact test with $\alpha = 0.05$ implemented via the "stats" package in R v. 3.2.2 (The R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Within our patient cohort there were 96 temporal bone CTs. Most studies (N = 67; 70%) were associated with an

inpatient admission, while the remaining patients were discharged from the ED (N = 29; 30%). The most common indications for imaging were evaluation of acute mastoiditis (N = 53; 55%) or trauma (N = 39; 41%). The otolaryngology service was consulted for 68 patients, representing 79% of our patient cohort.

Otalgia, otorrhea, and post-auricular swelling were the most common presenting symptoms among patients with concern for mastoiditis. Mastoid tenderness, auricular proptosis, tympanic membrane opacification, and otorrhea were the most commons signs. Of the 53 patients with concern for mastoiditis, five had CT head performed prior to CT temporal bone, and otolaryngology was consulted for 66% of all infectious patients (N = 35) (Table 1). There was a total of 27 otologic procedures among the cohort, which included myringotomy and tympanostomy tube insertion and mastoidectomy, with or without abscess incision and drainage.

To determine the utility of temporal bone CT for patients with infectious concerns, we compared patient-reported symptoms, physical examination signs, and radiographic findings between patients who required operative intervention and those who did not (Table 2). Presentation of altered mental status was significantly more prevalent in the operative group (N = 5) compared to the non-operative group (N = 0; $P = 0.02$). Also, proptosis ($P = 0.05$) and post-auricular fluctuance ($P = 0.02$) were

Table 1. Presenting signs, symptoms, radiographic findings, otolaryngology consults, and final diagnoses in trauma patients (N = 39) and patients with acute infectious concerns (N = 53).

	Trauma, N (%)	Infection, N (%)
Presenting symptoms		
Otalgia	6 (15)	42 (79)
Otorrhea	7 (18)	14 (26)
Hearing loss	7 (18)	6 (11)
Post-auricular pain / swelling	0 (0)	10 (19)
Presenting signs		
Mental status change	12 (31)	5 (9)
Acute otitis media	0 (0)	16 (30)
Mastoid tenderness	4 (10)	29 (55)
Hemotympanum	16 (41)	0 (0)
Auricular proptosis	0 (0)	17 (32)
Otorrhea	1 (3)	15 (28)
Bloody otorrhea	10 (26)	0 (0)
Abnormal tuning fork exam	9 (23)	2 (4)
Post-auricular erythema	0 (0)	10 (19)
Post-auricular fluctuance	0 (0)	6 (11)
Facial nerve paralysis	2 (5)	2 (4)
Radiographic findings		
No acute abnormality	2 (5)	10 (19)
Otic capsule-sparing fracture	29 (74)	0 (0)
Otic capsule-involving fracture	2 (5)	0 (0)
Mastoid effusion	16 (41)	19 (36)
Simple mastoiditis	0 (0)	11 (21)
Complicated mastoiditis	0 (0)	10 (19)
Otitis media	0 (0)	6 (11)
Otitis externa	0 (0)	8 (15)
Known cholesteatoma	0 (0)	5 (9)
Suspected cholesteatoma	0 (0)	1 (2)
Cavernous sinus thrombosis	0 (0)	1 (2)
Prior Head CT	29 (74)	5 (9)

CT, computed tomography.

Table 1. Continued.

	Trauma, N (%)	Infection, N (%)
Consults		
ENT Consult	33 (85)	35 (66)
Final diagnosis		
No acute ear pathology	2 (5)	9 (17)
Simple mastoiditis	0 (0)	6 (11)
Complicated mastoiditis	0 (0)	15 (28)
Simple otitis media	0 (0)	11 (21)
Complicated otitis media	0 (0)	2 (4)
Otitis externa	0 (0)	5 (9)
Eustachian tube dysfunction	0 (0)	1 (2)
Mastoid effusion	5 (13)	3 (6)
Temporal bone fracture	31 (79)	0 (0)
Cerumen impaction	1 (3)	1 (2)

ENT, ear, nose, and throat.

more frequent among the operative group. Radiographic findings of complicated mastoiditis (ie, post-auricular abscess, Bezold's abscess, sigmoid sinus thrombosis, intracranial abscess) were reported among 10 patients in the operative group, and no patients in the non-operative group (P <0.01). No other clinical or radiologic findings were statistically associated with operative intervention; however, there were two patients in the operative group with facial nerve paralysis, which is a clear indication for operative management in this setting of infection. As expected, otolaryngology was consulted for all patients in the operative group (N = 27) compared to 31% (N = 8) of the non-operative group.

Of the trauma patients (N = 39), the most common presenting otologic signs and symptoms included hemotympanum, bloody otorrhea, hearing loss, otalgia, mastoid tenderness, and otorrhea (Table 1). Seventy-four percent of trauma patients who had CT temporal bone also had CT head (N =29), and 85% had otolaryngology consults (N = 33). The most common final diagnoses among trauma patients based on radiographic results were temporal bone fracture and mastoid effusion without radiographic evidence of fracture (Table 1). Among those who had temporal bone CT in the setting of trauma, two patients had operative intervention, both for facial nerve decompression.

DISCUSSION

Temporal bone CT provides detailed anatomic information regarding the middle ear and temporal bone at the expense of a relatively high radiation dose, which is particularly undesirable in the pediatric population. To improve quality of care, clinicians should carefully weigh the risk of radiation exposure to the potential benefit of CT temporal bone imaging. Our study demonstrates that temporal bone CT is useful for surgical planning in the setting of complicated mastoiditis; however, mastoiditis remains primarily a clinical diagnosis that often does not require high-resolution imaging.[14-16] Traumatic fractures can often be presumed in the setting of air cell opacification on head CT without the need to visualize the fracture with a high-resolution image.[17] Moreover, surgical intervention is typically not required in the absence of complete facial nerve paralysis.[15,18] Therefore, temporal bone CT should not be a routine study in the workup of these patients, especially in the pediatric population.

Based on our findings, we have proposed approaches to obtaining temporal bone CT imaging between the specialties of emergency medicine and otolaryngology to maximize usefulness among pediatric patients with acute infectious concerns (Figure 1), as well as those with temporal bone fractures (Figure 2). In the setting of temporal bone fractures due to head trauma, it is possible that the patient will be sedated, intubated, or unable to follow commands. In such cases, assessment of facial paralysis may not be feasible and should be deferred until the patient is awake, and trauma evaluation should then proceed as indicated. However, it is important to note that if a patient is subsequently found to have a complete paralysis, the injury is treated as an immediate complete paralysis as opposed to delayed paralysis, and surgical intervention should be pursued.[19,20]

In our pediatric ED population, nearly half of patients who underwent CT to evaluate for mastoiditis required operative intervention. This indicates that half of patients who received temporal bone CT did not require surgery, potentially exposing these children to unnecessary ionizing radiation. While it is possible that patients may require a

Table 2. Presenting signs, symptoms, and radiographic findings in patients with concern for mastoiditis, comparing the non-operative (N = 26) to the operative group (N = 27).

	Non-operative, N (%)	Operative, N (%)	*P*-value
Presenting symptoms			
Otalgia	22 (85)	20 (74)	0.74
Otorrhea	6 (23)	8 (30)	0.54
Hearing loss	4 (15)	2 (7)	0.67
Post-auricular pain	4 (15)	6 (22)	0.5
Mental status change	0 (0)	5 (19)	**0.02**
Presenting signs			
Tympanic membrane opacification	10 (38)	6 (22)	0.77
Mastoid tenderness	18 (69)	11 (41)	0.27
Auricular proptosis	4 (15)	13 (48)	**0.05**
Otorrhea	7 (27)	8 (30)	0.77
Post-auricular erythema	6 (23)	4 (15)	0.73
Post-auricular fluctuance	0 (0)	6 (22)	**0.02**
Facial nerve paralysis	0 (0)	2 (7)	0.24
Abnormal tuning fork exam	0 (0)	2 (7)	0.24
Radiographic findings			
Mastoid effusion	12 (46)	7 (26)	0.25
Simple mastoiditis	4 (15)	7 (26)	0.32
Complicated mastoiditis	0 (0)	10 (37)	<0.01
Prior Head CT	2 (8)	3 (11)	0.70
Consults			
ENT Consult	8 (31)	27 (100)	

CT, computed tomography; *ENT,* ear, nose, and throat.

temporal bone CT for admission for medical management of suspected mastoiditis, our data does highlight the importance of identifying clinical findings that raise suspicion for surgical intervention (ie, mental status changes, proptosis, fluctuance) when deciding whether temporal bone CT is necessary.

The literature suggests that CT may be beneficial in confirming the diagnosis of mastoiditis in patients who do not present with a clear clinical picture.[7] Future studies should examine scenarios in which CT can be avoided altogether in patients with acute infection and when head CT alone or other lower-radiation temporal bone CT techniques may be sufficient, thereby limiting radiation exposure if surgical intervention is unlikely. Additionally, recognizing the clinical signs and symptoms associated with acute infection of the temporal bone can help guide initial medical management in the emergency setting for situations when surgical intervention may be delayed or unnecessary. The literature suggests that uncomplicated mastoiditis, meaning no neurologic deficits or sepsis, should be managed with intravenous antibiotics, and CT temporal bone should only be obtained if deterioration or lack of clinical improvement is observed.[15,16] Of note, no patients in our cohort had sepsis, which would have allowed us to further assess the utility of CT temporal bone specifically among patients with this acute concern. Operative intervention should be considered as a reasonable next step following medical management in such cases of disease progression or lack of improvement.[21]

In the setting of trauma evaluation, children are often exposed to significant radiation due to extensive radiologic workup. If initial findings on head CT suggest temporal bone fracture, a temporal bone CT may, in practice, be obtained to better visualize the fracture. Studies consistently indicate that facial nerve decompression is recommended in temporal bone fracture if the patient has complete facial nerve paralysis and a loss of greater than 90% function on ENoG.[10,22] In such scenarios, temporal bone CT is useful in delineating the anatomical course of the facial nerve and locating the exact site of injury, guiding the decision on surgical approach (ie, trans-mastoid vs middle cranial fossa). Yet only 6% (N = 2) of trauma patients who underwent temporal bone CT in our study ultimately required facial nerve decompression. Even patients with incomplete facial

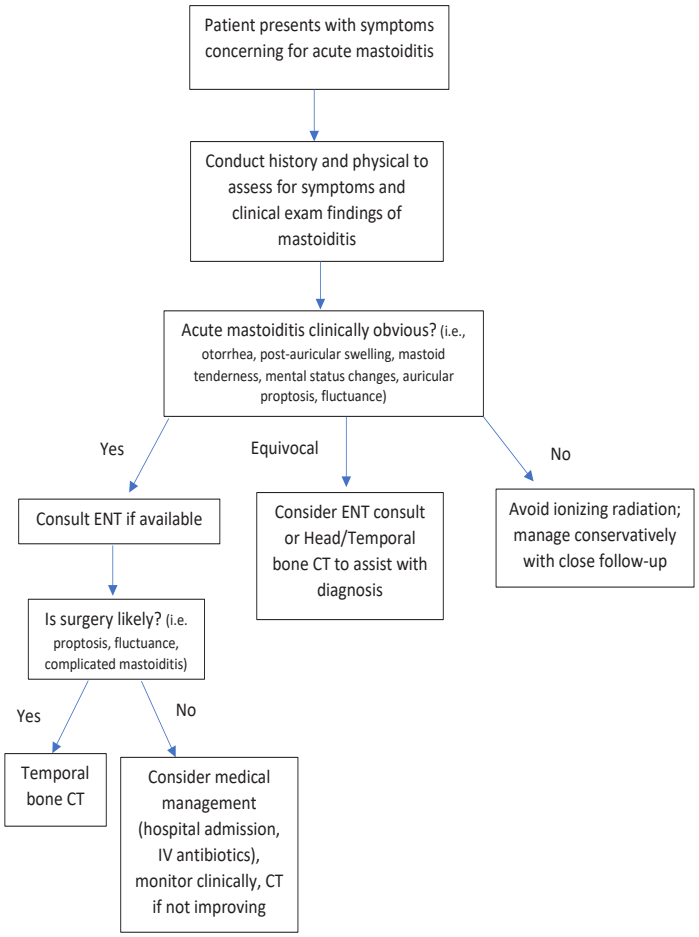


Figure 1. Proposed approach for guiding decision-making in pediatric patients with concern for acute infection of the temporal bone.
ENT, ear nose throat; *CT*, computed tomography; *IV*, intravenous.

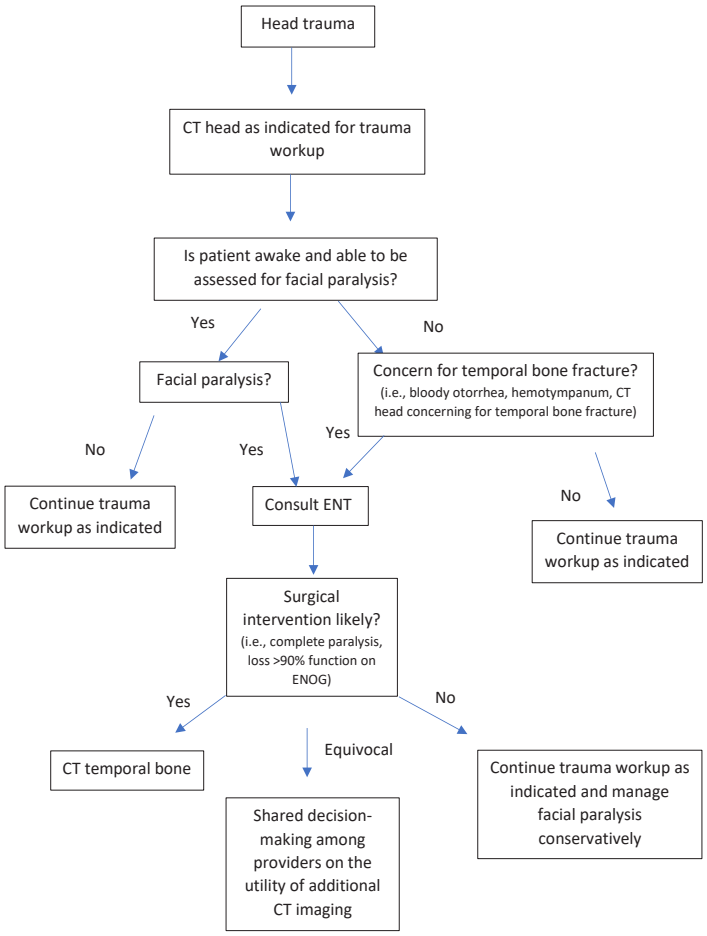


Figure 2. Proposed algorithm for guiding decision-making in pediatric trauma patients with concern for temporal bone fracture.
CT, computed tomography; *ENT*, ear, nose, and throat; *ENoG*, electroneuronography.

nerve paralysis on initial presentation generally do well with expectant management.[10]

Surgical decompression for incomplete facial paralysis has a Grade D aggregate evidence level in the Otolaryngology – Head and Neck Surgery Clinical Practice Guidelines due to the lack of definitive benefits of surgery in this setting.[22] Otherwise, temporal bone fractures are only monitored for hearing outcomes, which includes a delayed audiogram performed 3-6 weeks after injury to allow enough time for resolution of hemotympanum to accurately assess for ossicular discontinuity.[23] Therefore, if there is no concern for complete facial nerve paralysis, a head CT alone obtained during routine trauma workup may be sufficient, since additional imaging is unlikely to change this management strategy and would increase radiation exposure. Following consultation with otolaryngology, consideration may be given for obtaining a temporal bone CT if there is concern for cerebrospinal fluid leak or otic capsule-violating fracture; however, even in these scenarios expectant management is often sufficient.[24,25]

It is worth noting that significant trauma is required to cause a temporal bone fracture, and many patients with such a finding have other more serious injuries taking precedence. Our algorithm (Figure 2) presupposes that no urgent/emergent neurosurgical pathology in or around the temporal bone is present, such as epidural hematoma or carotid canal injury, which may require additional imaging or other expedient management.

Previous studies have demonstrated that the radiologic finding of mastoid air cell opacification is non-specific, rarely clinically significant, and found incidentally in the pediatric population at rates of 14% and 21% with CT and magnetic resonance imaging (MRI), respectively.[26,27] Additionally, Polat et al reported that only 17% of patients with mastoid opacification on MRI were found to have clinical infectious otologic disease.[28] Therefore, despite the benefit of no radiation exposure with MRI, it is not necessarily superior to CT in ruling out this incidental finding. Furthermore, additional evaluation based on this

finding can result in unnecessary treatment and expenditure of healthcare resources.[29,30]

Our study demonstrates that there were 68 total otolaryngology referrals for CT temporal bone findings among the patient cohort. We found that 94% of trauma patients and 23% of infectious patients for whom otolaryngology was consulted ultimately did not require operative intervention. Therefore, CT head findings should be closely correlated with clinical examination to reduce unnecessary temporal bone CT, and further imaging should be based on a coordinated approach between services when specialty consultation is requested. This descriptive study has identified trends for certain inefficiency and redundancy at our institution. With this data, we have developed algorithms to streamline the decision process in ordering temporal bone CT in the acute setting to foster shared decision-making between clinicians and specialties to ultimately reduce radiation exposure among the pediatric population and improve quality of patient care.

LIMITATIONS

There are limitations to the findings of our study. First, this was a retrospective review performed at a single institution with a small sample size, and thus some of our conclusions may not be generalizable to other populations as practice patterns may vary by institution. Additionally, the chart abstractors were not blinded to the study hypothesis. While the study demonstrates an opportunity to reduce the decision to perform a CT, our study did not evaluate whether that decision was made by the ED, trauma surgery, or the consulting service. However, we hope that by highlighting this opportunity it will foster more collaboration between services in providing multidisciplinary care.

CONCLUSION

Our study demonstrates that temporal bone CT can be beneficial in guiding diagnosis and management of acute infectious pathology in the pediatric emergency setting. Clinical examination findings such as mental status changes, proptosis, and fluctuance should guide decision-making surrounding the utility of temporal bone CT for mastoiditis. There may be circumstances in which imaging could be avoided to reduce radiation exposure. In traumatic pathology of the temporal bone, CT did not lead to operative intervention in patients without a clinically apparent facial nerve paralysis. We propose approaches to addressing CT imaging among pediatric patients with acute infectious concerns as well as those with temporal bone fractures, which emphasize using clinical findings likely to lead to operative intervention. By identifying scenarios in which imaging may be unnecessary, we hope to continue public health efforts to reduce ionizing radiation among the pediatric population.

Address for Correspondence: Neerav Goyal, MD, MPH, The Pennsylvania State University College of Medicine, Department of Otolaryngology – Head and Neck Surgery, 500 University Drive, MC H091, Hershey, PA 17033-0850. Email: ngoyal1@pennstatehealth.psu.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. Miglioretti DL, Johnson E, Williams A, et al. The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. *JAMA Pediatr*. 2013;167(8):700-7.
2. Brody AS, Frush DP, Huda W, et al. Radiation risk to children from computed tomography. *Pediatrics*. 2007;120(3):677-82.
3. Shah NB, Platt SL. ALARA: Is there a cause for alarm? Reducing radiation risks from computed tomography scanning in children. *Curr Opin Pediatr*. 2008;20(3):243-7.
4. Goske MJ, Applegate KE, Boylan J, et al. The Image Gently campaign: working together to change practice. *AJR Am J Roentgenol*. 2008;190(2):273-4.
5. Slovis TL. Sedation and anesthesia issues in pediatric imaging. *Pediatr Radiol*. 2011;41 Suppl 2:514-6.
6. Zalzal GH, Shott SR, Towbin R, et al. Value of CT scan in the diagnosis of temporal bone diseases in children. *Laryngoscope*. 1986;96(1):27-32.
7. Stähelin-Massik J, Podvinec M, Jakscha J, et al. Mastoiditis in children: a prospective, observational study comparing clinical presentation, microbiology, computed tomography, surgical findings and histology. *Eur J Pediatr*. 2008;167(5):541-8.
8. Leng S, Diehn FE, Lane JI, et al. Temporal bone CT: improved image quality and potential for decreased radiation dose using an ultra-high-resolution scan mode with an iterative reconstruction algorithm. *AJNR Am J Neuroradiol*. 2015;36(9):1599-603.
9. Nauer CB, Rieke A, Zubler C, et al. Low-dose temporal bone CT in infants and young children: effective dose and image quality. *AJNR Am J Neuroradiol*. 2011;32(8):1375-80.
10. Patel A, Groppo E. Management of temporal bone trauma. *Craniomaxillofac Trauma Reconstr*. 2010;3(2):105-13.
11. Palma S, Fiumana E, Borgonzoni M, et al. Acute mastoiditis in children: the "Ferrara" experience. *Int J Pediatr Otorhinolaryngol*. 2007;71(11):1663-9.
12. Pang LH, Barakate MS, Havas TE. Mastoiditis in a paediatric population: a review of 11 years experience in management. *Int J*

Pediatr Otorhinolaryngol. 2009;73(11):1520-4.

13. van den Aardweg MT, Rovers MM, de Ru JA, et al. A systematic review of diagnostic criteria for acute mastoiditis in children. *Otol Neurotol*. 2008;29(6):751-7.
14. Myer CM. The diagnosis and management of mastoiditis in children. *Pediatr Ann*. 1991;20(11):622-6.
15. Chesney J, Black A, Choo D. What is the best practice for acute mastoiditis in children? *Laryngoscope*. 2014;124(5):1057-8.
16. Marom T, Roth Y, Boaz M, et al. Acute mastoiditis in children: necessity and timing of imaging. *Pediatr Infect Dis J*. 2016;35(1):30-4.
17. Ulano AC, Vedantham S, Takhtani D. Revisiting the indirect signs of a temporal bone fracture: air, air, everywhere. *Emerg Radiol*. 2017;24(5):497-503.
18. Kynion R. Mastoiditis. *Pediatr Rev*. 2018;39(5):267-9.
19. Hato N, Nota J, Hakuba N, et al. Facial nerve decompression surgery in patients with temporal bone trauma: analysis of 66 cases. *J Trauma*. 2011;71(6):1789-92.
20. Darrouzet V, Duclos JY, Liguoro D, et al. Management of facial paralysis resulting from temporal bone fractures: our experience in 115 cases. *Otolaryngol Head Neck Surg*. 2001;125(1):77-84.
21. Anne S, Schwartz S, Ishman SL, et al. Medical versus surgical treatment of pediatric acute mastoiditis: a systematic review. *Laryngoscope*. 2019;129(3):754-60.
22. Baugh RF, Basura GJ, Ishii LE, et al. Clinical practice guideline: Bell's palsy. *Otolaryngol Head Neck Surg*. 2013;149(3 Suppl):S1-27.
23. Johnson F, Semaan MT, Megerian CA. Temporal bone fracture: evaluation and management in the modern era. *Otolaryngol Clin North Am*. 2008;41(3):597-618, x.
24. Dedhia RD, Chin OY, Kaufman M, et al. Predicting complications of pediatric temporal bone fractures. *Int J Pediatr Otorhinolaryngol*. 2020;138:110358.
25. Diaz RC, Cervenka B, Brodie HA. Treatment of temporal bone fractures. *J Neurol Surg B Skull Base*. 2016;77(5):419-29.
26. Lafferty DJ, Cohn JE, McKinnon BJ. Incidental mastoid opacification on computed tomography in the pediatric population. *Int J Pediatr Otorhinolaryngol*. 2020;128:109688.
27. Singh S, Rettiganti MR, Qin C, et al. Incidental mastoid opacification in children on MRI. *Pediatr Radiol*. 2016;46(5):704-8.
28. Polat S, Aksoy E, Serin GM, et al. Incidental diagnosis of mastoiditis on MRI. *Eur Arch Otorhinolaryngol*. 2011;268(8):1135-8.
29. Royal JM, Peterson BS. The risks and benefits of searching for incidental findings in MRI research scans. *J Law Med Ethics*. 2008;36(2):305-14, 212.
30. Wilkinson SL, Sahota RS, Constable JD, et al. Does incidental mastoid opacification on computerized tomography necessitate referral to ENT? *Laryngoscope*. 2017;127(12):2860-5.

Impact of COVID-19 on Emergency Medicine Residency Programs: A Cross-Sectional Study in New York State

Muhammad Waseem, MD, MS[*†‡]
Nidhi Garg, MD[§¶]
Bernard P. Chang, MD, PhD[‖]
Juan Acosta, DO, MS[#**]
John DeAngelis, MD, RDMS[††]
Mary E. McLean, MD[‡‡]
Laura D. Melville, MD, MS[†¶¶]
Timothy Pistor, BS[¶¶]
Kaushal H. Shah, MD[†]
JoAnne Tarantelli, BS[¶¶]
Susan M. Wojcik, PhD, ATC[‖‖]
James Gerard Ryan, MD[#]

[*]Lincoln Medical and Mental Health Center, Department of Pediatrics and Emergency Medicine, Bronx, New York
[†]Weill Cornell Medicine, Department of Pediatric Emergency Medicine, New York, New York
[‡]New York's Medical College, Department of Pediatric Emergency Medicine, Valhalla, New York
[§]Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Hempstead, New York
[¶]South Shore University Hospital/Northwell Health, Department of Emergency Medicine, Bay Shore, New York
[‖]Columbia University Medical Center, Department of Emergency Medicine, New York, New York
[#]Saint Catherine of Siena Medical Center, Department of Emergency Medicine, Smithtown, New York
[**]New York Institute of Technology College of Osteopathic Medicine, Department of Emergency Medicine, Glen Head, New York
[††]University of Rochester, Department of Emergency Medicine, Rochester, New York
[‡‡]St. John's Riverside Hospital, Department of Emergency Medicine, Yonkers, New York
[§§]New York Presbyterian-Brooklyn Methodist Hospital, Department of Emergency Medicine, Brooklyn, New York
[¶¶]New York Chapter American College of Emergency Physicians, Webster, New York
[‖‖]SUNY Upstate Medical University, Department of Emergency Medicine, Syracuse, New York

Section Editor: Jeffrey Druck, MD
Submission history: Submitted July 26, 2021; Revision received August 12, 2021; Accepted October 12, 2021
Electronically published January 18, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.10.54266

Introduction: The 2019 novel coronavirus pandemic has caused significant disruptions in the clinical operations of hospitals as well as clinical education, training, and research at academic centers. New York State was among the first and largest epicenters of the pandemic, resulting in significant disruptions across its 29 emergency medicine (EM) residency programs. We conducted a cross-sectional observational study of EM residency programs in New York State to assess the impact of the pandemic on resident education and training programs.

Methods: We surveyed a cross-sectional sample of residency programs throughout New York State in June 2020, in the timeframe immediately after the state's first "wave" of the pandemic. The survey was distributed to program leadership and elicited information on pandemic-prompted curricular modifications and other educational changes. The survey covered topics related to disruptions in medical education and sought details on solutions to educational issues encountered by programs.

Results: Of the 29 accredited EM residency programs in New York State, leadership from 22 (76%) responded. Of these participating programs, 11 (50%) experienced high pandemic impact on clinical services, 21 (95%) canceled their own trainees' off-service rotations, 22 (100%) canceled or postponed visiting medical student rotations, 22 (100%) adopted virtual conference formats (most within the first week of the pandemic wave), and 11 (50%) stopped all prospective research (excluding COVID-19 research), while most programs continued retrospective research.

Conclusion: This study highlights the profound educational impact of the pandemic on residency programs in one of the hardest- and earliest-hit regions in the United States. Specifically, it highlights the ubiquity of virtual conferencing, the significant impact on research, and the concerns about canceled rotations and missed training opportunities for residents, as well as prehospital and non-physician practitioner trainees. This data should be used to prompt discussion regarding the necessity of alternate educational modalities for pandemic times and the sequelae of implementing these plans. [West J Emerg Med. 2022;23(2)246–250.]

INTRODUCTION

The 2019 novel coronavirus (COVID-19) pandemic has upended broad swaths of the medical and educational world. The World Health Organization declared COVID-19 a global pandemic on March 11, 2020,[1] and on March 18, 2020, Governor Andrew Cuomo of New York State (NYS) declared a state of emergency. The disruptive effects of the pandemic influenced individuals' lives broadly across the healthcare system. The state of New York was one of the earliest COVID-19 epicenters across the nation. It is also home to the largest number of emergency medicine (EM) residencies in the country, most of which are located within the New York City epidemic area. As the pandemic crisis evolved, the Accreditation Council for Graduate Medical Education (ACGME) monitored the needs of the graduate medical education community and provided appropriate guidance for residency training programs by declaring pandemic status for affected institutions.

These guidelines increased flexibility, allowing sponsoring programs to increase availability of physicians in clinical care settings. However, programs are required to maintain adequate resident supervision, continue meeting work hours limits, and provide alternative educational resources. Both anecdotally and through personal experiences, we learned that the pandemic resulted in canceled core rotations, conferences, other educational sessions, and research activities for EM residents in NYS. Through this study, we endeavored to document and analyze the pandemic's disruptions on clinical training, didactic educational experiences, research programs, and wellness activities at NYS EM residency programs.

Population Health Research Capsule

What do we already know about this issue?
COVID-19 significantly disrupted hospital clinical operations in New York State—the first and among the largest of the United States epicenters.

What was the research question?
How did the first pandemic surge impact New York State EM residency program education, training, research, and wellness?

What was the major finding of the study?
Programs adopted virtual conferencing, canceled clinical rotations and research, and instituted changes to wellness initiatives.

How does this improve population health?
Residency is crucial for training proficient physicians. Studying pandemic impacts equips educators to maintain high-quality training in the face of such disasters.

METHODS

In this study we used a cross-sectional design, the setting was virtual, participants were offered no research incentives, and there was no funding. The institutional review board determined the study to be exempt. A survey was developed by the Research Committee of the New York chapter of the American College of Emergency Physicians (ACEP), which consists of 12 active educational faculty and research expert members representing EM residency programs in various institutional settings across NYS. The survey was developed and validated by this group using an iterative process. The questions were proposed and discussed, reworked and re-vetted until the committee reached consensus on face validity and internal consistency. The survey included program demographic questions along with questions related to pandemic-triggered academic program changes. These questions were structured to assess the overall changes to clinical schedules, lecture format, presence of external rotators, and departmental research and wellness programs. A copy of the survey is included in the Appendix.

The survey was distributed via email from the New York ACEP to program directors of the 29 ACGME-accredited EM residencies in NYS. Three contact attempts were made over the one-month period of active data collection. Only one response per program was reported, and none of the survey creators were respondents. We analyzed data using SPSS version 26 (IBM Corporation, Armonk, New York). Descriptive data was reported for each of the variables, and we used a chi square analysis to compare differences across categorical variables.

RESULTS

Of 29 ACGME-accredited NYS EM residencies, program directors from 22 (76%) completed the survey. Respondents self-identified their program's primary geographical class, with 15 (68%) identifying as urban, six (27%) as suburban, and one (5%) as rural. Respondents identified their program's primary hospital type, with 15 (68%) identifying as academic/university and seven (32%) as community. Respondents specified their residency length, with 13 (59%) indicating three-year duration and nine (41%) indicating four-year duration.

Table 1 depicts the program leadership reports of overall COVID-19 pandemic impact on off-service clinical rotations, including both aggregate and subanalyses for program length, hospital setting, and geographic location/population density. Table 2 depicts cancellation rate of the most frequently canceled off-service rotations. Notably, of all responding programs, 21 (95%) canceled at least one off-service rotation.

Table 3 depicts program leadership report rates of ACGME pandemic status placement, overall rotation

Table 1. Perceived impact of the 2019 Novel Coronavirus on off-service rotations after the first pandemic wave in New York State. Impact categories were defined by percentage of residents affected, with high, moderate, neutral, and minimal impact signifying 61-100%, 41-60%, 21-40%, and <20% of residents affected, respectively. Sub-analyses of program length, hospital setting, and geographic location revealed no significant differences in impact severity.

	Off-service rotation impact n(%)		
	High	Moderate	Minimal
Overall analysis	11(50%)	5(23%)	6(27%)
Sub- analyses			
Program length			
3-Year	6(46%)	2(16%)	5(38%)
4-Year	5(56%)	3(33%)	1(11%)
Hospital setting			
Academic	7(47%)	3(20%)	5(33%)
Community	4(57%)	2(29%)	1(14%)
Geographic location			
Rural	0(0%)	1(100%)	0(0%)
Suburban	4(25%)	1(6%)	7(69%)
Urban	7(47%)	3(20%)	5(33%)

Table 2. Clinical rotation cancellations. The "Other" category includes all rotations that were canceled by fewer than 10% of participating residency programs, including medical and surgical intensive care units, otorhinolaryngology, radiology, burn, coronary care unit, internal medicine, and psychiatry. EMS, emergency medical services; OB/GYN, obstetrics/gynecology.

Rotation	Cancellations n(%)
Anesthesia	14(64%)
EMS	14(64%)
Toxicology	12(55%)
OB/GYN	12(55%)
Ultrasound	9(41%)
Orthopedics	8(36%)
Research	7(32%)
Ophthalmology	5(23%)
Administration	4(18%)
Teaching	4(18%)
Trauma	3(14%)
Other	12(55%)

cancellation rates for internal and visiting trainees, and effects on weekly conferences and research. Of the 22 participating programs, 22 (100%) reported that prior to the pandemic wave they had rotating medical students in their emergency departments, 15 (68%) had physician assistant students, 11 (50%) had emergency medical technician interns, 11 (50%) had nursing students, and 10 (45%) had nurse practitioner students. All programs did transition to virtual conferencing, ostensibly due to NYS social distancing requirements. Adoption of alternate lecture formats occurred rapidly, with 16 (73%) transitioning to virtual conference within one week of the ACGME declaring pandemic status, and 20 (91%) transitioning within four weeks. Half of programs halted all prospective research, and at least two respondents noted that only COVID-19 specific research continued.

Table 4 depicts frequency of resident wellness initiative changes. Of 22 responding programs, 20 (91%) made significant changes to resident wellness programs during this first pandemic wave.

DISCUSSION

In the past century, there has been no opportunity other than during COVID-19 to study the effects of a worldwide pandemic on medical education and training. Understanding its impact on residency programs provides insight to better prepare teaching hospitals for future disasters, including pandemics, natural disasters, war, terrorism, electrical blackouts, etc. We found that COVID-19 impacted residency education in all participating programs in NYS, including clinical, didactic, research, and wellness experiences.

The high overall clinical impact suggests that effects were universal without regard to duration of training programs, hospital setting, or geographical location. The fact that over 90% of offsite rotations were canceled depicts significant limitations to training opportunities, amplified by the fact that rotations historically thought of as crucial to EM education were not spared. The fact that anesthesia and emergency medical services (EMS) were the most canceled rotations is a particularly powerful message. Anesthesia exposure aids in resident training on critical airway management,[2] and EMS aids in crucial resident understanding of prehospital care (eg, EMS protocols and operations).[3]

All programs adopted virtual platforms and curricula for weekly conferences, which requires institutional investment and guidance.[4] It has previously been suggested that the didactic portion of medical student education should transition to online curricula.[5] Several medical schools have embraced this change, even finding ways to administer team-based exercises, interactive clinical cases, and real-time quizzes using these virtual platforms.[6] The advantages and disadvantages of virtual didactic curricula (and the determination of whether virtual curricula can provide the same degree of knowledge acquisition as traditional in-person education) requires further study.

Over half of the participating programs reported a complete interruption of clinical research activities, and a third of programs were able to continue retrospective chart review studies. In some instances, in-person data collection was postponed due to safety considerations for

Table 3. Descriptive statistics portraying the impact of the 2019 Novel Coronavirus pandemic on hospital training environment programs in New York State, including clinical, didactic, and research experiences. Wherever applicable, percentages are calculated from total institutions reporting on the measure (programs answering "not applicable" are excluded). Also wherever applicable, the denominator is specified if fewer than 22 programs reported on a measure.

Measure	n(%)
Pandemic status placement	15(68%)
Canceled internal trainees' off-service rotations	21(95%)
Canceled outside trainees' visiting rotations	-
Medical students	16/22(73%)
Physician assistant students	10/15(67%)
Nurse practitioner students	7/12(58%)
Nursing students	7/11(64%)
Emergency medical technician interns	7/11(64%)
Postponed outside trainees' visiting rotations	-
Medical students	6/22(27%)
Physician assistant students	5/15(33%)
Nurse practitioner students	5/12(42%)
Nursing students	4/11(36%)
Emergency medical technician interns	3/11(27%)
Weekly conference	-
Virtual conference format adopted	22(100%)
Limited to small groups <10	2(9%)
Changed to self-directed learning	2(9%)
Institutional research	-
Prospective research stopped	11(50%)
Prospective research continued with video/phone	6(28%)
Retrospective research stopped	1(5%)
Retrospective research continued	7(32%)

Table 4. Types and frequencies of changes made by participating emergency medicine residency programs to resident wellness initiatives during the first New York State wave of the 2019 Novel Coronavirus pandemic.

Change	n(%)
Solicited/obtained donations by outside companies (food, discounts, services)	18(95%)
Scheduled virtual social gatherings	15(79%)
Solicited/obtained donations facilitated/paid for by the hospital	11(58%)
Established new wellness and respite space	9(47%)
Planned for later additional wellness events to make up for canceled plans	8(42%)
Reduced resident workload	8(42%)
Moved residents off high stress/demanding rotations to distribute workflow	7(37%)
Added a virtual class for yoga/meditation	5(26%)

research teams, while other research-related activities such as analysis and manuscript writing continued. While many non-COVID-19 research projects were paused during the pandemic, a significant increase in COVID-19 related work was noted by many participating programs. This provided novel opportunities for innovative research, including grant-funded projects, although this potentially narrowed the focus of resident institutional research. The combination of these factors may lead to significantly reduced research experiences for graduating residents.[7]

The COVID-19 pandemic produced a significant change in resident wellness programs. Survey participants reported using new methodologies to improve wellness, including soliciting or obtaining food or discounts, and virtual social gatherings. This leads us to think that on an everyday basis, procuring food during shifts can be a challenge for EM residents, presumably because there is little downtime. This knowledge suggests that such interventions are beneficial on a routine basis, reflected in the fact that many programs provide food stipends or meal cards. Beyond food incentives, participants also reported using virtual environments in creative ways (including social gatherings, group meditation, and yoga). We suspect that further innovative uses of virtual environments will be forthcoming.

LIMITATIONS

As with any similar survey-based research, our study was potentially impacted by recall bias of participants, and this may be especially true given the physical and emotional stress experienced during the pandemic. We attempted to keep the questions as factual as possible to reduce bias that may have presented with subjective responses. However, limiting the answers to objective data may have led to oversimplification of a complex and dynamic situation. Furthermore, these questions were not from a validated source, but were crafted to extract factual answers by members of the New York ACEP Research Committee, who are experts in the field. It is unknown whether respondents perceived pressure to over- or underestimate their answers. It is also unknown how generalizable these findings are to all United States EM residency programs given that the NYS COVID-19 experience may have been unique. Despite these limitations, we believe that this study has provided useful and revealing objective data, and that this information can guide future investigations. Ultimately, more research is needed to measure the relative level of impact for residents who trained during the pandemic vs those who did not, focusing specifically on competency and milestone achievement.

CONCLUSION

The COVID-19 pandemic has dramatically transformed education for physicians in training. It has also challenged EM residency programs to rebalance priorities of patient care,

resident education, and wellness. The present study provides important information regarding the effects of COVID-19 on EM residency programs regarding these priorities. Pandemic times have called for difficult decisions to be made, for innovation, and for rapid adoption of unconventional teaching modalities, such as virtual platforms, to minimize training disruptions. They also have called for new ways to connect socially and promote wellness. Adaptability and flexibility during this challenging time is not unique to EM, but it is often recognized as one of our strongest attributes. This study highlights many of the difficult training decisions that NYS EM residency leadership made during the state's first COVID-19 wave, and the ways in which programs have met challenges presented by the pandemic. Such discussions of the pandemic's short-term effects on resident education are crucial, but the long-term effects of COVID-19 on EM education and training remain to be seen.

Address for Correspondence: Muhammad Waseem, MD, MS, Lincoln Medical and Mental Health Center, Department of Pediatrics and Emergency Medicine, 234 E 149th Street, Bronx, NY 10451. Email: Muhammad.waseem@nychhs.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. World Health Organization. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - 11 March 2020. 2020. Available at: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020. Accessed January 1, 2021.
2. Grissom T, Samet R. The anesthesiologist's role in teaching airway management to nonanesthesiologists. *Adv Anesth*. 2020;38:131-56.
3. Ray A, Sole D. Emergency medicine resident involvement in EMS. *J Emerg Med*. 2007;33(4):385-94.
4. Vasavda C, Ho B, Davison A. Socially distant medical education in the face of COVID-19. *Med Sci Educ*. 2020;31(1):231-3.
5. Emanuel E. The inevitable reimagining of medical education. *JAMA*. 2020;323(12):1127.
6. Wray A, Wolff M, Boysen-Osborn M et al. Not another boring resident didactic conference. *AEM Educ Train*. 2019;4(Suppl 1):S113-S121.
7. Hopkins L, Hampton B, Abbott J et al. To the point: medical education, technology, and the millennial learner. *Am J Obstet Gynecol*. 2018;218(2):188-92.

Burnout and Post-traumatic Stress Disorder Symptoms Among Emergency Medicine Resident Physicians During the COVID-19 Pandemic

Jungsoo Chang, BS*
Jessica M. Ray, PhD†
Daniel Joseph, MD†
Leigh V. Evans, MD†
Melissa Joseph, MD†

*Yale School of Medicine, New Haven, Connecticut
†Yale School of Medicine, Department of Emergency Medicine, New Haven, Connecticut

Section Editor: Jeffrey Druck, MD
Submission history: Submitted May 11, 2021; Revision received November 8, 2021; Accepted November 3, 2021
Electronically published February 28,2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.11.53186

Introduction: Emergency medicine is characterized by high volume decision-making while under multiple stressors. With the arrival of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus in early 2020, physicians across the world were met with a surge of critically ill patients. Emergency physicians (EP) are prone to developing burnout and post-traumatic stress disorder (PTSD), due to experiencing emotional trauma as well as the cumulative stress of practice. Thus, calls have been made for attempts to prevent physician PTSD during this current pandemic.

Methods: From July 2019–January 2020, emergency medicine (EM) resident physicians at a large, academic healthcare system were surveyed for symptoms of burnout using the Maslach Burnout Inventory (MBI). In late April and early May 2020, during the outbreak surge of coronavirus disease 2019 (COVID-19) in the Northeast USA, these same residents and the whole EM residency at the institution were again surveyed for symptoms of burnout as well as post-traumatic stress using the PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (PCL-5). A final survey was administered to the EM residents after the COVID-19 surge had largely subsided in June 2020.

Results: Twenty-two residents participated in the pre-pandemic study and completed the MBI. Twelve (55%) completed the two follow-up MBI surveys. In the larger EM residency cohort, 31/60 residents completed the MBI and PCL-5 survey during the pandemic peak and 30/60 (50%) completed the follow-up surveys. There were no significant differences in the three MBI burnout category measures of emotional exhaustion (P = 0.49), depersonalization (P = 0.13), and personal accomplishment (P = 0.70) pre-, during, and post-COVID. Of 31 participants, 11 (35%) scored greater than 31 on the PCL-5. Two residents had scores between 21-30, interpreted as "at risk." At greater than one month follow-up, 2/30 continued to meet criteria for a preliminary PTSD diagnosis, and five were "at risk."

Conclusion: A significant proportion of residents (35%) experienced post-traumatic symptoms acutely during the COVID-19 pandemic crisis, potentially indicating a high prevalence of acute stress disorder in this population and increased risk of developing PTSD. However, there was no significant difference in burnout levels in this cohort before, during, or after the initial COVID-19 surge. Early screening for physicians at risk and referral for assessment and treatment may be important to mitigate pandemic-related PTSD. [West J Emerg Med. 2022;23(2)251–257.]

INTRODUCTION

Emergency medicine (EM) is characterized by a high volume of decision-making under high stress. Emergency physicians (EP) are particularly prone to developing burnout, with 35-77.8% of physicians reporting significant risks.[1,2] Burnout, characterized by emotional exhaustion, depersonalization, and feelings of decreased personal accomplishment, affects the physicians and their patients.[3-6]

Workload, violence, traumatic events, uncontrolled stress, work-family conflict, and poor staffing have been identified as factors in EM that contribute to burnout.[1,7,8] Burnout has been associated with lower reported quality of life and of education among residents, as well as increased early retirement and turnover among EPs in practice.[6,9]

Emergency physicians are also at increased risk of developing post-traumatic stress disorder (PTSD), both due to experiencing emotional trauma as well as the cumulative stress of practice.[10,11] One study identified 15.8% of EP respondents as meeting preliminary criteria for PTSD, with prior trauma or abuse as the primary predictor.[12] Post-traumatic stress disorder is characterized by exposure to an extreme stressor or traumatic event followed by at least one month of three distinct types of symptoms: re-experiencing the event; avoidance of reminders of the event; and hyperarousal.[13] In addition to prior trauma, female gender, genetics, family and personal psychiatric history, impaired executive function, trauma intensity and type, and physiological arousal have been identified as risk factors for development of PTSD after trauma. Social support has been identified as a protective factor.[14] For EM resident physicians, one institution found that 11.9% met criteria to diagnose PTSD, and that the proportion of residents meeting criteria increased with level of training.[15] A recent survey of surgical residents found 22% screened positive for PTSD, with an additional 35% considered "at risk."[16]

With the arrival of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus in early 2020, physicians across the world were met with a surge of critically ill patients. From experience in prior pandemics such as SARS in 2003, we know that healthcare workers who treated SARS patients had significantly higher levels of burnout and PTSD, a condition that portends a high risk of suicidal ideations, attempts, and completions.[17-20] Physicians may be particularly at risk, and thus calls have been made for attention to helping to prevent PTSD during this current pandemic.[17,21] Data from China, the first country to experience the pandemic surge, confirms this prediction, with 27% of their medical staff who treated coronavirus disease 2019 (COVID-19) patients reporting post-traumatic stress symptoms.[22]

After the arrival of Sars-CoV-2 to the United States, the Northeast experienced an influx of cases during the months of March, April, and May 2020. (CDC). By May 31, 2020, as the initial surge waned, 42,743 people had been infected with SARS-CoV-2 and 3970 had died. There was an average daily hospital census of 1174 persons statewide.[23] As the majority of hospital admissions are first managed and stabilized in the emergency department (ED), the volume of COVID-19 patients and its strain on resources was acutely felt by the ED staff. In this study, we examine the association between the peak and wane of COVID-19 cases on physicians at a large, academic healthcare system and symptoms of burnout and post-traumatic stress among our EM resident population. We were able to compare the burnout across a same matched cohort across three time periods: before, during, and after the peak COVID surge in the Northeast US to better elucidate the effectiveness of current methods to reduce physician burnout.

Population Health Research Capsule

What do we already know about this issue?
Emergency physicians are prone to burnout and post-traumatic stress disorder (PTSD), due to emotional trauma and the cumulative stress of practice.

What was the research question?
With coronavirus disease 2019 (COVID-19), was there a change in burnout and PTSD symptoms among the emergency medicine resident physicians?

What was the major finding of the study?
Our study population had no change in burnout during or after the COVID-19 surge in the Northeast US but had increased symptoms of PTSD.

How does this improve population health?
Most residents' PTSD symptoms had improved at follow-up. Early screening for physicians at risk and referral for treatment may help mitigate pandemic-related PTSD.

METHODS

Study Design

This was a prospective, cohort longitudinal study of EM resident physicians before and during the COVID-19 pandemic. This study was determined to be exempt by the institutional review board.

Study Setting and Population

From July 2019–January 2020, EM resident physicians (postgraduate years [PGY] 1-4) at a large, academic healthcare system were surveyed for symptoms of burnout during their elective rotation. We had pre-COVID Maslach Burnout Inventory Human Services Survey for Medical Personnel (MBI-HSS (MP) data from EM resident cohorts that had rotated through the simulation rotation up to the point of the pandemic outbreak. In late April and early May 2020, during the outbreak surge of COVID-19 in the Northeast, a sample of residents from this same resident cohort were again surveyed for symptoms of burnout and post-traumatic stress as they worked in clinical areas. A final survey was administered to the entire EM residency cohort after the COVID-19 surge had largely subsided in June 2020. The EM residents in

this institution worked solely in the ED, without off-service rotations, from April 7–July 1, 2020.

During the initial survey period, there were no reported cases of COVID-19 in the US. On data collection days during the COVID-19 surge from late April to mid-June 2020, there were 50 average daily admissions, an average daily hospital census of 634 patients, and 153 patients in the intensive care unit with COVID-19 throughout this academic healthcare system. During the final survey in late June 2020, there was an average of six daily COVID-19 admissions, and a daily census of 52 admitted patients with COVID-19 across the healthcare system, with 26 at the primary teaching site.

Study Protocol

Resident physicians completed a MBI-HSS (MP)) as part of a separate study and results were de-identified. During the COVID-19 pandemic, a follow-up MBI-HSS (MP), as well as the PTSD Checklist (PCL-5) for the *Diagnostic and Statistical Manual of Mental Disorders, 5th Edition* (*DSM-5*) were distributed to this cohort as well as the larger residency cohort via anonymous survey using Qualtrics software (Qualtrics, Provo, UT). An identical survey was again distributed after the initial COVID-19 surge subsided in the Northeast. Responders were matched between the second and third surveys via a unique self-identifying code. Responders to the second and third surveys were also asked to indicate whether they had participated in the initial, pre-COVID-19 MBI-HSS (MP) survey so that results could be compared longitudinally within this smaller cohort. For the initial survey, written consent was obtained in person. For the follow-up surveys, written consent was obtained electronically. With the second and third surveys, participants were provided with a list of resources for support during the pandemic, both departmentally and institutionally.

Outcome Measures

The primary outcome measures of this study were the scored differences between sequential MBI-HSS (MP) and PCL-5 surveys. The MBI-HSS (MP) is a version of the Maslach Burnout Inventory that was developed for healthcare professionals who have direct contact with patients. The MBI has been validated in many different populations, including healthcare professionals and is the most widely used survey to measure burnout. It is scored in three categories: emotional exhaustion (EE); depersonalization (DP); and personal accomplishment (PA), with high levels of EE and DP and low levels of PA characteristic of burnout.[24-26] While there is no cutoff score that represents a diagnosis of burnout, each category score is interpreted by its frequency of symptoms, which ranges from *Never* (0) to *Every Day* (6).[26]

The PCL-5 is one of the most widely used self-report measures of PTSD, and respondents indicate how much they have been bothered by each PTSD symptom over the prior month using a five-point Likert scale ranging from 0 to 4 with 0 (*not at all*) to 4 (*extremely*).[27] The item scores are summed to yield a continuous measurement indicating PTSD symptom severity (range 0-80). The PCL-5 is a revised version of the PCL, reflecting the initial *DSM-5* criteria changes for PTSD.[28] While the PCL-5 score has not yet had extensive cut-off score evaluation for PTSD symptomatology, a PCL-5 score of 31-33 or greater predicts PCL scores of > 40s, a previously established cutoff score that suggests the participant may benefit from PTSD treatment if they meet other diagnostic criteria such as time since stressor. Any item rated 2 (*moderately*) or higher can be considered as a PTSD symptom endorsed based on *DSM*-5.[27-29]

We used the reported hospital systemwide COVID inpatient volume as a proxy for the volume and burden of SARS-CoV-2 spread within the state and relative cases seen in the ED. In-patient COVID-19 positive numbers were reported beginning mid-March and have been continuously updated within the system.

Data Analysis

The responses from the initial survey period (July 2019–January 2020), COVID-19 peak period (April–May 2020), and post-surge period (July 2020) were collected. We calculated a one-way analysis of variance (ANOVA) with R 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria) to determine whether there was a statistically significant difference in burnout symptom categories (EE, DP, and PA) between the three time periods surrounding the COVID pandemic. Both a paired (N = 15 for individuals who had filled both the second and third surveys) and unpaired (N = 28 and N = 30 for second and third surveys, respectively) two-sided t-test were performed on the results from the latter two MBI surveys to determine statistically significant differences in measured burnout categories during peak COVID-19 volume at our site and again in late June. Similarly, paired and unpaired two-sided t-tests were performed on the PCL-5 results using R.

Using the academic healthcare system's COVID-19 day-to-day inpatient monitor, we used R to determine whether a correlation between in-patient COVID-19 positive rates and MBI or PCL-5 scores existed.

RESULTS

Peak COVID-19 inpatient volume occurred in mid-April, with 787 COVID positive patients across our academic healthcare system. After this peak, there was a gradual downward trend in both COVID-19 positive inpatients and new admissions. Twenty-two residents who were in an elective rotation participated in the pre-pandemic study and completed the MBI at that time. Twelve of these residents (55%) completed the sequent two follow-up MBI surveys. In the larger cohort, 31/60 residents completed the MBI and PCL-5 survey during the pandemic peak, and 30/60 completed the follow-up survey, indicating a follow-up response rate of approximately 50% (Figure 1). Fifteen of these residents completed both the intra- and post-pandemic surveys (Table 1).

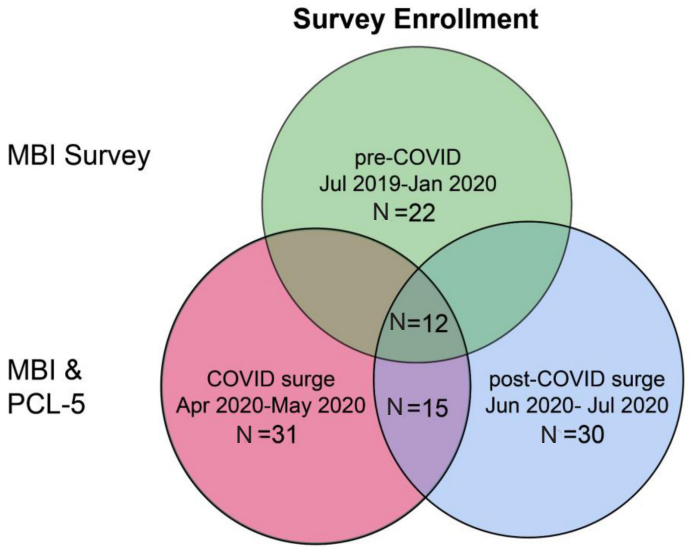


Figure 1. Venn diagram illustrating the survey enrollment population and the surveys taken by each cohort.
MBI, Maslach Burnout Inventory; *PCL,* post-traumatic stress disorder checklist; *COVID,* coronavirus disease 2019.

Table 1. Maslach Burnout Inventory for medical personnel category outcomes based on pre-, intra-, and post COVID-19 time periods.

	Emotional Exhaustion	Depersonalization	Personal Accomplishment
Pre-COVID 19 (N = 22)			
Mean	2.64	2.51	4.68
SD	1.31	1.49	0.7
Intra-COVID 19 (N = 28)			
Mean	2.74	2.57	4.61
SD	1.47	1.15	0.84
Post-COVID 19 (N = 30)			
Mean	2.33	2.33	5.00
SD	1.14	1.27	0.67

COVID-19, coronavirus disease; *SD,* standard deviation.

Maslach Burnout Inventory-HSS

There was no significant difference in burnout category measures of EE (unbalanced one-way ANOVA $P = 0.49$), DP ($P = 0.13$), and PA ($P = 0.70$) pre-, during, and post-COVID (Figure 2).

MBI-HSS scores from the smaller cohort of individuals who completed the surveys during the peak and post-surge (n=15, paired two sided t-test) were consistent with that of the larger cohort for the latter two time points where there was no significant difference in the burnout category measures for EE (p=0.05516), D (p=0.825), and PA (p=0.7474). There was also no statistically significant difference in burnout categories for all the participants of the survey during the peak and post-surge (EE p=0.2667; D p=0.3859; PA p=0.07574). Additionally, there was no correlation found between MBI-HSS scores and inpatient COVID-19 volume.

Post-traumatic Stress Disorder Checklist-5

Of the surveyed 31 participants, 11 EM residents (35%) scored greater than 31 on the PCL-5, which has a maximum possible score of 80. An additional two residents had scores between 21-30, which was interpreted as "at risk." At >1 month follow-up, 2/30 respondents continued to meet criteria for a preliminary PTSD diagnosis, and five were classified as "at risk." Figure 3 shows a boxplot of PCL-5 scores of EM residents throughout the study period with a scatterplot of the number of COVID-19 positive patients, with the width of boxplot corresponding to the dates the surveys were collected (Figure 3).

A threshold line of 31 on the box plot represents the cutoff score of the PCL-5. There was a statistically significant difference in PCL-5 values during these two study periods. Peak COVID surge PCL-5 mean was 22 while post-surge was 13 (N = 28 for peak surge and N = 30 for post-surge, unpaired two-sample t-test $P = 0.03$). When comparing the smaller group of paired individuals (N = 15), there was no statistically significant difference in PCL-5 values (paired t-test P-value = 0.14), with a mean of 22 during and 14 post COVID-19 surge volumes. A majority of residents reported using exercise and watching TV or movies as tools to help manage stress (88.4%, 83.7% respectively). A minority of residents reported engaging in art, music, meditation, and/or reading (Figure 4).

DISCUSSION

Attention to physician mental health is perhaps now more than ever imperative. The stressor of the ongoing pandemic, laid on top of a limitation in resources, public skepticism of the disease, and a field that is mentally taxing at baseline puts our healthcare clinicians at increased risk for crisis. This is highlighted by the death of Dr. Lorna M. Breen, who died by suicide while in the midst of treating COVID-19 victims as the medical director of an ED in Manhattan, New York City, NY.[30]

Our work did not show a significant change in burnout symptom frequency pre-, intra-, and post-COVID-19 surge among the EM residents, which was unexpected. Possible reasons for a lack of change include work hours limitations, higher baseline burnout among resident physicians, or duration of the pandemic peak, and perceived increase of public opinion of healthcare workers and emergency physicians in particular, among others, although our small sample size may also be masking significant findings. Additionally, all residents practice under a supervising physician, and deliberate changes

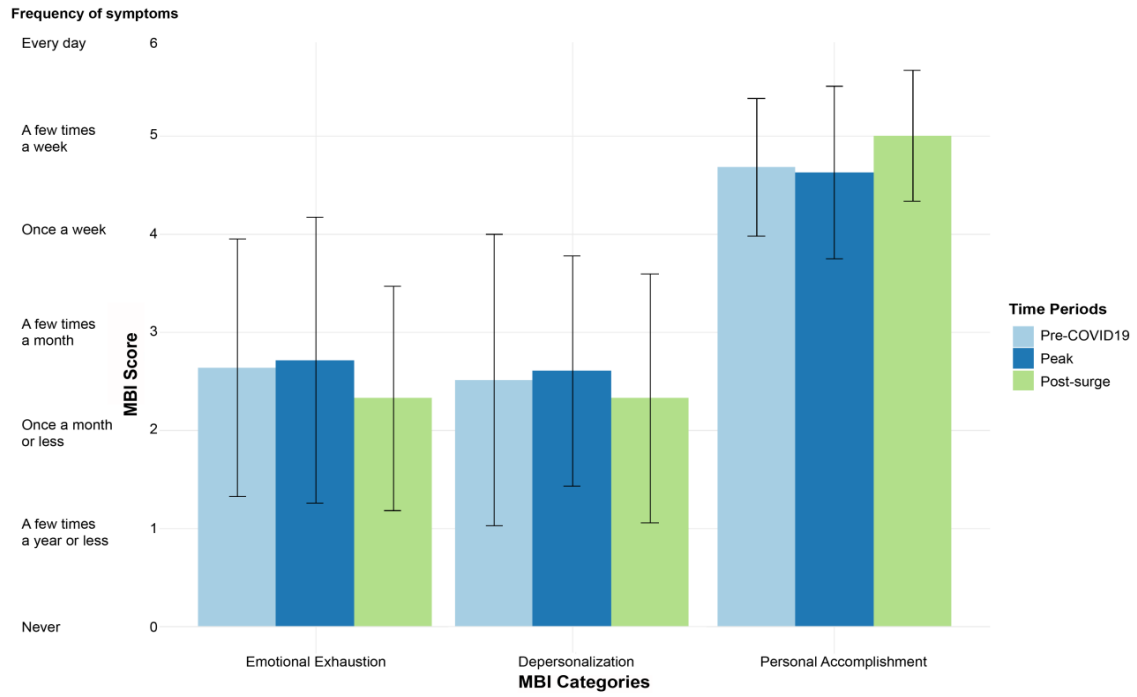


Figure 2. Paired outcomes based on Maslach Burnout Inventory categories (emotional exhaustion, depersonalization, and personal accomplishment) across three different time periods surrounding the first COVID-19 outbreak. The corresponding symptom description is on the y axis corresponding to the Maslach Burnout Inventory (MBI) score.

within the department limited exposure of junior residents to very ill COVID-19 patients. For example, only PGY-3 and PGY-4 residents were involved in intubations or resuscitation of unstable, suspected COVID-19 persons under investigation at the primary teaching site. Further studies within the institution and across the country examining burnout among healthcare personnel at large are forthcoming and should help to elucidate some of these factors.

Our cohort of residents did experience a significant number of PTSD symptoms related to COVID-19 during the peak volume, with two residents having persistent symptoms sufficient to make a preliminary diagnosis of PTSD at and a further five just under the defined threshold. While physicians have a higher baseline level of PTSD, 35% of our participants screened positive based on the PCL-5, which is far higher than the prevalence found in prior studies. The significant decrease in scores on the follow-up survey is consistent with existing knowledge that many persons who experience initial acute stress disorder symptoms do not progress to PTSD, although they are at higher risk.[13]

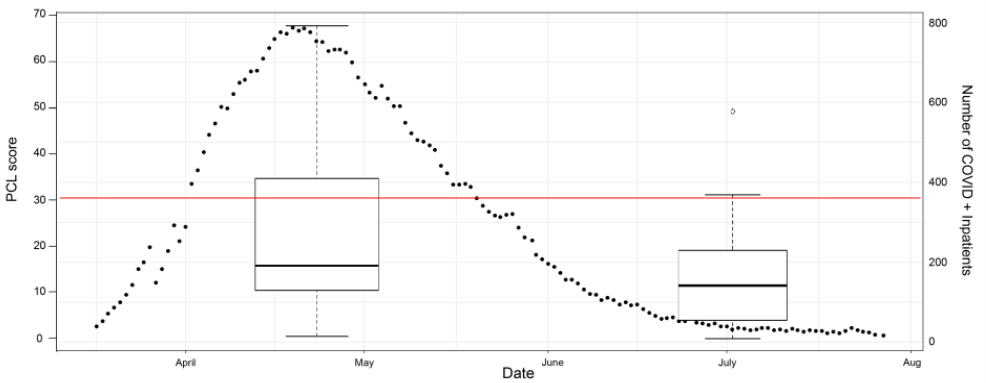


Figure 3. Scatterplot of inpatient COVID-19 patients based on the corresponding dates (right side y axis) with box plot of PCL-5 score during the two survey periods, with box plot width corresponding to the survey administration period. A threshold at 31 is depicted for the PCL-5 score to demonstrate positive screening for PTSD symptoms

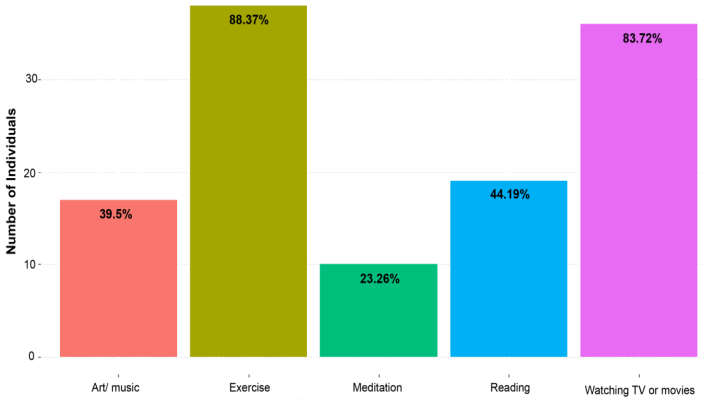


Figure 4. Bar graph depicting how residents reported managing stress across the study period.
Number of individuals is on the y axis, and percentage of total residents participating in the activity is written in each bar.
EM, emergency medicine.

Interestingly, in our smaller cohort, PTSD symptoms did not decrease significantly, which suggest more persistent symptoms in this subgroup. With the number of rising cases across the country again, it is crucial to identify the physicians at risk for development of PTSD and work toward prevention and treatment of those who are affected.

Post-traumatic stress disorder has an identifiable onset and symptom profile, making it accessible for early diagnosis and intervention. Cognitive behavioral therapy (CBT) is the current mainstay of treatment. The therapy can involve different approaches and aims, such as exposure-based treatment, aimed at controlling reactions and decreasing avoidance, and cognitive-based CBT, which is aimed at challenging beliefs surrounding meaning and implications of the trauma using available evidence and guidance.[31,32] For physicians with PTSD symptoms it is thus imperative that early recognition and referral are priorities of programs and care aimed at helping this population.

LIMITATIONS

Our study is limited foremost by sample size. We felt that it was important that we had pre-COVID MBI-HSS data, but this limited our participants to the resident cohort that had rotated through their simulation rotation up to the point of the pandemic outbreak. We found that our MBI results were similar to a larger, multicenter study of 261 EM residents, suggesting our smaller cohort is representative of a typical EM program.[33] Our overall follow-up response rate was approximately 50%. Informally, we received feedback that the residents had survey fatigue during this time, with several ongoing study initiatives during the pandemic in addition to clinical duties amounting to a palpably increased overall workload.

We found that 35% of our participants screened positive for PTSD symptoms related to the COVID-19 pandemic using the PCL-5. This instrument cannot, however, be used in isolation as a diagnostic tool. A formal diagnosis of acute stress disorder and/or PTSD would rely on a structured diagnostic interview, which was not done in this study. Additionally, further work would be needed to compare underlying risk factors of our cohort and COVID-19 volume, institutional support, case severity, and other factors with EM residents at large to inform generalizability of our findings across programs. Our paired cohort had a decrease in PCL-5 scores that did not reach significance, which we suspect may be secondary to a lower N but could also be due to more persistent symptoms in this subgroup.

CONCLUSION

Our resident physician study population did not experience a significant change in burnout symptoms from pre-COVID-19 baseline during or following the case surge in Northeast US. A substantial proportion of residents (35%) experienced post-traumatic stress symptoms acutely during the crisis, potentially indicating a high prevalence of acute stress disorder in this population and increased risk of developing PTSD. The majority of residents had improvement of these symptoms at a greater than one month follow-up. Future work in delineating factors in burnout and PTSD in healthcare personnel may be interesting given these findings. Early screening for physicians at risk and referral for assessment and treatment will be crucial to help mitigate pandemic-related PTSD. Strategies for early detection and primary prevention of PTSD among physicians is ripe for further study, with the most important factors being early identification and referral.

This research was presented at the New England Regional Meeting of SAEM (4/7/2021) as Lightning Oral Presentation, and SAEM Lightning Oral (May 13, 2021).

Address for Correspondence: Melissa Joseph, MD, Yale School of Medicine, Department of Emergency Medicine, 728 Howard Avenue, New Haven, CT 06519. Email: melissa.joseph@yale.edu.

Conflicts of Interest: By the WestJEM 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. Funding for the Maslach Burnout Inventory licenses was granted by the Society of Academic Emergency Medicine Foundation (SAEMF) via the Educational Project Grant, which was funded through December 31, 2020. Dr. Melissa Joseph has received grant funding from the SAEMF for investigator-initiated research. Dr. Leigh Evans has received grant funding from the Department of Defense for investigator-initiated research.

REFERENCES

1. Schneider A, Weigl M. Associations between psychosocial work factors and provider mental well-being in emergency departments: A systematic review. *PLoS One*. 2018;13(6):e0197375.
2. Boutou A, Pitsiou G, Sourla E, Kioumis I. Burnout syndrome among emergency medicine physicians: an update on its prevalence and risk factors. *Eur Rev Med Pharmacol Sci*. 2019;23(20):9058-9065.
3. Popa F, Arafat R, Purcărea VL, et al. Occupational burnout levels in emergency medicine--a stage 2 nationwide study and analysis. *J Med Life*. 2010;3(4):449-53.
4. Rosenstein AH. Addressing physician stress, burnout, and compassion fatigue: the time has come. *Isr J Health Policy Res*. 2013;2(1):32.
5. Shanafelt TD, Bradley KA, Wipf JE, Back AL. Burnout and self-reported patient care in an internal medicine residency program. *Ann Intern Med*. 2002;136(5):358-67.
6. Block L, Wu AW, Feldman L, et al. Residency schedule, burnout and patient care among first-year residents. *Postgrad Med J*. 2013;89(1055):495-500.
7. Bragard I, Dupuis G, Fleet R. Quality of work life, burnout, and stress in emergency department physicians: a qualitative review. *Eur J Emerg Med*. 2015;22(4):227-34.
8. Cheng FJ, Wu CH, Syue YJ, et al. Association of physician risk tolerance with ED CT use for isolated dizziness/vertigo patients. *Am J Emerg Med*. 2014;32(10):1284-8.
9. Zhang Y, Feng X. The relationship between job satisfaction, burnout, and turnover intention among physicians from urban state-owned medical institutions in Hubei, China: a cross-sectional study. *BMC Health Serv Res*. 2011;11:235.
10. Lazarus A. Traumatized by practice: PTSD in physicians. *J Med Pract Manage*. 2014;30(2):131-4.
11. Wilberforce N, Wilberforce K, Aubrey-Bassler FK. Post-traumatic stress disorder in physicians from an underserviced area. *Fam Pract*. 2010;27(3):339-43.
12. DeLucia JA, Bitter C, Fitzgerald J, et al. Prevalence of post-traumatic stress disorder in emergency physicians in the United States. *West J Emerg Med*. 2019;20(5):740-6.
13. Yehuda R. Post-traumatic stress disorder. *N Engl J Med*. 2002;346(2):108-14.
14. Helzer JE, Robins LN, McEvoy L. Post-traumatic stress disorder in the general population. Findings of the epidemiologic catchment area survey. *N Engl J Med*. 1987;317(26):1630-4.
15. Mills LD, Mills TJ. Symptoms of post-traumatic stress disorder among emergency medicine residents. *J Emerg Med*. 2005;28(1):1-4.
16. Jackson T, Provencio A, Bentley-Kumar K, et al. PTSD and surgical residents: Everybody hurts… sometimes. *Am J Surg*. 2017;214(6):1118-24.
17. Dutheil F, Mondillon L, Navel V. PTSD as the second tsunami of the SARS-Cov-2 pandemic. *Psychol Med*. 2021;51(10):1773-4.
18. Mak IW, Chu CM, Pan PC, et al. Risk factors for chronic post-traumatic stress disorder (PTSD) in SARS survivors. *Gen Hosp Psychiatry*. 2010;32(6):590-8.
19. Maunder RG, Lancee WJ, Balderson KE, et al. Long-term psychological and occupational effects of providing hospital healthcare during SARS outbreak. *Emerg Infect Dis*. 2006;12(12):1924-32.
20. Nickell LA, Crighton EJ, Tracy CS, et al. Psychosocial effects of SARS on hospital staff: survey of a large tertiary care institution. *CMAJ*. 2004;170(5):793-8.
21. Rajkumar RP. Post-traumatic stress in the wake of the COVID-19 pandemic: a scoping review. *F1000Res* 2020;9:675.
22. Huang JZ, Han MF, Luo TD, et al. Mental health survey of medical staff in a tertiary infectious disease hospital for COVID-19. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi*. 2020;38(3):192-5.
23. Ct DATA. COVID-19 Tests, Cases, Hospitalizations, and Deaths (Statewide). 2020. Available at: https://data.ct.gov/Health-and-Human-Services/COVID-19-Tests-Cases-Hospitalizations-and-Deaths-S/rf3k-f8fg. Accessed July 27, 2020.
24. Iwanicki EF, Schwab RL. A cross validation study of the Maslach Burnout Inventory. *Educ Psychol Meas* 1981;41:1167-74.
25. Gil-Monte PR. Factorial validity of the Maslach Burnout Inventory (MBI-HSS) among Spanish professionals. *Rev Saúde Pública*. 2005;39(1):1-8.
26. Maslach C, Jackson SE, Leiter MP, et al. (1986). Maslach Burnout Inventory. Palo Alto, CA:Consulting Psychologists Press.
27. Weathers FW, Litz BT, Keane TM, et al. PTSD Checklist for DSM-5 (PCL-5). 2013. Available at: https://www.ptsd.va.gov/professional/assessment/adult-sr/ptsd-checklist.asp. Accessed March 26th, 2020.
28. Blevins CA, Weathers FW, Davis MT, et al. the posttraumatic stress disorder checklist for DSM-5 (PCL-5): development and initial psychometric evaluation. *J Trauma Stress*. 2015;28(6):489-98.
29. Bovin MJ, Marx BP, Weathers FW, et al. Psychometric properties of the PTSD Checklist for *Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition* (PCL-5) in veterans. *Psychol Assess*. 2016;28(11):1379-91.
30. Watkins A, Rothfeld M, Rashbaum WK, et al. Top E.R. doctor who treated virus patients dies by suicide. 2020. Available at: https://www.nytimes.com/2020/04/27/nyregion/new-york-city-doctor-suicide-coronavirus.html. Accessed July 26, 2020.
31. Bisson JI, Roberts NP, Andrew M, Cooper R, Lewis C. Psychological therapies for chronic post-traumatic stress disorder (PTSD) in adults. *Cochrane Database Syst Rev*. 2013;2013(12):CD003388.
32. Kar N. Cognitive behavioral therapy for the treatment of post-traumatic stress disorder: a review. *Neuropsychiatr Dis Treat*. 2011;7:167-81.
33. Williamson K, Lank PM, Cheema N, et al. Emergency Medicine Education Research Alliance (EMERA). Comparing the Maslach Burnout Inventory to other well-being instruments in emergency medicine residents. *J Grad Med Educ*. 2018;10(5):532-6.

Development and Validation of a Novel Triage Tool for Predicting Cardiac Arrest in the Emergency Department

Chu-Lin Tsai, MD, ScD*†
Tsung-Chien Lu, MD, PhD*†
Cheng-Chung Fang, MD*†
Chih-Hung Wang, MD, PhD*†
Jia-You Lin, MS*
Wen-Jone Chen, MD, PhD*†
Chien-Hua Huang, MD, PhD*†

*National Taiwan University Hospital Department of Emergency Medicine, Taipei, Taiwan
†National Taiwan University College of Medicine, Department of Emergency Medicine, Taipei, Taiwan

Section Editor: David Page, MD
Submission history: Submitted May 6, 2021; Revision received July 11, 2021; Accepted August 2, 2021
Electronically published February 23, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.8.53063

Background: Early recognition and prevention of in-hospital cardiac arrest (IHCA) have played an increasingly important role in the chain of survival. However, clinical tools for predicting IHCA are scarce, particularly in the emergency department (ED). We sought to estimate the incidence of ED-based IHCA and to develop and validate a novel triage tool, the Emergency Department In-hospital Cardiac Arrest Score (EDICAS), for predicting ED-based IHCA.

Methods: In this retrospective cohort study we used electronic clinical warehouse data from a tertiary medical center with approximately 100,000 ED visits per year. We extracted data from 733,398 ED visits over a seven-year period. We selected one ED visit per person and excluded out-of-hospital cardiac arrest or children. Patient demographics and computerized triage information were included as potential predictors.

Results: A total of 325,502 adult ED patients were included. Of these patients, 623 (0.2%) developed ED-based IHCA. The EDICAS, which includes age and arrival mode and categorizes vital signs with simple cut-offs, showed excellent discrimination (area under the receiver operating characteristic [AUROC] curve, 0.87) and maintained its discriminatory ability (AUROC, 0.86) in cross-validation. Previously developed early warning scores showed lower AUROC (0.77 for the Modified Early Warning Score and 0.83 for the National Early Warning Score) when applied to our ED population.

Conclusion: In-hospital cardiac arrest in the ED is relatively uncommon. We developed and internally validated a novel tool for predicting imminent IHCA in the ED. Future studies are warranted to determine whether this tool could gain lead time to identify high-risk patients and potentially reduce ED-based IHCA. [West J Emerg Med. 2022;23(2)258–267.]

INTRODUCTION

In-hospital cardiac arrest (IHCA) has increasingly been recognized as a separate entity from out-of-hospital cardiac arrest (OHCA).[1] Out-of-hospital cardiac arrests are typically sudden events that have a primary cardiac cause, whereas IHCAs occur typically in older patients with both cardiac and respiratory causes.[1] Although IHCA has been traditionally understudied, recent studies have begun to reveal its incidence and survival using data from large clinical registries, such as the United Kingdom National Cardiac Arrest Audit (UK NCAA) database[2] and the American Heart Association's (AHA) Get With the Guidelines-Resuscitation registry.[3] In the

United States, the incidence of adult-treated IHCA was about 10 per 1000 bed-days (~290,000 patients per year), about 10% of which occurred in the emergency department (ED).[4,5]

There has been increasing interest in research on ED-based IHCA.[6] Patients in the ED may be more prone to IHCA because of infrequent physiologic measurements, ED crowding, and unstable patient conditions.[7] However, previous IHCA studies have focused primarily on ward patients,[8,9] with few studies attempting to validate ward-based IHCA prediction tools in selected ED patients.[10-12] To our knowledge, two ED-based risk prediction tools have been developed; however, they were used to predict in-hospital mortality instead of imminent cardiac arrest in the ED.[13,14] Emergency department-based IHCA events requiring resuscitation are rarer and more difficult to predict than the downstream endpoint of mortality (with or without resuscitation), but are highly relevant to patients and clinicians. Taken together, as EDs around the world see more and sicker patients, there is a need to understand the incidence of IHCA in the ED and to develop better tools at triage to predict catastrophic IHCA events in a crowded ED.

In this study, we aimed to estimate the incidence of cardiac arrest in the ED and to develop and validate a novel triage tool for predicting IHCA in the ED.

Population Health Research Capsule

What do we already know about this issue?
Early recognition of in-hospital cardiac arrest (IHCA) is important in the chain of survival; however, clinical tools for predicting IHCA in the ED are scarce.

What was the research question?
We sought to develop and validate a novel triage tool for predicting ED-based IHCA.

What was the major finding of the study?
The Emergency Department In-hospital Cardiac Arrest Score (EDICAS) was developed and internally validated for predicting imminent IHCA in the ED.

How does this improve population health?
Future studies are warranted to determine whether this novel tool could potentially reduce ED-based IHCA.

METHODS

Study Design and Setting

We conducted a retrospective cohort study using data from the integrated Medical Database of National Taiwan University Hospital (NTUH). This database serves as a central clinical data warehouse for all electronic health records (EHR) in the healthcare system (a main hospital and six branch hospitals), including inpatient, outpatient, and ED records. The electronic database houses a variety of information, including demographics, diagnosis, treatment, imaging, laboratory, prescription, nursing, billing, and administrative data. The database is maintained and updated by dedicated research personnel and has been used for previous research studies.[15,16]

For the current study, we retrieved seven years of ED data from the main hospital between January 1, 2009 and December 31, 2015. The NTUH main hospital is a tertiary academic medical center with approximately 2400 beds and 100,000 ED visits per year. The ED also manages an ED observation unit (EDOU), which is staffed by emergency physicians. This study was approved by the NTUH Institutional Review Board, which waived the requirement for patient informed consent.

Study Population

We extracted data from 733,398 ED visits over the seven-year period, including those in the EDOU. For repeat visits, we selected the last visit per patient to maximize statistical power for cardiac arrest analysis. Because cardiac arrest may result in death during an ED visit that became the last visit for the patient. We further excluded patients aged <18 years or those who presented with OHCA. The OHCA population was identified by the structured chief complaint list in the computerized triage system. Few OHCA patients may have a return of spontaneous circulation prior to ED arrival. These patients were still excluded from our study, as we focused on the IHCA population. The subject selection process is shown in Supplementary eFigure 1.

Variables

We extracted patient demographics and the following time-stamped clinical information at triage: chief complaint on presentation; mode of arrival; transfer status; vital signs (temperature, heart rate, systolic and diastolic blood pressure, respiratory rate, oxygen saturation); and levels of consciousness coded using the Glasgow Coma Scale (GCS). The data extractors were hospital information technology engineers who were blinded to the study hypothesis. After investigator meetings, data underwent rigorous electronic cleaning, and invalid data were set to missing values (eg, out-of-range vital signs). For example, we defined that the respiratory rate ranged between 0-50 breaths per minute.

At ED triage, when assessing levels of consciousness the triage nurse also indicated whether there was an acute change in levels of consciousness from baseline on the structured EHR. Pain scores were evaluated on a numeric rating scale (NRS) of 0 to 10, with 0 being no pain and 10 being the worst pain

imaginable. We further categorized the NRS scores into no (0), mild (1-3), moderate (4-6), and severe (7-10) pain.[17] We also classified levels of consciousness as severe coma (GCS ≤ 8), moderate coma (9-12), and minor coma to normal status (GCS ≥ 13).[18] Patients with special conditions, such as aphasia, tracheostomy, and endotracheal tube intubation, were classified as "other" on the GCS evaluation. We classified ED as day (7 AM-2:59 PM), evening (3 PM-10:59 PM), and night (11 PM-06:59 AM) shifts. The primary diagnosis fields of ED discharge codes were grouped into clinically meaningful categories using the Clinical Classification Software for the *International Classification of Diseases*, *9th Revision, Clinical Modification*.[19]

We extracted the five-level computerized Taiwan Triage and Acuity Scale (TTAS), which contains information on 179 structured chief complaints. Based on computerized algorithms, the TTAS classifies patients in the following order of acuity: level 1, resuscitation; level 2, emergent; level 3, urgent; level 4, less urgent; and level 5, non-urgent. The TTAS was adapted from the Canadian Triage and Acuity Scale and has been validated against hospitalization, length of stay in the ED, and resource utilization.[20]

Outcome Measure

We identified the primary outcome measure, ED-based IHCA, via a cardiopulmonary resuscitation (CPR) code (ie, treated cardiac arrest). Patients with do-not-resuscitate (DNR) status were not counted as treated cardiac arrests. Per the consensus guidelines on reporting IHCA,[1] we calculated the ED-based IHCA incidence as the number of treated arrests (numerator) divided by the ED study population (denominator). The secondary outcome was mortality in the ED.

Statistical Analysis

Summary statistics are presented as proportions (with 95% confidence intervals [CI]), means (with standard deviations), or medians (with interquartile ranges). We examined bivariate associations using Student's t-tests, Mann-Whitney tests, chi-square tests, and chi-square trend tests, as appropriate. We used complete-case analysis, as the vast majority of variables in the analysis had few or no missing values except for respiratory rate. We used multivariable logistic regression to examine the independent factors associated with ED-based IHCA. Variables associated with the primary outcome measure at $P < 0.10$ in bivariate analyses were considered for inclusion in the multivariable analysis. To determine the functional form and cut-off points used for continuous predictors, we grouped these predictors into bins of equal width to see whether log odds of ED-based IHCA changed at certain inflection points. Inflection points were also chosen based on inspection of locally weighted least squares regression smoother. After constructing a full multivariable model, we selected a parsimonious model using the least absolute shrinkage and selection operator. This operator uses a shrinkage parameter to perform the variable selection by penalizing the coefficients of less strong predictors, thereby mitigating potential model overfitting.

We used the variables and their odds ratios (OR) in the condensed model to derive an ED In-hospital Cardiac Arrest Score (EDICAS). The eight-item composite score ranges from 0-13, in which GCS and acute change in consciousness may be used interchangeably. Sensitivity and specificity were calculated with varying cut-off points. We evaluated the discriminatory ability of the final models by using the area under the receiver operating curve (AUROC). The CI of the AUROC was calculated using the DeLong method.[21] We re-evaluated the performance of the final model by 10-fold cross-validation to assess potential model overfitting, and the average AUROC was reported.[22] We also computed model AUROCs by using other early warning scores (EWS), including the National Early Warning Score (NEWS)[8, 23] and Modified Early Warning Score (MEWS)[9] for comparison purposes. Finally, a net reclassification improvement was calculated to estimate the benefit of the EDICAS as compared to the TTAS triage levels.

All OR and beta-coefficients are presented with 95% CIs. We performed all analyses using Stata 16.0 software (StataCorp, College Station, TX). All *P*-values are two-sided, with $P < 0.05$ considered statistically significant.

RESULTS

Of 733,398 ED visits during the seven-year study period, 405,891 unique patient visits were included. After excluding children aged <18 years or patients with OHCA, we included 325,502 patient visits in the analysis. The patient selection process is shown in Supplementary eFigure 1. Overall, the mean age of these patients was 49 years, and 53% were women. The overall incidence of ED-based IHCA was 0.19% (95% CI: 0.18%-0.21%). As shown in Table 1, compared with non-IHCA patients, patients with IHCA were much older and predominantly male. In terms of season, weekend, or time of ED presentation, there were no significant differences between the two groups. Compared with non-IHCA patients, IHCA patients were more likely to arrive by ambulance, to be transferred from other facilities, and to present with dyspnea and chest pain. Patients with IHCA were also more likely to present with higher triage levels, with impaired consciousness or acute change in consciousness, but were less likely to express pain of any levels. Regarding triage vital signs, IHCA patients presented with higher heart and respiratory rates but lower oxygen saturation and systolic blood pressure. In the IHCA group, the median time to CPR was about seven hours. The median length of ED stay was about nine hours in the IHCA group and about three hours in the non-IHCA group. The admission and ED mortality rates were high among patients with IHCA. The most common discharge diagnoses/symptoms for ED patients with IHCA were pneumonia, chest pain, and gastrointestinal hemorrhage (Supplementary eTable 1).

Table 1. Baseline clinical characteristics of emergency department patients by in-hospital cardiac arrest status.

Variable	IHCA (N = 623)	No IHCA (N = 324,879)	*P*-value
Age, mean (SD), yr	67.1 (16.5)	48.6 (19.9)	<0.001
Female gender, N (%)	241 (38.7)	172,109 (53.0)	<0.001
Season, N (%)			0.338
Spring (Mar. – May)	163 (26.2)	83,330 (25.6)	
Summer (June – Aug.)	148 (23.8)	81,779 (25.2)	
Fall (Sep. – Nov.)	139 (22.3)	78,565 (24.2)	
Winter (Dec. – Feb.)	173 (27.8)	81,205 (25.0)	
Weekend, N (%)	183 (29.4)	102,959 (31.7)	0.214
Time of presentation, N (%)			0.069
7 AM to 2:59 PM	271 (43.5)	127,477 (39.2)	
3 PM to 10:59 PM	236 (37.9)	136,297 (42.0)	
11 PM to 6:59 AM	116 (18.6)	61,105 (18.8)	
Arrival by ambulance, N (%)	245 (39.3)	30,453 (9.4)	<0.001
Transfer in, N (%)	104 (16.7)	23,008 (7.1)	<0.001
Presenting chief complaint, N (%)			<0.001
Abdominal pain	33 (5.3)	38,480 (11.9)	
Fever	41 (6.6)	23,198 (7.1)	
Dyspnea	163 (26.2)	16,639 (5.1)	
Dizziness	15 (2.4)	14,830 (4.6)	
Chest pain	41 (6.6)	9,951 (3.0)	
Other	328 (52.8)	219,994 (68.1)	
Triage level, N (%)			<0.001
1	254 (40.8)	8,519 (2.6)	
2	226 (36.3)	82,112 (25.3)	
3	135 (21.7)	191,290 (58.9)	
4	6 (1.0)	30,938 (9.5)	
5	2 (0.3)	12,020 (3.7)	
Pain score, N (%)			<0.001
Severe (7-10)	62 (10.4)	71,071 (22.0)	
Moderate (4-6)	40 (6.7)	67,971 (21.0)	
Mild (1-3)	5 (0.8)	13,410 (4.2)	
No pain (0)	488 (82.0)	170,527 (52.8)	
GCS, N (%)			<0.001
13-15	461 (74.0)	315,070 (97.0)	
9-12	54 (8.7)	4,663 (1.4)	
3-8	75 (12.0)	2,408 (0.7)	
Other (A, E, T)	33 (5.3)	2,738 (0.8)	
Acute change in consciousness, %	145 (23.3)	6595 (2.0)	<0.001
Vital signs at triage			
Systolic blood pressure, mean (SD), Mm Hg	122.2 (36.3)	136.2 (26.7)	<0.001
Heart rate, mean (SD), beats per minute	99.0 (28.6)	88.9 (19.1)	<0.001
Body temperature, mean (SD), °C	36.9 (1.3)	36.9 (0.8)	0.073
Respiratory rate, mean (SD), breaths per minute[a]	21.3 (4.9)	18.2 (2.2)	<0.001

IHCA, in-hospital cardiac arrest; *SD*, standard deviation; *mm Hg*, millimeters of mercury; *GCS*, Glasgow Coma Scale; *A,E,T,* aphasia, tracheostomy, and endotracheal tube intubation; *GCS-A*, aphasia; *GCS-E*, endotracheal tube; *GCS-T*, tracheostomy

Table 1. Continued.

Variable	IHCA (N = 623)	No IHCA (N = 324,879)	*P*-value
Oxygen saturation, median (IQR), %	96 (92-98)	97 (96-99)	<0.001
Time to CPR, median (IQR), hr	7.0 (3.1-23.3)		
Length of ED stay, median (IQR), hr	8.7 (3.5-26.5)	2.8 (1.4-7.9)	<0.001
Discharge status, N (%)			<0.001
Discharge	0	252,998 (77.9)	
Admission	293 (47.0)	61,112 (18.8)	
Death	308 (49.4)	1,430 (0.4)	
Other[b]	22 (3.5)	9,329 (2.9)	

[a] Available in 546 IHCA and 307,767 non-IHCA patients. [b] The 22 patients in the IHCA group left the hospital to die at home. The 9329 patients in the non-IHCA group were transferred to a nursing home, were discharged against medical advice, or left without being seen. *IQR*, interquartile range; *CPR*, cardiopulmonary resuscitation; *ED*, emergency department; *hr*, hour.

Multivariable analysis showed that factors associated with an increased risk of ED-based IHCA included older age, arrival by ambulance, transfers, day and night (vs evening) shifts, low systolic blood pressure (<90 millimeters of mercury [mm Hg]), brady- (<60/minute) and tachycardia (>90/minute), low oxygen saturation (<95%), tachypnea (≥22/min), hypothermia (<36°C), and triage levels 1 and 2 (Table 2). By contrast, moderate and severe pain (vs no pain) and triage levels 4 and 5 were associated with a decreased risk of IHCA in the ED.

A condensed model of multivariable analysis included the following strong predictors of ED-based IHCA: age ≥ 65years; arrival by ambulance; low systolic blood pressure (<90 mm Hg); brady- (<60/minute [min]) and tachycardia (>90/min); low oxygen saturation (<95%); tachypnea (≥22/min); hypothermia (<36°C); and GCS<15 (Table 3). This condensed model showed excellent discrimination (AUROC, 0.87; Supplementary eFigure 2) and maintained its discriminatory ability (AUROC, 0.86) in 10-fold cross-validation. Previously developed early warning scores showed lower AUROC (0.77 for MEWS and 0.83 for NEWS, *P* <0.001 for either one vs EDICAS) when applied to our ED population (Figure 1).

Based on the condensed model, we developed a predictive tool, the EDICAS (Table 4). The eight-item composite score ranges from 0-13, in which GCS and acute change in consciousness may be used interchangeably. The alternative EDICAS model with acute change in levels of consciousness

Table 2. Multivariable analysis of factors associated with emergency department-based in-hospital cardiac arrest.

Variable	Adjusted Odds Ratio	95% Confidence Interval	*P*-value
Age (per 10-year increase)	**1.34**	1.25 - 1.42	<0.001
Female gender	1.19	0.97 - 1.47	0.099
Time of presentation			
7 AM to 2:59 PM	**1.30**	1.03 - 1.64	0.026
3 PM to 10:59 PM (reference)	1.00		
11 PM to 6:59 AM	**1.35**	1.003 - 1.81	0.047
Arrival by ambulance	**1.89**	1.46 - 2.45	<0.001
Transfer	**1.41**	1.04 - 1.89	0.025
Chief complaint			
Abdominal pain	1.22	0.76 - 1.95	0.414
Fever	0.85	0.55 - 1.3	0.451
Dyspnea	1.06	0.78 - 1.44	0.711
Dizziness	0.82	0.45 - 1.49	0.512
Chest pain	1.48	0.94 - 2.31	0.089
Other (reference)	1.00		

Significant odds ratios are highlighted in bold.

Table 2. Continued.

Variable	Adjusted odds ratio	95% Confidence interval	*P*-value
Triage level			
1	**2.48**	1.64 - 3.76	<0.001
2	**1.96**	1.51 - 2.54	<0.001
3 (reference)			
4	**0.33**	0.12 - 0.91	0.032
5	**0.30**	0.42 – 2.16	0.232
Pain score			
No pain (reference)			
Mild (1-3)	0.35	0.09 - 1.43	0.144
Moderate (4-6)	**0.63**	0.42 - 0.95	0.028
Severe (7-10)	**0.65**	0.46 - 0.94	0.021
GCS			
15 (reference)	1.00		
14	1.35	0.55 - 3.32	0.508
9-13	1.06	0.73 - 1.52	0.767
≤ 8	1.06	0.66 - 1.68	0.819
Other (A, E, T)	1.1	0.66 - 1.83	0.714
Vital signs at triage			
Systolic blood pressure < 90 mm Hg	**2.84**	2.05 - 3.91	<0.001
Heart rate			
< 60 beats per minute	**1.87**	1.15 - 3.02	0.011
60-90 (reference)	1.00		
> 90 beats per minute	**2.14**	1.68 - 2.73	<0.001
Body temperature			
< 36°C	**2.26**	1.69 - 3.04	<0.001
36-39 °C (reference)			
> 39°C	1.16	0.72 - 1.88	0.541
Respiratory rate ≥ 22 breaths per minute	**2.34**	1.76 - 3.11	<0.001
Oxygen saturation < 95%	**1.52**	1.18 - 1.96	0.001

Significant odds ratios are highlighted in bold.
GCS, Glasgow Coma Scale; *GCS-A*, aphasia; *GCS-E*, endotracheal tube; *GCS-T*, tracheostomy; *mm Hg*, millimeters of mercury.

yielded similar results (Supplementary eTable 2). We defined an EDICAS of 0-2, 3-5, 6+ as low-, medium-, and high-risk categories, respectively. Most patients were in the low-risk group (81%), and others were in the medium-risk (17%) and high-risk groups (2%). An EDICAS of 6+ corresponded to a specificity of 98%, and a positive likelihood ratio of 12.7 (Table 5). Compared with the TTAS triage levels, the EDICAS risk categories yielded a net reclassification improvement of 19%. In the IHCA group, 14% were correctly reclassified using the EDICAS. Finally, the EDICAS also showed outstanding discrimination power in predicting ED mortality (AUROC, 0.91).

DISCUSSION

In this ED-based study of 325,502 patients, we found that a relatively small fraction of patients (2 in 1000) developed IHCA. A novel and simple eight-item triage score predicted imminent ED-based IHCA with excellent discriminatory power, with an AUROC outperforming previous early warning scores. Future prospective studies are warranted to replicate our results and to determine whether the implementation of this tool could actually gain lead time to identify high-risk patients and potentially reduce devastating, ED-based IHCA events.

Despite the catastrophic nature of IHCA, the epidemiology of IHCA remains largely unknown worldwide.[24] The vast majority of data came from the AHA and UK NCAA databases.[2,4] The most recent US data reported an estimated incidence of IHCA of 9-10 per 1000 admissions,[4] while the UK database provided a much smaller figure of IHCA of 1.6 per 1000 admissions.[2] Both data sources suggested that approximately 10% of IHCA events occurred in the ED. However, the denominators

Table 3. Condensed multivariable model of factors associated with emergency department-based in-hospital cardiac arrest.

Variable	Adjusted odds ratio	95% Confidence interval	*P*-value
Age ≥ 65 years	2.76	2.20 - 3.47	<0.001
Arrival by ambulance	2.11	1.66 - 2.67	<0.001
Systolic blood pressure < 90 mm Hg	4.03	2.97 - 5.46	<0.001
Heart rate			
< 60 beats per minute	2.16	1.33 - 3.50	0.002
60-90 (reference)	1.00		
> 90 beats per minute	2.26	1.86 - 2.99	<0.001
Body temperature < 36°C	2.61	1.95 - 3.49	<0.001
Respiratory rate ≥ 22 breaths per minute	3.18	2.46 - 4.12	<0.001
Oxygen saturation < 95%	1.94	1.52 - 2.48	<0.001
GCS < 15	1.57	1.19 - 2.07	0.001

mm Hg, millimeters of mercury; *GCS*, Glasgow Coma Scale.

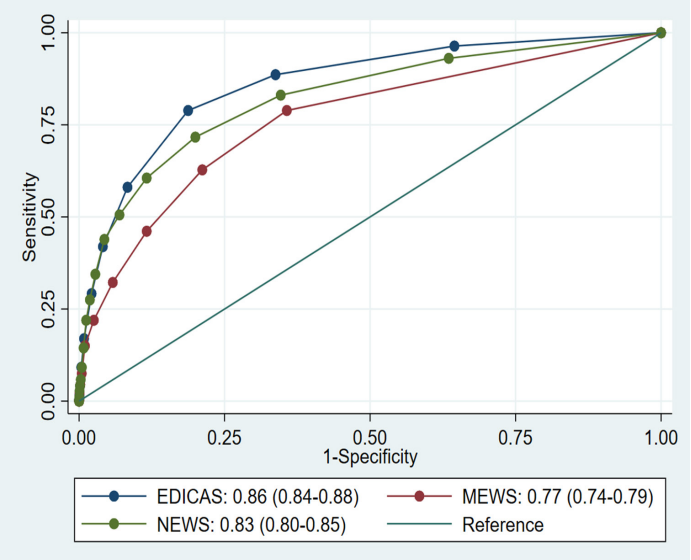


Figure 1. Receiver operating characteristic curves for three early warning scores: EDICAS, MEWS, and NEWS.* The numbers in parentheses indicate the confidence intervals for the area under the receiver operating characteristic curve. The diagonal line represents a model of no discriminatory ability.
**EDICAS*, Emergency Department In-hospital Cardiac Arrest Score; *MEWS*, Modified Early Warning Score; *NEWS*, National Early Warning Score.

of the abovementioned IHCA incidence rates were based on inpatient admissions, not ED visits. Given a larger denominator of ED visits and a subset of IHCA events occurring in the ED, the ED-based IHCA incidence was expected to be lower than the inpatient IHCA incidence. Indeed, our estimate of IHCA incidence was about 1.9 per 1000 ED visits, which was much lower than the US inpatient IHCA incidence. This figure may be useful for benchmarking future ED-based IHCA studies.

Regarding seasonal variation, the incidence of ED-based IHCA in our study peaked in the winter, paralleling that in the UK study.[2] The increased ED-based IHCA events during the winter months may result from concurrent increased cardiovascular and respiratory diseases. Interestingly, the EDICAS also peaked in the winter (mean score, 1.47 in the winter vs 1.26 in the summer [data not shown]), supporting its concurrent validity. In terms of disease burden, with approximately seven million ED visits annually in Taiwan,[25] this small incidence could potentially translate into ~14,000 IHCA events in the ED. Given a high mortality rate of ~80% for IHCA patients,[2,24,26] many patients could benefit from early recognition of IHCA.

As shown in recent resuscitation guidelines,[27] the first link of the in-hospital chain of survival is early recognition and prevention of IHCA. Emergency department-based IHCA has increasingly been recognized as a distinct entity from IHCAs in other locations, such as on the ward or in the intensive care unit.[24,28] The median time to cardiac arrest was about two days in previous reports of ward patients,[5,29] while ours was about seven hours. As our ED also manages an EDOU, some of the IHCA patients deteriorated later in their ED course, which might have lengthened the time to arrest. Nonetheless, the relatively shorter time to cardiac arrest in ED patients suggests the time-sensitive nature of some emergencies, such as acute respiratory compromise and acute coronary syndrome. Indeed, the most common presentations were dyspnea and chest pain in our IHCA population, with discharge codes suggesting possible diagnoses of pneumonia, shock, and syncope. Despite the shorter time to cardiac arrest, ED-based IHCAs have been linked to improved survival to hospital discharge than those occurring in other locations, probably due to 24-hour on-site physician coverage and quick access to advanced life support equipment.[5] With these advantages, early recognition of imminent IHCA in the ED should have great potential to reverse the course of further deterioration.

We developed and validated an ED-specific, eight-item EWS that we call the EDICAS, which is intended to be used at ED triage to augment traditional triage in predicting imminent cardiac arrest. After a stringent selection of the strongest predictors, the condensed model comprised older age, arrival mode, and primarily vital signs. Some of the original predictors, such as time of presentation and pain score, were selected out due to concerns of model overfitting. The inclusion of older age in the EDICAS highlights the importance of age in the triage process[30] because a previous study suggested that older patients requiring an immediate life-saving intervention were more likely to be missed by using the Emergency Severity Index at triage.[31] The addition of arrival by ambulance to this ED-specific tool seems quite reasonable because this variable should be readily available in most EDs. Some of the cut-offs for vital signs in the EDICAS were much simpler than those in previous EWS,[8,9,13] making it easier to calculate and use at ED triage or before seeing the patient. We speculate that some unique characteristics of the ED population, such as a broad spectrum of acuity, may have contributed to a sharp contrast in severity between urgent and critically ill patients, resulting in fewer vital-sign cut-offs in the EDICAS. For example, the EDICAS does not assign points for high body temperature and high blood pressure as other EWSs do. Along these lines, previous ED-based studies showed that hyperthermia and high blood pressure did not seem to be strongly associated with adverse events in the ED.[32,33]

We defined an EDICAS of 3-5 as a medium-risk category, which may be used to flag patients needing an urgent physician assessment, particularly those who are initially triaged to lower levels. We also defined an EDICAS of 6 or above as a high-risk category as it corresponded to a specificity of 98% and a positive likelihood ratio of 12.7, both of which could raise the probability

Table 4. The items and scoring of the Emergency Department In-hospital Cardiac Arrest Score (EDICAS). The 8-item score ranges from 0 to 13.

Variable	Scoring		
	1	2	3
Age, year		≥ 65	
Arrival by ambulance	Yes		
Systolic blood pressure, mm Hg			<90
Heart rate, beats per min	<60 or > 90		
Body temperature, °C		<36	
Respiratory rate, breaths per minute		≥ 22	
Oxygen saturation, %	<95		
GCS < 15 or acute change in levels of consciousness	Yes		

GCS, Glasgow Coma Scale.

Table 5. Test characteristics of the Emergency Department In-hospital Cardiac Arrest Score (EDICAS).

Cut point	Risk category	Sensitivity, %	Specificity, %	PPV, %	NPV, %	LR+	LR-
≥ 1	Low	97	35	0.2	99.98	1.5	0.1
≥ 2		89	66	0.4	99.96	2.6	0.2
≥ 3	Medium	80	81	0.6	99.94	4.2	0.3
≥ 4		59	91	0.9	99.92	6.8	0.4
≥ 5		43	96	1.4	99.89	9.9	0.6
≥ 6	High	29	98	1.8	99.88	12.7	0.7
≥ 7		17	99	2.5	99.87	18.3	0.8
≥ 8		9	99	3.1	99.86	22.6	0.9
≥ 9		4	99	3.0	99.86	22.3	0.9
≥ 10		2	99	2.9	99.85	21.5	0.9
≥ 11		1	99	2.3	99.85	16.7	0.9
≥ 12		1	99	10.0	99.85	78.8	0.9

PPV, positive predictive value; *NPV*, negative predictive value; *LR+,* positive likelihood ratio; *LR-*, negative likelihood ratio.

of finding rare ED-based IHCA. Similar to the recommendations from the NEWS Working Group,[34] we recommend that a high-risk EDICAS at triage should prompt emergency assessment by an attending physician in the ED and/or transfer of the patient to a critical care area, if available. Physicians' bedside reassessment is important to further increase the positive predictive value of IHCA, ie, confirming imminent IHCA after using the EDICAS as a screening measure. Furthermore, a continuous assessment of patient status would be prudent, as a previous ED study found an increase in NEWS after ED management and the use of a vasoactive agent predicted ED-based IHCA.[35]

LIMITATIONS

This study has some potential limitations. First, this was a single-center study at a tertiary medical center, and our findings may not be generalizable to hospitals of different settings. Second, we did not externally validate our prediction model, and further studies are needed to evaluate our model performance in different patient populations. Third, our predictive tool is intended to be used at ED triage; whether a continuous assessment of EDICAS would also be predictive of ED-based IHCA requires further research.

CONCLUSION

In this large study of 325,502 adult ED patients, 0.2% developed IHCA. We developed and validated a novel eight-item ED triage tool for predicting imminent IHCA in the ED with excellent discriminatory ability. While promising, our results need to be replicated in other EDs. Further research is also warranted to test whether this tool could gain lead time to identify high-risk patients and potentially reduce ED-based IHCA and associated deaths.

Earlier and partial results from this study were presented at the 2017 American Heart Association Scientific Sessions (Anaheim, CA; November 2017).

Address for Correspondence: Chien-Hua Huang, MD, PhD, National Taiwan University Hospital, Department of Emergency Medicine, 7 Zhongshan S. Rd, Taipei 100, Taiwan. Email: chhuang5940@ntu.edu.tw.

Conflicts of Interest: By the WestJEM 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 grants from the National Taiwan University Hospital and the Far Eastern Memorial Hospital; and the Ministry of Science and Technology grant 109-2634-F002-041.

REFERENCES

1. Morrison LJ, Neumar RW, Zimmerman JL, et al. Strategies for improving survival after in-hospital cardiac arrest in the United States: 2013 consensus recommendations: a consensus statement from the American Heart Association. *Circulation.* 2013;127(14):1538-63.
2. Nolan JP, Soar J, Smith GB, et al. Incidence and outcome of in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit. *Resuscitation.* 2014;85(8):987-92.
3. Merchant RM, Yang L, Becker LB, et al. Incidence of treated cardiac arrest in hospitalized patients in the United States. *Crit Care Med.* 2011;39(11):2401-6.
4. Holmberg MJ, Ross CE, Fitzmaurice GM, et al. Annual Incidence of Adult and Pediatric In-hospital Cardiac Arrest in the United States. *Circ Cardiovasc Qual Outcomes.* 2019;12(7):e005580.
5. Kayser RG, Ornato JP, Peberdy MA. Cardiac arrest in the emergency department: a report from the National Registry of Cardiopulmonary Resuscitation. *Resuscitation.* 2008;78(2):151-60.
6. Mikati N, Callaway CW, Coppler PJ, et al. Data-driven classification of arrest location for emergency department cardiac arrests. *Resuscitation.* 2020;154:26-30.
7. Camargo CA Jr, Tsai CL, Sullivan AF, et al. Safety climate and medical errors in 62 US emergency departments. *Ann Emerg Med.* 2012;60(5):555-63.e520.
8. Prytherch DR, Smith GB, Schmidt PE, et al. ViEWS—Towards a national early warning score for detecting adult inpatient deterioration. *Resuscitation.* 2010;81(8):932–7.
9. Subbe CP, Kruger M, Rutherford P, et al. Validation of a modified Early Warning Score in medical admissions. *QJM.* 2001;94(10):521-6.
10. Alam N, Vegting IL, Houben E, et al. Exploring the performance of the National Early Warning Score (NEWS) in a European emergency department. *Resuscitation.* 2015;90:111-5.
11. Spencer W, Smith J, Date P, et al. Determination of the best early warning scores to predict clinical outcomes of patients in the emergency department. *Emerg Med J.* 2019;36(12):716-21.
12. Bilben B, Grandal L, Søvik S. National Early Warning Score (NEWS) as an emergency department predictor of disease severity and 90-day survival in the acutely dyspneic patient - a prospective observational study. *Scand J Trauma Resusc Emerg Med.* 2016;24:80.
13. Lee SB, Kim DH, Kim T, et al. Emergency department Triage Early Warning Score (TREWS) predicts in-hospital mortality in the emergency department. *Am J Emerg Med.* 2020;38(2):203-10.
14. Olsson T, Terent A, Lind L. Rapid Emergency Medicine Score: a new prognostic tool for in-hospital mortality in nonsurgical emergency department patients. *J Intern Med.* 2004;255(5):579-87.
15. Heerspink HJL, Karasik A, Thuresson M, et al. Kidney outcomes associated with use of SGLT2 inhibitors in real-world clinical practice (CVD-REAL 3): a multinational observational cohort study. *Lancet Diabetes Endocrinol.* 2020;8(1):27-35.
16. Wu CS, Kuo CJ, Su CH, et al. Using text mining to extract depressive symptoms and to validate the diagnosis of major depressive disorder from electronic health records. *J Affect Disord.* 2020;260:617-23.

17. Boonstra AM, Stewart RE, Köke AJA, et al. Cut-off points for mild, moderate, and severe pain on the numeric rating scale for pain in patients with chronic musculoskeletal pain: variability and influence of sex and catastrophizing. *Front Psychol.* 2016;7;1466.
18. Kerby JD, MacLennan PA, Burton JN, et al. Agreement between prehospital and emergency department glasgow coma scores. *J Trauma.* 2007;63(5):1026-31.
19. Agency for Healthcare Research and Quality. The Clinical Classifications Software (CCS) for ICD-9-CM by the Agency for Healthcare Research and Quality. 2017. Available at: https://www.hcup-us.ahrq.gov/toolssoftware/ccs/ccs.jsp. Accessed July 1, 2021.
20. Ng CJ, Yen ZS, Tsai JC, et al. Validation of the Taiwan Triage and Acuity Scale: a new computerised five-level triage system. *Emerg Med J.* 2010;28(12):1026-31.
21. DeLong ER, DeLong DM, Clarke-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics.* 1988;44(3):837-45.
22. Steyerberg EW, Harrell FE Jr, Borsboom GJ, et al. Internal validation of predictive models: efficiency of some procedures for logistic regression analysis. *J Clin Epidemiol.* 2001;54(8):774-81.
23. Smith GB, Prytherch DR, Meredith P, et al. The ability of the National Early Warning Score (NEWS) to discriminate patients at risk of early cardiac arrest, unanticipated intensive care unit admission, and death. *Resuscitation.* 2013;84(4):465-70.
24. Andersen LW, Holmberg MJ, Berg KM, et al. In-hospital cardiac arrest: a review. *JAMA.* 2019;321(12):1200-10.
25. Cheng TM. Reflections on the 20th anniversary of Taiwan's single-payer National Health Insurance System. *Health Aff (Millwood).* 2015;34(3):502-10.
26. Girotra S, Nallamothu BK, Spertus JA, et al. Trends in survival after in-hospital cardiac arrest. *N Engl J Med.* 2012;367(20):1912-20.
27. Merchant RM, Topjian AA, Panchal AR, et al. Part 1: Executive Summary: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation.* 2020;142(16_suppl_2):S337-S357.
28. Mitchell OJL, Edelson DP, Abella BS. Predicting cardiac arrest in the emergency department. *J Am Coll Emerg Physicians Open.* 2020;1(4):321-6.
29. Churpek MM, Yuen TC, Park SY, et al. Derivation of a cardiac arrest prediction model using ward vital signs. *Crit Care Med.* 2012;40(7):2102-8.
30. Malinovska A, Pitasch L, Geigy N, et al. Modification of the Emergency Severity Index improves mortality prediction in older patients. *West J Emerg Med.* 2019;20(4):633-40.
31. Platts-Mills TF, Travers D, Biese K, et al. Accuracy of the Emergency Severity Index triage instrument for identifying elder emergency department patients receiving an immediate life-saving intervention. *Acad Emerg Med.* 2010;17(3):238-43.
32. McAlister FA, Youngson E, Rowe BH. Elevated blood pressures are common in the emergency department but are they important? A retrospective cohort Ssudy of 30,278 adults. *Ann Emerg Med.* 2021;77(4):425-32.
33. Schuttevaer R, Brink A, Alsma J, et al. The association of body temperature with antibiotic therapy and mortality in patients attending the emergency department with suspected infection. *Eur J Emerg Med.* 2021;28(6):440-7.
34. Royal College of Physicians. National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS. 2018. Available at: https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news-2. Accessed May 1, 2021.
35. Srivilaithon W, Amnuaypattanapon K, Limjindaporn C, et al. Predictors of in-hospital cardiac arrest within 24 h after emergency department triage: a case-control study in urban Thailand. *Emerg Med Australas.* 2019;31(5):843-50.

Symptoms and Physical Exam Findings in Sexual Assault-related Non-fatal Strangulation

Hannah H. Spungen, MD, MPH* *UCLA Center for Health Sciences, Department of Emergency Medicine, Los Angeles, California
Karen M. Bryan, BS†
Carolyn J. Sachs, MD, MPH*†
†UCLA David Geffen School of Medicine, Los Angeles, California
Malinda J. Wheeler, MSN, FNP‡
‡Forensic Nurse Specialists, Long Beach, California

Section Editor: Emily Manchada, MD
Submission history: Submitted November 19, 2020; Revision received February 24, 2021; Accepted February 25, 2021
Electronically published February 8, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.2.50919

Objective: Our goal was to investigate the frequency of specific signs and symptoms following sexual assault-related non-fatal strangulation (NFS) and to explore the interaction between assault characteristics and physical exam findings.

Methods: This retrospective observational study included all adults (>18 years) reporting strangulation during sexual assault who presented for a forensic sexual assault exam at one of six urban community hospitals contracted with a single forensic nurse agency. Demographic information, narrative elements, and physical exam findings were abstracted from standardized sexual assault reporting forms. We analyzed data with descriptive statistics and compared specific variables using chi-square testing.

Results: Of the 580 subjects 99% were female, with a median age of 27 (interquartile range 22-35 years). The most common injury location was the neck (57.2%), followed by the mouth (29.1%). We found that 19.1% of the victims had no injuries evident on physical exam and 29.8% reported a loss of consciousness. Eye/eyelid and neck findings did not significantly differ between subjects who reported blows to the head in addition to strangulation and those who did not. The time that elapsed between assault and exam did not significantly correlate with the presence of most head and torso physical exam findings, except for nose injury ($P = 0.02$).

Conclusion: Slightly more than half of the victims who reported strangulation during sexual assault had visible neck injuries. Other non-anogenital findings were present even less frequently, with a substantial portion of victims having no injuries documented on physical exam. The perpetrators' use of blows to the head may account for many of the non-anogenital injuries observed, but not for the neck and eye/eyelid injuries, which may be more specific to non-fatal strangulation. More research is needed to definitively establish strangulation as the causal mechanism for these findings, and to determine whether any long-term neurologic or vascular sequelae resulted from the observed injuries. [West J Emerg Med. 2022;23(2)268–275.]

INTRODUCTION

While most emergency physicians (EP) rarely perform forensic sexual assault (SA) exams, the emergency department (ED) remains a critical access point for SA referral and resources, particularly in rural areas or in departments where a sexual assault nurse examiner (SANE) is not available on-call.[1] Thus, it is imperative that EPs be familiar with the patterns of injury and morbidity associated with SA-related complaints, particularly those injuries that are associated with airway or circulatory compromise. Strangulation is one such potentially lethal mechanism of injury wherein external pressure applied to

a victim's neck ultimately obstructs the airway or cerebral blood flow.

Strangulation is not uncommonly reported in the course of SA. Zilkens et al (2016) estimated the frequency of non-fatal strangulation in SA victims to be about 7%,[2] while McQuown et al (2016) reported an incidence of 12% among a similar population, noting that 97% of these cases had "significant risk for lethality."[3] Medical sequelae of strangulation have been well-documented and range from difficulty speaking and sore throat to laryngeal fracture, pulmonary edema, carotid dissection, stroke, coma, and death.[1,4,5] Moreover, victims of intimate partner violence (IPV) who report a history of non-fatal strangulation have been shown to be at 7.48-fold greater risk of death by homicide than cohort-matched controls,[6] making non-fatal strangulation an important prognostic indicator for recidivism and mortality.

Despite the consistency with which non-fatal strangulation is reported in SA survivors and the potential severity of risk that a history of strangulation confers, little is known about the specific injury patterns resulting from SA-related strangulation. Plattner et al (2003) attempted to generate a classification system for strangulation-related injury severity based on a retrospective chart review of 134 cases but went on to note that 95 (71%) of these cases did not fit criteria for just one category of classification.[7] Another review of 300 domestic violence cases in San Diego County, California, noted that 50% of strangulation victims had no visible injury,[8] a phenomenon that has historically led to trivialization of the violence that transpired (and potential medical sequelae thereof) by both law enforcement and medical personnel.[9,18]

Complicating matters further, medical documentation has been shown to significantly impact outcomes in the minority of SA cases that do go to trial,[10] although there is a relative paucity of literature describing how often physical exam findings are documented in non-fatal strangulation during SA. In this study we sought to determine the frequency and characteristics of various symptoms and physical exam findings present in SA victims reporting strangulation, and to describe how these findings correlate with the mechanism of strangulation described in the victim's account of the assault.

Population Health Research Capsule

What do we already know about this issue?
Strangulation is a common injury sustained during sexual assault that can cause injury ranging from temporary pain or dyspnea to carotid dissection, coma, or death.

What was the research question?
What is the frequency, nature, and severity of the injuries associated with non-fatal strangulation in survivors of sexual assault?

What was the major finding of the study?
About 57% of subjects reporting strangulation during their assault had an associated positive finding on physical exam of the neck. Almost 20% had no positive physical exam findings.

How does this improve population health?
Understanding the injury patterns in sexual assault is essential to providing sensitive, trauma-informed care to this highly vulnerable population.

METHODS

Study Design

We performed a retrospective observational study describing the demographics, assault characteristics, and signs/symptoms present among adult SA victims presenting for forensic evaluation between January 2006– May 2019. An exemption to informed consent was granted by our institutional review board due to the absence of any personally identifying information recorded in our dataset.

Study Setting and Population

The study population consisted of all adult (>18 years) SA victims reporting strangulation who were examined by a single forensic nurse examination agency contracted with six urban, community hospitals in the Southern California area between January 1, 2006–May 30, 2019. We excluded those victims who were unsure whether they had been strangled due to loss of consciousness, amnesia related to drug/alcohol use, or blunt head injury. We included those victims who reported strangulation even if a strangulation addendum form (as described in the study protocol) was not attached to their record. We excluded those victims whose recollection of the assault was so unclear, or so sparsely documented, that it was uncertain whether they had been strangled.

Study Protocol

The patient exams were performed by 38 SANE professionals who had been trained in accordance with the educational standards for the Office of Emergency Services in California and the International Association of Forensic Nurses. All exams were documented using the State of California Emergency Management Agency (Cal EMA) Form 2-923. The median number of exams performed by each nurse examiner was six, with an interquartile range of 2-12.75. During the forensic examination, all study subjects underwent a standardized interview, external physical exam with photo documentation, pelvic exam with photo documentation (unless

specifically declined), and external anogenital exam with photo documentation (unless specifically declined). The Cal EMA 2-923 form contents were entered into a database management software TACT (Thorough Assault Case Tracking, Infosys Business Solutions, Bengaluru, India), which was then used to retrospectively identify all eligible subjects flagged as reporting strangulation during the assault. We then used the original Cal EMA 2-923 form as the source document for study data abstraction. Study variables were entered into a spreadsheet in Microsoft Excel (Microsoft Corporation, Redmond, WA).

Study Variables

We collected demographic data including the victims' gender, age, and race. The method of strangulation (eg, manual, ligature) the perpetrator's relationship to the victim, and the victim's pregnancy status were also reported. The presence of weapons (including type, if applicable), alcohol or drug use in the 24 hours preceding the assault, loss of consciousness, and a history of blows to the head during the assault were recorded, along with the presence or absence of specific symptoms: nausea/vomiting; breathing difficulty; urinary incontinence; difficulty swallowing; and voice changes. Each of these items was specifically included as a discrete question on the Cal EMA 2-923 form. The presence of any physical exam finding was reported for the following categories: face; head (excluding face); eyes/eyelids; ear; nose; mouth; under chin; neck; chest; and shoulders. We recorded the time that elapsed between the assault and the victim's presentation as a quantitative variable. In cases where the assault occurred over several hours, the midpoint of the given time range between assault and exam was recorded. All time intervals were rounded to the nearest half hour.

Data Analysis

Spreadsheet data were imported and analyzed with descriptive statistics using R version 3.6.3 (The R Foundation for Statistical Computing, Vienna, Austria). In addition to calculating percentage of positive physical exam findings in the entire study population, we performed several exploratory analyses to evaluate whether injury patterns differed based on specific assault characteristics. First, we calculated the difference in percentage of positive physical exam findings between victims who reported blows to the head vs those who did not, along with a 95% confidence interval (CI), for each physical exam category. Next, we calculated a difference in percentage between IPV vs a collapsed non-IPV cohort (including acquaintance, stranger, and "other" categories) along with a 95% CI for each physical exam category. Finally, a chi-square test with Yates' continuity correction was performed to evaluate for interaction between selected study variables for hypothesis-generating purposes. For continuous variables, data was first logarithmically transformed to generate a more normal distribution and then broken up into tertiles. The tertiles were treated as discrete categories and subjected to chi-square testing as previously described.

RESULTS

We identified 623 subjects ≥18 years of age in the TACT database search, which returned all SA victims who were flagged as reporting strangulation. Ultimately, we included 580 of these subjects in the study database (see Figure 1 for exclusions). The

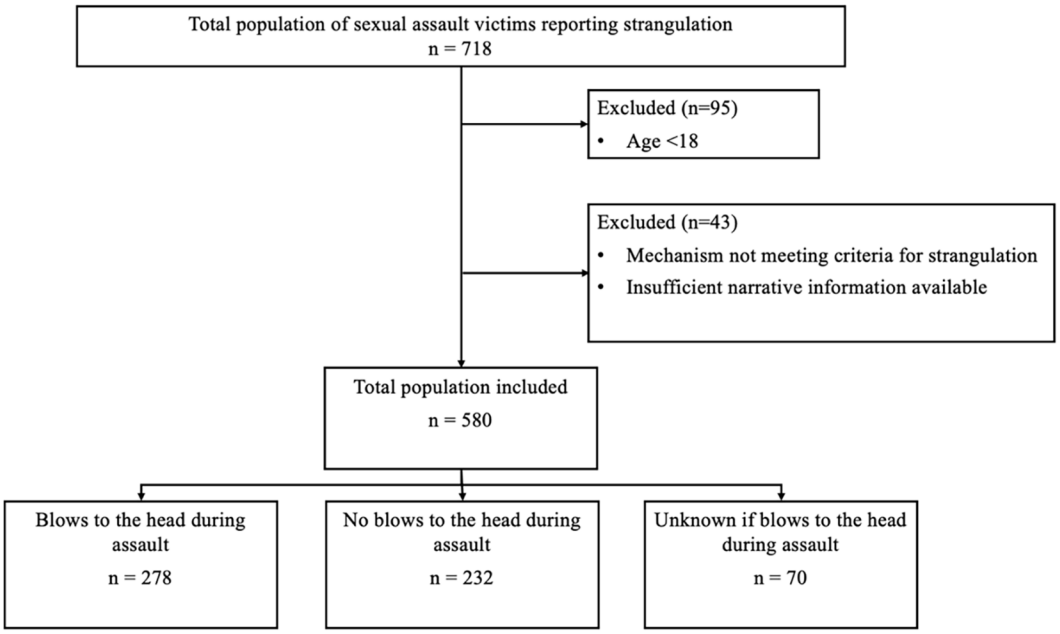


Figure 1. Flow diagram of study population inclusion showing breakdown of subjects who reported blows to the head, including a breakdown of the number of subjects who also reported blows to the head during the assault.

demographics of included subjects are summarized in Table 1, as are the specific characteristics of the assault narrative.

Table 1. Demographics and assault characteristics of sexual assault victims who experienced non-fatal strangulation.

	Frequency (N = 580)	%
Demographics		
Gender		
Female	574	99
Male	6	1
Age (years)*		
18-30	356	61.3
31-40	136	23.4
41-50	57	9.8
51-60	24	4.1
>= 61	7	1.2
Race		
Asian	33	5.7
Black	125	21.7
Hispanic	203	35.2
Other	13	2.3
Unknown	4	0.7
White	202	35.1
Characteristics of Assault		
Assault to Presentation Time (hours)*	10 (5-22)	
Perpetrator		
Acquaintance	241	41.6
Stranger	91	15.7
IPV	192	33.1
Unknown	48	8.3
Other	8	1.4
Method		
Ligature	15	2.6
Manual	506	87.2
Other	8	1.4
Not documented	51	8.8
Alcohol use (up to 24 hours prior to assault)		
Yes	242	41.7
No	347	58.1
Unknown	1	0.2
Drug use (up to 24 hours prior to assault)		
Yes	188	32.4
No	381	65.7
Unknown	11	1.9
Pregnant		
Yes	33	5.7
No	529	91.2
Unknown	18	3.1
Hair pulled		
Yes	128	22.1
No	345	59.5
Unknown	107	18.4
Blows to head		
Yes	278	47.9
No	232	40.0
Unknown	70	12.1
Perpetrator threatened to kill victim		
Yes	168	29.0
No	321	55.3
Unknown	91	51.7
Victim expected to die		
Yes	216	37.2
No	240	41.4
Unknown	124	21.4
Weapon present		
Gun	57	9.8
Gun and knife	10	1.7
Knife	77	13.3
None	377	65
Other	47	8.1
Unknown	12	2.1

*Expressed as median (interquartile range).
IPV, intimate partner violence.

The frequency of specific symptoms and of positive physical exam findings in specific anatomic locations is shown in Table 2**.** We found that 19.1% of subjects had no positive physical exam findings in any category. The difference in percentages of positive physical exam findings for victims who experienced blows to the head vs those who did not varied in magnitude, although it was always positive (ie, with higher percentages in the "blows to the head" subgroup). The data can be viewed in Supplemental Table e1**.** Notably, the percentage of positive findings was roughly similar (based on 95% CI) for the eyes/eyelids and neck physical exam categories. Injury patterns in IPV victims were similar to those in non-IPV victims for most physical exam categories. Exceptions included under chin (28.6% positive findings in IPV vs 15.6% positive findings in non-IPV), chest (29.7%

Table 2. Symptoms and physical exam findings present in non-fatally strangled sexual assault victims.*

	Yes	No	Unknown/Missing
Symptoms reported			
Loss of consciousness	173 (29.8%)	402 (69.3%)	5 (0.9%)
Breathing difficulty	253 (43.6%)	240 (41.4%)	87 (15.0%)
Voice changes	212 (36.6%)	280 (48.3%)	88 (15.2%)
Swallowing difficulty	211 (36.4%)	280 (48.3%)	89 (15.3%)
Nausea and/or vomiting	122 (21.0%)	361 (62.2%)	97 (16.7%)
Urinary incontinence	41 (7.1%)	450 (77.6%)	89 (15.3%)
Physical exam findings present			
Face	141 (24.3%)	366 (63.1%)	73 (12.6%)
Eyes/eyelids	74 (12.6%)	455 (78.4%)	51 (8.8%)
Nose	45 (7.8%)	476 (82.1%)	59 (10.2%)
Ears	47 (8.1%)	473 (81.6%)	60 (10.3%)
Mouth	169 (29.1%)	355 (61.2%)	56 (9.7%)
Head	67 (11.6%)	458 (79.0%)	55 (9.5%)
Neck	332 (57.2%)	177 (30.5%)	71 (12.2%)
Under chin	117 (20.2%)	407 (70.2%)	56 (9.7%)
Chest	132 (22.8%)	393 (67.8%)	55 (9.5%)
Shoulders	116 (20%)	409 (70.5%)	55 (9.5%)

*Expressed as number of subjects (%)

positive findings in IPV vs 18.5% positive findings in non-IPV), and shoulders (28.6% positive findings in IPV vs 15.3% positive findings in non-IPV). This data can be viewed in Supplemental Table e2**.**

The interactions between selected assault characteristics and positive physical exam findings of interest for hypothesis-generating purposes are shown in Table 4**.** In addition, we evaluated the interaction between race and physical exam findings using Pearson's chi-square test. The only physical exam variables that showed significant interaction with race included under chin, chest, and shoulders (all of which had $P < 0.05$; complete results are available in Table e1). See Supplemental Table e3 for complete data**.**

DISCUSSION

Neck findings (ecchymoses, erythema, swelling, abrasions, lacerations, or petechiae) were present in 57.2% of our study population, which is higher than previous estimates of physical exam findings in non-fatal strangulation[2,8,11]; however, most of the available literature is not specific to a SA population, and SA perpetrators may be more likely to use violent and/or prolonged strangulation as a means of subjugation. Another possibility is that our forensic examiners detected higher injury rates due to the thorough nature of their training and systematic documentation requirements. The fact that almost 43% of victims reporting non-fatal strangulation had no visible neck exam findings on a rigorous and systematic examination nevertheless reinforces existing literature demonstrating the inconsistency with which this mechanism of injury is associated with physical exam findings, even by the most highly trained of forensic nurse examiners. Apart from neck injury, the remainder of exam findings (excluding anogenital exam, which was not included in our dataset) were present in less than 30% of victims for each category, suggesting that assault-related strangulation in this population is not necessarily associated with a high frequency of visible comorbid head/trunk injuries.

We calculated the difference in percentage between physical exam findings in victims who reported blows to the head vs those who did not to ascertain the extent to which our findings might be accounted for by physical blows rather than strangulation. Because our study was not designed to isolate the exam findings among strangled vs non-strangled SA victims, we used this comparison instead as an indicator of whether our results might be systematically biased by the presence of injuries from an alternative mechanism. Unsurprisingly, we found that subjects who reported battering had higher rates of positive findings in most categories. More interesting were those categories that did *not* show a significant percent difference among the battering vs non-battering populations, namely, for eyes/eyelids and neck. The similarity across these two populations suggests that neck findings and eye/eyelid findings might be specific to strangulation, although further research involving a control

Table 3. Interaction between selected assault characteristics and physical exam findings in sexual assault-related non-fatal strangulation.[≠]

	LOC p-value	Log(age) tertile p-value	Log (assault-exam interval) tertile p-value
Physical exam category			
Face	0.06869	0.2192	0.5242
Eyes/eyelids	0.001417***	0.4731	0.87
Nose	0.0001602***	0.9806	0.02281*
Ear	0.00002694***	0.2376	0.2367
Mouth	0.4535	0.8524	0.5563
Under chin	0.01538*	0.5242	0.4369
Chest	0.3602	0.6204	0.6957
Shoulders	0.4568	0.01223*	0.09011
Neck	0.007889**	0.5244	0.9678
Head	0.8797	0.358	0.06237
Assault characteristics			
Method	0.3866	0.09953	0.6646
Perpetrator	0.0009043***	0.003762**	0.0004507***
Presence of weapon	0.04543*	0.2369	0.1565
Victim expected to die	0.01923*	0.01124	0.3067
Perpetrator threatened to kill victim	0.327	0.07986	0.501

[≠] Using Pearson's chi-squared test with Yates' continuity correction.
**P* <0.05.
***P* <0.01.
****P* <0.005.
LOC, location.

population would be required to definitively demonstrate this.

Another variable that might be expected to have an impact upon injury patterns is the use of ligature vs manual strangulation. Few comparisons or conclusions can be drawn about the impact of ligature vs manual strangulation on injury patterns from our data, as only a small number of assailants (2.6%) used a ligature. This low prevalence of ligature use has been observed in other populations of SA-related non-fatal strangulation, as well.[2] Other factors that had significant associations with loss of consciousness, which has widely been used as an indicator of strangulation severity,[3,6,12] included positive physical exam findings for most exam location categories, the type of perpetrator, the victim expecting to die, and the perpetrator having a weapon. While none of these associations are not surprising, it is notable that one of the most robust correlations we found was between loss of consciousness and eye/eyelid findings (P <0.001). Petechiae and subconjunctival hemorrhage (SCH) have both been reported as potential candidates for predictors of strangulation severity.[2,7,12] While the frequency of reported eye/eyelid findings in our population was only 12.8%, the significant association between eye/eyelid findings and loss of consciousness supports the previously proposed hypothesis that there may be a threshold for cerebral venous outflow obstruction after which petechiae are more likely to appear, and that this threshold may exceed that amount of time necessary to produce loss of consciousness;[7] however, because eye/eyelid findings in our dataset were not limited to SCH/petechiae, more granular comparison of different types of findings (SCH, petechiae, periorbital ecchymosis, conjunctival injection, etc) would be needed to determine whether this association holds true for more specific findings. Likewise, much more data would be needed in the form of prospective comparisons of strangulation vs non-strangulation patients to determine whether any of the aforementioned mechanisms are causative as opposed to just correlative.

Our sample demonstrates a high prevalence of IPV-related assaults, which is consistent with prior epidemiologic studies of assailant types in non-fatal strangulation,[6] although surprisingly, acquaintances represented the most frequent assailant type in our sample. Because the perpetrator relationship is self-reported by the victim, more complex interpersonal relationships between victim and perpetrator may have escaped either the coding by the forensic nurse examiner or the categorization scheme that we used to report the perpetrator category. Additional data would be required to determine whether this phenomenon holds true in the more general population of SA victims.

Much of the literature related to non-fatal strangulation has grown out of the pioneering work by Strack et al (2001) in their landmark, 300-subject case series of IPV-related, non-fatal strangulation, which showed even higher rates of reported strangulation without physical exam findings, on the order of 50% with no visible injury.[8] While only 19.1% of the subjects in our study had no physical exam findings whatsoever, there are several methodological differences that may account for this discrepancy. First, our study data was gathered by forensically trained nurse specialists as opposed to police officers, the former of whom are much more highly trained and adept at recognizing physical injury patterns in assault. Secondly, we had a substantial percentage of subjects missing one or more physical exam categories, which may have introduced substantial bias. Lastly, our population consisted of those victims who sought medical assessment as opposed to those victims whose cases were prosecuted. It is possible that victims who sought forensic assessment in a healthcare setting had a greater symptom burden and/or more severe injuries than those retrospectively analyzed from prosecution cases. It is also important to note that our population was not restricted to IPV, which may render our results more externally generalizable than the Strack case series.

We also used our data to explore a hypothesized differential prevalence of physical exam findings in people of color. Previous studies have shown that Black women experience higher rates of SA than their White counterparts within specific age and socioeconomic subcategories.[13,14] Moreover, it has also been demonstrated that Black and Brown victims of SA have decreased rates of visible injury than their White counterparts.[14,15] Our data corroborated these prior observations for specific categories, namely that race was significantly associated with the presence or absence of neck, under chin, and chest findings. Although the chi-square test we performed was limiting in that it did not indicate which populations were more or less likely to have positive findings, it does suggest that this is a topic worth examining on a more granular level.

LIMITATIONS

Our study had several significant limitations in addition to those already addressed. First and foremost, we only studied individuals over the age of 18; thus, our data does not necessarily generalize to a child/teenage population. Additionally, there is substantial inherent sampling bias in any study of individuals voluntarily presenting for a forensic SA. Estimates of the proportion of SA victims who present for forensic exam range from around 14-21%[13,16,17]; thus, our observations are not necessarily generalizable to the broader population of SA survivors. This bias could have affected our conclusions in divergent ways. Our data may reflect a greater frequency of injuries if victims who sought care did so due to more substantial injury/symptom burden than the general population; however, our study population also excluded those individuals too acutely ill to consent to a forensic examination, which would shift our conclusions toward underestimating injury burden. Although the latter category likely represents a small percentage of total SA-related non-fatal strangulation victims, more research is needed to determine the characteristics and prevalence of injury patterns in this more critically ill cohort.

Finally, between 9-12% of subjects were missing data for each physical exam category. The similarity across all exam categories likely reflects the portion of exam reports wherein a physical exam section was erroneously omitted or left blank. Although this likely introduced a degree of bias into our results (as described above), we felt it was more important to include the subjects with missing exam data to gain a more accurate picture of assault characteristics and victim demographics.

CONCLUSION

In sexual assault survivors who have been strangled, the presence of non-anogenital physical exam findings is inconsistent, and the absence thereof does not undermine the veracity of a reported history of strangulation. Neck findings were seen much more commonly than any other facial, head, or torso injuries. The time elapsed between exam and assault did not significantly interact with most of the exam finding categories, nor did the victim's age. Further research is necessary to determine a causal relationship between the variables we examined and specific physical exam findings.

Address for Correspondence: Hannah Spungen, MD, MPH, UCLA Center for Health Sciences, Department of Emergency Medicine, 924 Westwood Blvd Suite 300, Los Angeles, CA 90095. Email: hspungen@mednet.ucla.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. Loder RT, Robinson T. The demographics of patients presenting for sexual assault to US emergency departments. *J Forensic Leg Med*. 2020;69:101887.
2. Zilkens RR, Phillips MA, Kelly MC, et al. Non-fatal strangulation

in sexual assault: a study of clinical and assault characteristics highlighting the role of intimate partner violence. *J Forensic Leg Med*. 2016;43:1–7.

3. McQuown,C, Frey J, Steer S, et al. Prevalence of strangulation in survivors of sexual assault and domestic violence. *Am J Emerg Med*. 2016;34(&):1281-5.
4. De Boos J. Non-fatal strangulation: Hidden injuries, hidden risks. *Emerg Med Australas*. 2019;31(3):302–8.
5. Malek AM, Higashida RT, Halbach VV, et al. Patient presentation, angiographic features, and treatment of strangulation-induced bilateral dissection of the cervical internal carotid artery: report of three cases. *J Neurosurg*. 2000;92(3):481–7.
6. Glass N, Laughon K, Campbell J, et al. Non-fatal strangulation is an independent risk factor for homicide of women. *J Emerg Med*. 2008;35(3):329–35.
7. Plattner T, Bolliger S, Zollinger U. Forensic assessment of survived strangulation. *Forensic Sci Int*. 2005;153(2-3):202-7.
8. Strack GB, McClane GE, Hawley D. A review of 300 attempted strangulation cases part I: criminal legal issues. *J Emerg Med*. 2001;21(3):303-9.
9. Strack GB, Gwinn C. On the edge of homicide: strangulation as a prelude. *Criminal Justice*. 2011;26(3);32-5.
10. McGregor MJ, Du Mont J, Myhr TL. Sexual assault forensic medical examination: Is evidence related to successful prosecution? *Ann Emerg Med*. 2002;39(6);639–47.
11. Armstrong M, Strack GB. Recognition and documentation of strangulation crimes: a review. *JAMA Otolaryngol Head Neck Surg*. 2016;142(9);891–7.
12. Hawley DA, McClane GE, Strack GB. A review of 300 attempted strangulation cases part III: injuries in fatal cases. *J Emerg Med*. 2001;21(3);317–22.
13. Santa Maria DM, Breeden K, Drake SA, et al. Gaps in sexual assault health care among homeless young adults. *Am J Prev Med*. 2020;58(2);191–8.
14. Avegno J, Mills TJ, Mills LD. Sexual assault victims in the emergency department: analysis by demographic and event characteristics. *J Emerg Med*. 2009;37(3);328–34.
15. Sommers MS, Fargo JD, Baker RB, et al. Health disparities in the forensic sexual assault examination related to skin color. *J Forensic Nurs*. 2009;5(4):191-20.
16. Zinzow HM, Resnick HS, Barr SC, et al. Receipt of post-rape medical care in a national sample of female victims. *Am J Prev Med.* 2012;43(2);183–7.
17. Wolitzky-Taylor, KB, Resnick HS, McCauley JL, et al. Is reporting of rape on the rise? A comparison of women with reported versus unreported rape experiences in the national women's study-replication. *J Interpers Violence*. 2011;26(4):807–32.
18. Pritchard AJ, Reckdenwald A, Nordham C. Nonfatal strangulation as part of domestic violence: a review of research. *Trauma Violence Abuse. 2017;18(4):407-24.*

Chronic Health Crises and Emergency Medicine in War-torn Yemen, Exacerbated by the COVID-19 Pandemic

Mohammed Alsabri,MD,MBBS,FISQUA[*†]
Luai M. Alsakkaf, MD, MBBS[†]
Ayman Alhadheri, MD, MS[‡]
Jennifer Cole, PhD[§]
Frederick M. Burkle Jr., MD, MPH, Ph.D (Hon.)[¶]

[*]Brookdale University Hospital and Medical Center, Department of Pediatrics , Brooklyn, New York, USA
[†]Al Thawra Modern General Hospital, Department of Emergency Medicine, Sana'a City, Yemen
[‡]McLaren Oakland/Michigan State University, Department of Emergency Medicine, Pontiac, Michigan, USA
[§]Royal Holloway University of London, Department of Health Studies, Egham Hill, Egham, Surrey TW20 0EX, United Kingdom
[¶]Harvard University & T.H. Chan School of Public Health, Harvard Humanitarian Initiative, Cambridge, Massachusetts, USA

Section Editor: Christopher Greene, MD, MPH
Submission history: Submitted January 26, 2021; Revision received September 30, 2021; Accepted October 5, 2021
Electronically published February 28, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2021.10.51926

Introduction: Much of Yemen's infrastructure and healthcare system has been destroyed by the ongoing civil war that began in late 2014. This has created a dire situation that has led to food insecurity, water shortages, uncontrolled outbreaks of infectious disease and further failings within the healthcare system. This has greatly impacted the practice of emergency medicine (EM), and is now compounded by the coronavirus disease 2019 (COVID-19) global pandemic.

Methods: We conducted a systematic review of the current state of emergency and disaster medicine in Yemen, followed by unstructured qualitative interviews with EM workers, performed by either direct discussion or via phone calls, to capture their lived experience, observations on and perceptions of the challenges facing EM in Yemen. We summarize and present our findings in this paper.

Results: Emergency medical services (EMS) in Yemen are severely depleted. Across the country as a whole, there are only 10 healthcare workers for every 10,000 people – less than half of the WHO benchmark for basic health coverage – and only five physicians, less than one third the world average; 18% of the country's 333 districts have no qualified physicians at all. Ambulances and basic medical equipment are in short supply. As a result of the ongoing war, only 50% of the 5056 pre-war hospitals and health facilities are functional. In June 2020, Yemen recorded a 27% mortality rate of Yemenis who were confirmed to have COVID-19, more than five times the global average and among the highest in the world at that time.

Conclusion: In recent years, serious efforts to develop an advanced EM presence in Yemen and cultivate improvements in EMS have been stymied or have failed outright due to the ongoing challenges. Yemen's chronically under-resourced healthcare sector is ill-equipped to deal with the additional strain of COVID-19. [West J Emerg Med. 2022;23(2)276–284.]

INTRODUCTION

Of Asia's 48 countries, Yemen is the 12th largest in terms of total area (527,970 square kilometers) and the 20th in terms of population (30 million).[1] Over the past three decades, many religious, geographical, historical, and economic obstacles have caused harsh divisions in the country, resulting in a civil

war that started in 2014 and continues today. This conflict has led to an unprecedented humanitarian crisis, including extensive violations of humanitarian law and the Geneva Convention by combatants from all factions.[2] Attacks and airstrikes that began in March 2015 have included strikes on hospitals and medical facilities – an egregious violation of international, humanitarian, and human rights laws.[3] This includes, according to conservative documentation by the World Health Organization (WHO), at least 142 attacks on medical facilities in Yemen between 2015– 2019.[4]

The conflict in Yemen has so far claimed the lives of 233,000 people. according to the United Nations Office for the Coordination of Humanitarian Affairs, [5] As a result of the ongoing war, only 50% of the 5056 pre-war hospitals and health facilities are functional.[6] The conditions of even those hospitals are nowhere near full potential: they are in dire need of essential equipment and proper funding.[6] The ongoing blockade by land, air, and sea has limited the extent of secure access to international aid, proper supplies, and humanitarian support, creating the world's most extreme humanitarian crisis.[3] The many years of prolonged instability has led to the proliferation of armed militias and militant groups which, despite several attempts at a ceasefire, have continued and escalated their aggression. Most disheartening is that the situation is not in the hands of Yemenis themselves but is perpetrated by both international and local powers. The continued instability caused by the pandemic enables terrorist groups to continue their operations,[7] threatens financial collapse,[8] and causes the absence of government protections.[9]

Even before the coronavirus 2019 (COVID-19) pandemic reached Yemen, widespread repercussions of the ongoing war had proved devastating: Yemen is one of the poorest countries not only in the Middle East but in the entire world.[10] The population has been left to fend for itself as Yemenis face severe hunger, outbreaks of infectious diseases, unattended acute and chronic diseases, and lack of basic healthcare infrastructure. Healthcare workers lack equipment and supplies.[6] Most recently, the COVID-19 pandemic has added to this already devastating humanitarian crisis. We report here on the practice of emergency medicine (EM) in Yemen, which is operating in a chronic crisis mode, exacerbating and increasing the unprecedented new challenges brought about by the COVID-19 pandemic. Where not explicitly cited to another source, observations in this report come from the first-hand experience of the authors.

Population Health Research Capsule

What do we already know about this issue?
Yemen has been severely impacted by civil war and now COVID-19. This has impacted its emergency medical services and left many hospitals under-resourced.

What was the research question?
What is the state of emergency medical care in Yemen including prehospital care and emergency ambulance services?

What was the major finding of the study?
Yemen's under-resourced healthcare sector is ill-equipped to deal with the additional strain of COVID-19.

How does this improve population health?
By highlighting the lack of resources and paucity of training opportunities, we illustrate the need for the international healthcare community to support their Yemeni colleagues.

METHODS & DISCUSSION

In this report we review the status of EM in Yemen and describe the challenges faced by its practitioners. The information was gathered through systematic reviews of PubMed, Ovid, and governmental websites using the terms "emergency medicine." "disaster medicine," "emergency medical services," "challenges," "COVID-19," and "Yemen." Furthermore, we conducted multiple, unstructured interviews with EM workers, performed by either direct discussion or via phone calls, to capture their lived experience and their observations on and perceptions of the challenges facing EM in Yemen. We summarize and present our findings in the text and tables below. The participants were general practitioners (GP) and specialists who were identified by convenience sampling from different hospitals in Yemeni cities, and who have more than five years' experience working in EM. One author is a departmental vice chair, co-founder and first president of the Yemeni Association of Emergency Medicine and Disasters and has extensive knowledge of EM in the historic capital city, Sana'a. Two of the authors are emergency physicians who are involved in the development of EM residency training programs in Yemen. Their experiences provide unique insight into the challenges faced by a health system under crisis.

Challenges for Emergency Medicine

One of the key challenges facing Yemen is an acute shortage of healthcare workers. For every 10,000 people, there are only 10 healthcare workers in Yemen, which is less than half of the WHO benchmark for basic health coverage,[11] and only five physicians, less than one third the world average, compared with 26 per 10,000 in Saudi Arabia and 20 in Oman, Yemen's neighbouring countries.[12] Practicing as an emergency physician in Yemen is uniquely difficult, profoundly impacting one's overall perspective as a practicing physician. A shortage

of supplies presents insurmountable challenges to conditions that would be treatable under normal conditions, such as otitis media,[13] headache,[14] and nonspecific chest pain.[15] Such experiences have forced the specialty to reconsider and reshape how EM is practiced in Yemen. This has resulted in a process based on rapid decision-making in sub-optimal conditions across several domains, for example, managing challenging arrangements for transportation: trauma victims and acutely ill patients are often transported to hospital by bystanders who use their own, non-medical, vehicles.[8]

Current Emergency Medical Services and Paramedic Status

Yemen lacks any formal prehospital emergency medical services (EMS).[8] Ambulances available from the Ministry of Health, and those in public and private sector health facilities, are used solely for the sake of inter-hospital transportation, with little coordination. Medical helicopters are only available for military services and some oil production facilities. Even if a medical center does have an ambulance, that does not mean the vehicle is always available or can provide emergency care. Ambulance vehicles usually lack proper equipment, with the exception of some ambulances donated by non-governmental organizations (NGO)[16] and a few owned by the Ministry of Health. Transport-to-hospital policies are either not in place or not easily activated due to the lack of financial support. When mass casualty incidents occur in Yemen – a common occurrence due to the consequence of the ongoing conflict – victims are often transported to hospital in private cars by people present at the scene.[8]

Emergency call numbers often fail during medical emergencies. Even if calls are connected, requests for an ambulance are almost always rejected and the caller is advised to bring the patient in by any other available means. This situation has resulted from the lack of applicable policies and an overarching sense of insecurity prevalent among healthcare workers: ambulance staff fear direct assaults on the ambulance and on themselves personally,[8] as ambulances have been the target of airstrikes during the ongoing war. The Yemen Red Crescent Society has 60 ambulance vehicles; however, they are used only for inter-hospital or inter-healthcare facility transport, reporting directly from their headquarters in Sana'a, the historic, former capital of Yemen. The exact scale of the problem is difficult to quantify due to the challenges of carrying out research in Yemen: while frontline medical staff highlight a shortage of ambulances and vehicles it has not been possible to determine how many are in the country even after contacting key persons in the Yemeni healthcare authorities.[16]

In the city of Aden, the current capital, there are no dedicated ambulances for COVID-19 patients, although transport did improve when Médecins Sans Frontières (MSF) (Doctors Without Borders) took charge of the al-Amal facility's management following an escalation of the number of cases of COVID-19 in the governorate in May 2020.[17] Similar desperate situations have been witnessed across Yemen.

The country also lacks qualified paramedics. Nineteen paramedics graduated in 2014 from the Higher Institute of Health Sciences in Sana'a, with a one-year diploma in emergency and ambulance services; however, no graduates or formally trained paramedics have been certified since the beginning of the war, nor is there a formal training pathway approved or available for paramedics.[18] Thus, when compared to standard levels of care in other countries, Yemen's EMS services might be considered functionally non-existent, particularly when compared with those in neighboring Saudi Arabia, which has more than 20 training centers across the country, a four-year training curriculum based on the North American model, and two-year EM fellowships.[17,18]

Status of Training of Emergency Clinicians

Overall, emergency departments (ED) in Yemen primarily depend on general practitioners (GP) as the main emergency care clinicians, irrespective of their experience. There are more GPs available, and they are more affordable than trained EM specialists, as their annual income in some regions starts as low as $800 United States dollars (USD). Recently, there have been attempts in larger hospitals to employ more EM specialists. This has been augmented further by the Ministry of Public Health and Population (MOPHP) directive in 2020 that mandated hospitals hire EM specialists; in reality, however, these ambitions have been far from possible to realize considering the small number of available specialists in the country. It is, however, a step in the right direction toward increasing the value of EM and developing more EDs across the country.

In practice, GPs face even more obstacles than emergency physicians. Hospitals without emergency physicians lack the holistic approach in their care for patients who present to the ED. While the physicians have considerable experience in treating such patients, neither they nor their facilities are well-suited to providing emergency care. This impacts the care of patients as well as the experience of the GPs. At the patient level, for example, a trauma patient who comes in with multiple acute and complex issues might not be managed holistically and systematically, as there would more likely be a focus on a single injury such as traumatic brain injury or major limb fracture. Such a situation may delay other critical diagnoses for the same patient. General practitioners may struggle to manage their patients, to prepare their departments for receiving such patients, and assess patient flow.

It is common to see improperly planned and poorly supplied EDs: the GPs working in the EDs as well as EM specialists face ongoing challenges. Only one EM training center in Yemen, Al-thawra Modern General Hospital (TMGH) in Sana'a, is recognized by the Yemeni Board for Medical Specialisation and the Arab Board of Health Specializations (ArBHS). It is a Level I trauma center and a tertiary referral hospital with advanced healthcare services. This designation means that it has the capability

to comprehensively treat all types of injury and serves as a regional resource for patients of all ages. Its facilities include a kidney transplant center, dialysis center, stroke center, cardiac center with catheterization laboratory, and an advanced cardiac surgery center. The ED normally sees around 320,000 unique visits annually. It is the busiest hospital in Yemen and is considered the most prestigious, serving over 30 million people: the entire population of the country.

Al-thawra Modern General Hospital is ranked highly as an ArBHS-approved training center for multiple medical specialties including EM, regionally as well as locally. While EM trainees from countries such as Iraq, Syria, and Somalia choose to train at the facility, few of them choose to follow a career in Yemen. Graduates of the four-year EM medical training center – the only one in Yemen – who successfully pass their board examination receive the Arab Board of Emergency Medicine certification and are licensed by the Yemeni MOPHP and the Yemeni Physicians Syndicate. These graduates can work independently as consultants or attending physicians. As of May 2021, an estimated 220 physicians have finished their EM residency programme in Yemen. However, very few of these graduates still work in Yemen: most have moved to work throughout the world, mainly in other regions of the Arab Gulf.[8]

Board-certified emergency physicians tend to leave the country due to the war, the humanitarian crisis, and overall worsening poverty; they migrate to nearby countries in search of higher wages and an overall sense of greater respect for the specialty and security for themselves and their families. This pattern is not uncommon; such an exodus of qualified staff is common in conflict-affected regions and is recorded in many other countries, including Iraq[20] and Syria[21] to name but two. The EM specialists who have remained in Yemen continue to endure mediocre facilities, poor administration, and lack of proper compensation. They are usually overworked.[18,22] In Yemen, EM specialists and consultants annually earn between $6,000-15,000 USD with an annual average of $10,000 USD. For junior emergency physicians, the annual income starts around $4400 USD. In comparison, in the Kingdom of Saudi Arabia the annual income is $70,000-165,000 USD.[18] Nurses are similarly underpaid. This leads to a heavy dependence on newly graduated GPs: they are less of a financial burden and are more willing to work for lower wages but are not usually required to have any specialized training or to have attended any specific EM courses. Because of the marked shortage and urgent need for board-certified emergency physicians, most EDs and trauma centers are led by GPs.

Working in an Overwhelmed and Limited Environment

Yemen's poor economic state and the ongoing civil war has put a toll on the availability of critically important medical supplies. Those that are available are often poorly maintained, hindered by lack of finances. Respondents to our survey reported seeing broken radiograph or computed tomography machines, some of which have been inoperable since before the start of the civil war. Emergency physicians reported working without critical supplies and instruments and having to ask the relatives of patients suffering from cardiac arrest to buy epinephrine and endotracheal tubes to ensure their treatment. Benzodiazepines, vasopressors, and intravenous (IV) lines are not always available in EDs. Personal protective equipment (PPE) was scarce even before the COVID-19 pandemic. Previously, physicians faced the 2009 H1N1 outbreak with only basic surgical masks, and many reported having to buy their own PPE including N95 masks.[23] Some physicians have intubated diphtheria patients with only basic surgical masks to protect them.

Antivenoms, antidotes for common toxicities such as digoxin and opioids, and other basic medicines such as activated charcoal are rarely available. Physicians reported having to sometimes call small strikes in the ED to force the hospital to provide the bare minimum of life-saving drugs and supplies, including epinephrine and IV cannulas, as supplies are not readily available. In other instances, physicians reported demanding that pharmaceutical companies provide such supplies, using their own contacts at the local level. Respondents reported wealthier physicians bringing with them as many critical medications as they can personally obtain; they would often ask a patient's relatives to try to locate substitutes from outside of the hospital, in order to provide prompt interventions and prevent further delays to essential treatment. The damaged infrastructure in Yemen adds to the challenges. Emergency physicians report having to intubate with defective laryngoscopes and without any light at all. They resort to using flashlights from mobile phones or small lighters to provide illumination while intubating patients on the floor. Monitors and direct current (DC) shock devices in the cardiopulmonary (CPR)/resuscitation rooms are poorly or under-maintained: one respondent reported using a DC shock device as a cardiac monitor in the CPR/resuscitation room due to crowding and defective monitors.

Many Yemenis have adopted carrying weapons as part of their regional dress code. Hospital security has historically mandated gun-free zones; however, with the widespread absence of hospital security, relatives of patients enter the CPR/resuscitation room with machine guns while their relatives are resuscitated, to protect themselves from attacks on hospitals, which unfortunately is a reality in Yemen. Many physicians in EDs report instances (infrequent but often enough to impact their experience) where they have been threatened by armed relatives while trying to treat their patients. In the vast majority of triage rooms across the country, no formal system or protocol is used to process patients apart from shifting shocked patients through to the red zone.

Challenges of Infectious Disease Management During the COVID-19 Pandemic

The sparsity of medical professionals is evident across Yemen; around 18% of the country's 333 districts do not have

any physicians.[24] The country's instability and deaths among the medical community have resulted in an increasing exodus of medical personnel, and the ongoing instability has also led to disruptions in higher education, resulting in a decline in skilled medical professionals as few new ones come through the system.[5] The COVID-19 pandemic has only exacerbated this already existing problem. At the beginning of the COVID-19 outbreak, the complete lack of PPE and safety measures put ED staff and community health workers at great risk.[25] Healthcare workers also face increasing threats and attacks from family members of COVID-19 patients.[26] The human toll of one physician's death extends to the entire community, which will be left without access to the healthcare he or she would have provided. Due to the shortage of physicians to consult and lack of easy access to physicians, some COVID-19 patients initially misdiagnosed their symptoms and sought treatment with medications they could buy over the counter, putting pharmacists and pharmacy staff at a particularly high risk of infection from COVID-19 at a time when communities increasingly depend on those pharmacists and pharmacy staff due to the lack of emergency physicians and functioning hospitals, creating a vicious circle.[26]

Yemenis lack sufficient access to clean water and sanitation.[27] The ongoing war, the displacement of millions of people, and seasonal flooding create the ideal conditions for the spread of infectious and communicable diseases. In hospitals, infection control measures are often impossible to implement: many hospitals completely or partially lack sinks and soap.[26] There is no national workforce strategy to employ more epidemiologists, and there is a shortage of technical staff required for evidence-based field investigation or active surveillance.[28] In 2019 alone, there were more than 760,000 suspected cases of cholera, 25,000 cases of dengue, 1600 cases of diphtheria, and nearly 10,000 suspected cases of measles.[26] The country is still suffering a seemingly never-ending cholera epidemic that has led to over two million cases and over 3000 deaths,[26] the worst documented epidemic in the history of the disease.[29,30] Widespread dengue fever and chikungunya infections have made the diagnosis of COVID-19 even more difficult in areas without proper or adequate testing. Patients with such diseases often present with very similar symptoms to those of COVID-19, but they require different treatments.[26] With the lack of a functioning government, points of entry into the country, including the airports in Aden and Seiyun, as well as the ports of Alwadia'ah, Sharowrah, and Algaithah, do not have the necessary isolation stations for suspected or confirmed COVID-19 cases. There is little opportunity to enact or uphold the standards set by the International Health Regulations.

Challenges to the Patient-Clinician Relationship

According to the UN, in 2004 the overall literacy rate for the Yemeni population 15 and older was 54.1%.[31,32] While this number has been slowly improving, other aspects of education, such as health literacy, are of great concern as it exacerbates delays in seeking care, leads to poorer health status, and compounds lack of knowledge about medical conditions, particularly when healthcare professionals are hard to access. Physicians often face judgment by patients' relatives in the case of a complication or a death, and reports of assaults on physicians or other healthcare workers across the country are not uncommon. The COVID-19 pandemic has brought about an escalation of these extremes from the relatives of suspected COVID-19 patients. In April 2020, a physician in Aden was threatened at gunpoint when he could not admit a patient to his overwhelmed facility due to lack of equipment, medical staff, and available beds.[33] A combination of decades of conflict, illiteracy, and the ready availability of weapons to civilians is a toxic mix in which medical professionals struggle to practice.

Worsening Economic Crisis

The situation is not helped by the economic decline Yemen has been facing for many years. Fuel exports are drying up and the Yemeni rial (YR) is rapidly depreciating against foreign currencies. The COVID-19 crisis has led to a further drop in the demand for and prices of Yemen's fuel exports, leading to even greater depreciation of the rial. For example, in 2014, $1 USD equated to 214 YR. In 2021, $1 USD equated to 910 YR in Aden and 600 YR in Sana'a. The economic crisis is worsening even as other nations have made major cuts in funding for humanitarian assistance as they struggle to support their own economies during the pandemic. Inside Yemen, this is complicating the COVID-19 response: a severe fuel shortage in the northern governorates hinders the transportation of medical supplies and the powering of generators.

In addition to facing the heightened risk of contracting COVID-19 while treating patients in hospitals, many medical staff have not been paid a salary in up to two years.[26] For the last several years, the WHO had been paying incentives to thousands of medical staff throughout Yemen as a short-term measure.[26,34,35] However, as of mid-April 2020, the same week that the COVID-19 crisis started in Yemen, the WHO cut incentive payments for 10,000 healthcare workers in the country. Both the danger of COVID-19, coupled with the cuts to salaries and the removal of incentive payments, has led to a wave of resignations. Lise Grande, the UN humanitarian coordinator in Yemen, states that it is "a funding crisis of gargantuan proportions."[36]

Gaps in Disaster Preparedness

The 2011 Yemeni Revolution served as an opportune time to study the preparedness of the country in the face of disasters. A comparative study was conducted between 2011–2013[18] using the WHO checklist evaluation, but the study found that no significant progress had been made by Sana'a city hospitals concerning hospital disaster preparedness during that time. The checklist included nine key components:

command and control; communication; safety and security; triage; surge capacity; continuity of essential services; human resources; logistics and supply management; and post-disaster recovery.[37] The study was conducted in 11 hospitals in the capital city of Sana'a, indicating that these hospitals have remained poorly equipped to meet the needs of the patient population during times of disasters. Ongoing disasters have since rendered the system progressively weaker: they have cost the country dearly, shifting what little budget there is toward relief, instead of preparedness and development.

One may legitimately question how a country can prepare for disaster if it is constantly in a state of disaster? In the time of siege and war, airstrikes have only made matters worse. Housing has suffered greatly from direct airstrikes. The catastrophic impact of war has led to further cuts in MOPHP budgets. Local media footage shows the impacts of these budget cuts as victims of such incidents are evacuated using non-ambulance vehicles, which emphasize the lack of out-of-hospital disaster preparedness. According to the UN, the lack of fuel has also contributed to the absence of ambulances.[38]

In 2018 health professionals in Yemen were surveyed to determine their knowledge of and attitude toward disaster preparedness.[18] This included 531 healthcare professional responses. While the concept of disaster preparedness was not unheard of among participants, only a third had a sound understanding of the management of disasters. Among all the different staff members, nursing staff were the least knowledgeable, even when compared to health administrators. Of the study respondents, 41% stated they had never received instruction on disaster preparedness at any time during their academic studies or professional careers.[18]

Unfortunately, disaster preparedness in Yemen has not received the necessary attention from the authorities or the international community and will only be recognized when proper planning, funding, and budgeting exists. Disaster preparedness must be incorporated into informal training programs for all healthcare professionals including emergency medical technicians and other hospital staff. The development of EMS itself will aid in the development of disaster preparedness. The military, the Ministry of Interior, the MOPHP, firefighters, and others must all be involved in such planning and training, as the issue is multi-sectoral and cannot be the sole responsibility of the MOPHP.

COVID-19 Management Prognosis

Epidemiologists have estimated that without drastic action, COVID-19 will spread "faster, more widely and with deadlier consequences" in Yemen than in other countries. Jens Laerke, spokesman for the UN Office for the Coordination of Humanitarian Affairs stated that the COVID-19 pandemic is severely exacerbating the humanitarian crisis in the country, which was already the world's most severe.[39] Acute challenges include "[u]nsafe shelters, persistent migration and displacement, lack of essential medicines, inadequate food and insufficient access to safe drinking water, suppressed immunity among the malnourished population" and that many areas of the country lack the lower limit of hygiene standards. These are optimal conditions for the rampant spread of infectious diseases,[9] making preventing and combating infectious diseases more challenging in Yemen than elsewhere.

After reporting its first case of COVID-19 on the 10th April 2020, by June Yemen had a 27% mortality rate of Yemenis who were confirmed to have COVID-19 – more than five times the global average and among the highest in the world at that time, as physicians were forced to practice with the minimal levels of safety.[26] "We are re-using personal protective equipment because we don't have enough," said Dr. Khairil Musa, a MSF ICU specialist in the city of Aden in January 2021.[40] As a result of the ongoing situation, some hospitals closed because they were worried about contamination, or because of lack of essential supplies needed to protect the health of workers.[41] Médecins Sans Frontières, among other medical relief organizations working in Yemen, are desperately calling for more PPE to be imported to the country. Without corrective actions in place, Yemen's people and healthcare systems may completely crumble.

DISCUSSION

In this special report we bring together first-hand accounts that are often complex and difficult to collect. It is based on these internal insights that the complexity of the matters at hand can begin to be understood or at the very least appreciated. This report offers some of the first documented lived experiences of Yemeni physicians operating on the frontline of the COVID-19 pandemic. Previous studies have not gone into such depth; this report paves the way for even more first-hand accounts to be documented. Potential future research can begin addressing the individual ailments of the collective disease. The EM community is consistently at the forefront of a plethora of societal and humanitarian adversities: what troubles a society and people is usually evident first and foremost in the EDs to which they present. One of our goals in writing this overview was to provide insight to the global EM community into the extent and severity of the challenges, epidemics, conflicts, and disasters that affect the EM world.

Corrective actions to address these challenges include both short-term reactive measures as well as longer term preventative measures. Some Yemeni physicians and highly educated officials who have studied and worked outside of Yemen, have a robust knowledge base and a solid understanding of the disaster management and preparedness protocols used worldwide. Having this knowledge, however, is not enough. Resources are required for tangible change. The solutions to Yemen's current situation must target the challenges from multiple angles. Solutions must come from education and training programs dedicated to filling in the gaps throughout the short- and

long-term interventions. Solutions might include fostering community and neighborhood involvement and invoking assistance from volunteers and activists of all ages to pilot smaller improvement projects. Lastly, a systems approach to emergency and disaster management is needed.

Lessons can also be identified from disaster relief programs in other conflict-affected regions. Literature from the field of health systems research in fragile and conflict affected states, from countries including Syria,[21,42] Iraq,[43] Sri Lanka,[44] Afghanistan[45] and Sierra Leone,[46,47] points to many successful approaches to facilitating long-term health system recovery. In Syria, for example, an extremely effective relief solution has been the initiation and implementation of locally led projects supported by expatriate philanthropic and charitable funding. This has ensured that needs can be swiftly identified and prioritized on the ground in a rapidly changing context.[42,48] Professional associations link in-country medics with an expatriate diaspora that can provide training, help to establish new facilities through donations of finances, equipment and expertise, including facilitating e-health and telemedicine consultations,[48] and thus help to identify local gaps by facilitating remote links with overseas researchers.[49] Weak local research capacity creates challenges with attracting external funding and collaborators, particularly long term, while rapidly changing conditions mean that what research is conducted is soon outdated,[45] requiring innovative and flexible solutions[46] driven from the ground up: remote connection provides one such solution.

Secondly, systems need to be supported for systematic and robust data collection and surveillance,[45] including for breaches of human rights and humanitarian law as well as epidemiology, as the former can be used to improve advocacy and to keep both policymakers who are subject to rapid turnover and NGO workers up to date with situations on the ground.[49] Provision for surveillance systems can often take second place to provision for services,[45] but their breakdown can have dire consequences for early identification of disease outbreaks, particularly when coupled with concurrent breakdown of vaccination programs.[47] A third area of action should foster support for, or implementation of, programs for psychological support and resilience, particularly for those understandably traumatized by their experiences[50] and for children.[42]

Thirdly, facilities in conflict zones face challenges with water and electricity supply, and medical equipment supplies and personnel. Lack of water and electricity are symptomatic of wider challenges with maintaining infrastructure[44,51] and harder to solve unilaterally, but the availability of medical equipment and supplies can be improved by stockpiling better reserves in safe zones inside the country, to facilitate supply chain resilience. Such an approach has proved highly successful in Iraq[43] and can help to ease challenges such as needing to transfer patients from one facility to another due to shortage of materials rather than lack of ability to perform the necessary procedures.[44]

Fourthly, the issue of qualified medical staff leaving conflict zones for safer jobs elsewhere is not unique to Yemen: it has been well documented in Iraq,[20] Syria,[21] and Nigeria[50] among many other countries. One solution is for the government, local authorities, and humanitarian aid to provide better security to healthcare facilities and workers, as lack of such security presents challenges not only to retaining local staff but also to attracting NGO and humanitarian support, and to enabling such people to move around the country freely once they are in country.[45]

Finally, part of the challenge is to ensure that whatever measures and solutions are implemented, they are planned with the long-term perspective kept firmly in mind, so that any short-term humanitarian relief can transition smoothly to in-country sustainability and from there to strengthening the healthcare sytem, which will have lasting impact.[52]

A takeaway from this report is the need for standardized assessments of Yemen's current situation. Change can only occur when the challenges confronted are truly understood and evaluated. Moving forward, effort should be allocated to using two different, but equally effective, systemic resources. The first is the WHO toolkit for assessing healthcare-system capacity for crisis management.[53] This evaluation toolkit provides a standardized hospital emergency response checklist. The second resource is a popular model and organizational tool implemented in the EM world: the US Federal Emergency Management Agency's "Four Phases of Emergency Management" consists of mitigation, preparedness, response, and recovery (Figure). This tool is holistic and can continuously be referenced. It can be used before and after events, as well as in anticipation of future events and challenges.

CONCLUSION

As emergencies and disasters continue to occur, so does the sense of urgency and emphasis on improving reactive and future proactive measures. The Yemeni people have never been immune from suffering disasters caused by a wide spectrum of societal ills as well as the ravages of nature. The state of the nation, including ongoing conflicts and a poor

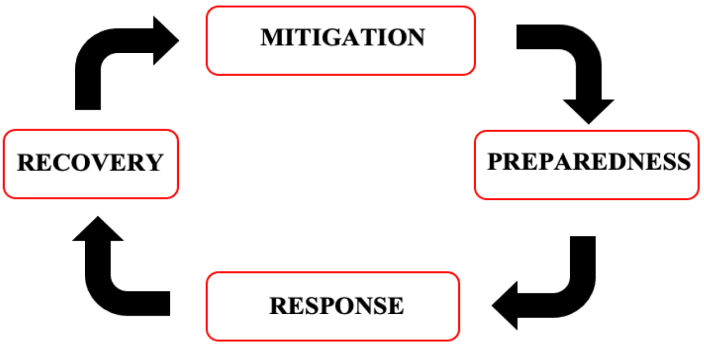


Figure. Four phases of emergency management per the US Federal Emergency Management Agency.

healthcare system superimposed on the current COVID-19 global pandemic, has exacerbated an already crippled emergency medicine infrastructure. David Beasley, executive director of the UN Security Council, states that this is the UN agency's biggest emergency and has made an appeal for the surrounding Gulf states to financially help save the lives of Yemenis. In this global public health emergency, only immediate attention from the international community will salvage the current health crisis.

Address for Correspondence: Mohammed Alsabri, MD, MBBS, FISQUA Brookdale University Hospital and Medical Center, Department of Emergency Medicine, 235 Court Street, Brooklyn, New York, 11201. Email: alsabritop@yahoo.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. International Database (IDB). Demographic Overview - Asia. 2021. Available at: https://www.census.gov/data-tools/demo/idb/#/table?YR_ANIM=2021&FIPS_SINGLE=YM&menu=tableViz&FIPS=AF,AM,AJ,BA,BG,BT,BX,BM,CB,CH,CY,GZ,GG,HK,IN,ID,IR,IZ,IS,JA,JO,KZ,KN,KS,KU,KG,LA,LE,MC,MY,MV,MG,NP,MU,PK,RP,QA,SA,SN,CE,SY,TW,TI,TH,TT,TU,TX,AE,UZ,VM,WE,YM&COUNTRY_YEAR=2021. Accessed January 16, 2021.
2. Ripoll Gallardo A, Burkle FM, Ragazzoni L, et al. Yemen's unprecedented humanitarian crisis: implications for international humanitarian law, the Geneva Convention, and the future of global health security. *Disaster Med Public Health Prep*. 2016;10(5):701-3.
3. Human Rights Watch. World Report 2019: Rights Trends in Yemen. 2019. Available at: https://www.hrw.org/world-report/2019/country-chapters/yemen#. Accessed January 16, 2021.
4. OCHA (United Nations Office for the Coordination of Humanitarian Affairs). Yemen: UN Humanitarian Coordinator condemns hospital attack. 2020. Available at: https://www.unocha.org/story/yemen-un-humanitarian-coordinator-condemns-hospital-attack. Accessed January 16, 2021.
5. UN News. UN humanitarian office puts Yemen war dead at 233,000, mostly from 'indirect causes'. 2020. Available at: https://news.un.org/en/story/2020/12/1078972. Accessed January 16, 2021.
6. Alsabri M, Nightingale B, Amin M, et al. When COVID-19 hit Yemen: dealing with the pandemic in a country under pressure from the world's worst humanitarian crisis. *Global J Med Public Health*. 2020;9(2):1-6.
7. Human Rights Watch. World Report 2019: Rights Trends in Yemen. 2019. Available at: https://www.hrw.org/world-report/2019/country-chapters/yemen#. Accessed January 16, 2021.
8. Ali H. Covid-19 and Civil wars in the Arab world: the cases of Syria, Libya and Yemen. *Asian Affair.* 2020;51(4):pp.838-855.
9. Alsabri M, Alhadheri A, Alsakkaf LM, et al. Conflict and COVID-19 in Yemen: beyond the humanitarian crisis. *Global Health*. 2021;(17)1:83.
10. Mousavi SM, Anjomshoa M. COVID-19 in Yemen: a crisis within crises. *Int J Equity Health.* 2020;19(1):120.
11. The World Bank. GDP (current US$). 2020. Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD. Accessed January 16, 2021.
12. MedGlobal. Our Global COVID-19 Response: 6 Months In. 2020. Available at: https://medglobal.org/our-global-covid-19-response-6-months-in/. Accessed January 16, 2021.
13. The World Bank. Physicians (per 1000 people). 2020. Available at: https://data.worldbank.org/indicator/SH.MED.PHYS.ZS. Accessed January 16, 2021.
14. Muftah S, Mackenzie I, Faragher B, et al. Prevalence of chronic suppurative otitis media (CSOM) and associated hearing impairment among school-aged children in Yemen. *Oman Medical Journal*. 2015;*30*(5):358-65.
15. Abdo SA, Amood Al-Kamarany M, Alzoubi KH, et al. Primary headache in Yemen: prevalence and common medications used. *Neurol Res Int*. 2014;2014:808126.
16. Dhabaan G, Chahin A, Buhaish A, et al. COVID-19 pandemic in Yemen: a questionnaire based survey, what do we know? *J Infect Dev Ctries*. 2020;14(12):1374-9.
17. Naser WN, Saleem HB. Emergency and disaster management training; knowledge and attitude of Yemeni health professionals- a cross-sectional study. *BMC Emerg Med*. 2018;18(1):23.
18. Health system in Yemen close to collapse. *Bull World Health Organ*. 2015;93(10):670-1.
19. Khattab E, Sabbagh A, Aljerian N, et al. Emergency medicine in Saudi Arabia: a century of progress and a bright vision for the future. *Int J Emerg Med*. 2019;12(1):16.
20. Naser WN, Saleem HB. Emergency and disaster management training; knowledge and attitude of Yemeni health professionals- a cross-sectional study. *BMC Emerg Med*. 2018;18(1):23.
21. Medecins Sans Frontieres. International Activity Report 2020. 2020. Available at: https://www.msf.org/sites/msf.org/files/2021-07/international-activity-report-2020.pdf. Accessed September 10, 2021.
22. Al-Kindi S. Violence against doctors in Iraq. *Lancet.* 2014;384(9947):954-5.
23. Abbara A, Orcutt M, Gabbar O. Syria's lost generation of doctors. *BMJ.* 2015;350:h3479.
24. Cole J, Alsabri M, Alsakkaf LM, et al. Conflict, collapse and COVID-19. *The RUSI Journal*. 2021;166(3):10–9.
25. Al-Ademi, Dina Abdulljabbar Abdullah, Abdulilah Hussein Al-Harazi, et al. Al-Shamahy, and Bushra Mohammed Jaadan. Detection of influenza

viruses among hospitalized cases suffering from acute respiratory illness (SARI in San'a City, Yemen). *J Pharm Res*. 2019;4:30-4.
26. Looi MK. Covid-19: Deaths in Yemen are five times global average as healthcare collapses. *BMJ*. 2020;370:m2997.
27. Al-Subari SMM, Saleem M, Khadka S, et al. COVID-19 pandemic in Yemen. *J Karnali Academy of Health Sciences*. 2020;*3*(2);159-63.
28. MedGlobal. A tipping point for Yemen's health system: the impact of COVID-19 in a fragile state. 2020. Available at: https://medglobal.org/yemen-covid-report-july2020/. Accessed January 16, 2021.
29. Burki T. Yemen health situation "moving from a crisis to a disaster." *Lancet*. 2015;385(9978):1609.
30. Dureab F, Al-Awlaqi S, Jahn A. COVID-19 in Yemen: preparedness measures in a fragile state. *Lancet Public Health*. 2020;5(6):e311.
31. UNICEF. Statement from UNICEF executive Director Anthony Lake and WHO Director-General Margaret chan on the cholera outbreak in Yemen as suspected Cases Exceed 200,000. 2021. Available at: https://www.unicef.org/press-releases/statement-unicef-executive-director-anthony-lake-and-who-director-general-margaret. Accessed September 15, 2021.
32. Center for Strategic and International Studies. Online event: Crisis and Survival amidst COVID-19 in Yemen. 2020. Available at: https://www.csis.org/analysis/online-event-crisis-and-survival-amidst-covid-19-yemen. Accessed January 16, 2021.
33. The World Bank. Literacy rate, adult total (% of people ages 15 and above) - Yemen, Rep. 2021. Available at: https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?locations=YE. Accessed January 16, 2021. UNESCO Institute for Statistics. Yemen. 2017. Available at: http://uis.unesco.org/country/YE. Accessed January 16, 2021.
34. Gharib M. 'I will kill you': health care workers face rising attacks amid COVID-19 outbreak. 2020. Available at: https://wamu.org/story/20/06/29/i-will-kill-you-health-care-workers-face-rising-attacks-amid-covid-19/. Accessed January 16, 2021.
35. Bryant Harris. Nurses receive training on using ventilators recently provided by the WHO at the intensive care ward of a hospital allocated for novel coronavirus patients in preparation for any possible spread of the coronavirus disease (COVID-19). 2020. Available at: https://www.al-monitor.com/originals/2020/04/yemen-trump-coronavirus-covid-19-who-houthi-saudi.html. Accessed September 17, 2021.
36. Slemrod A, Parker B. Pay cuts in a pandemic. *The New Humanitarian*. 2020. Available at: https://www.thenewhumanitarian.org/news/2020/05/07/coronavirus-health-yemen-unpaid-world-health-organisation-cuts. Accessed September 17, 2021.
37. OCHA. Yemen: UN extremely concerned by rapid spread of COVID-19. 2020. Available at: https://www.unocha.org/story/yemen-un-extremely-concerned-rapid-spread-covid-19. Accessed September 7, 2021.
38. Sorensen BS, Zane RD, Wante BE, et al. Hospital emergency response checklist- An all-hazards tool for hospital administrators and emergency managers. World Health Organization-The Regional Office for Europe of the WHO. 2011;1:1-26.
39. UN News. Yemen faces a dire health crisis with a major funding gap and 15.2 million lacking care, UN warns. 2015. Available at: https://news.un.org/en/story/2015/12/517112-yemen-faces-dire-health-crisis-major-funding-gap-and-152-million-lacking-care. Accessed January 17, 2021.
40. Kenny P. COVID-19: Yemen faces 'deadlier consequences' than many. 2020. Available at: https://www.aa.com.tr/en/middle-east/covid-19-yemen-faces-deadlier-consequences-than-many/1850873. Accessed January 16, 2021.
41. Doctors Without Borders. Yemen: Aden's collapsed health system grapples with COVID-19. 2020. Available at: https://www.doctorswithoutborders.org/what-we-do/news-stories/story/yemen-adens-collapsed-health-system-grapples-covid-19. Accessed January 16, 2021.
42. Hincks J. How COVID-19 is spreading undetected through Yemen. 2020. Available at: https://time.com/5843732/yemen-covid19-invisible-crisis/. Accessed January 16, 2021.
43. Hallam R. Response to Syria's health crisis. *Lancet*. 2013;382(9893):679-80.
44. Al Hasnawi S. Iraqi health minister works to reform, restore neglected system. Interview by Rebecca Voelker. *JAMA*. 2008;300(6):639.
45. Taira BR, Cherian MN, Yakandawala H, et al. Survey of emergency and surgical capacity in the conflict-affected regions of Sri Lanka. *World J Surg*. 2010;34(3):428-32.
46. Woodward A, Sheahan K, Martineau T, et al. Health systems research in fragile and conflict affected states: a qualitative study of associated challenges. *Health Res Policy Syst*. 2017;15(1):44.
47. ReBUILD Consortium. Becoming more effective actors for evidence-based health systems policy and practice; Experiences of research, research uptake and capacity-building from the ReBUILD research programme consortium. https://www.rebuildconsortium.com/resources/becoming-more-effective-actors-for-evidence-based-health-systems-policy-and-practice-experiences-of-research-research-uptake-and-capacity-building-from-the-rebuild-research-programme-consortium/. Accessed 17 July 2021.
48. Cole J. Conflict, post-conflict and failed states: challenges to healthcare. *The RUSI Journal.* 2014;159(5):14-8.
49. Zwi AB, Grove NJ, MacKenzie C, et al. Placing ethics in the center: negotiating new spaces for ethical research in conflict situations. *Glob Public Health*. 2006;1(3):264-77.
50. Gulland A. Attacks on health workers in conflict areas should be documented for advocacy purposes, conference hears. *BMJ*. 2013;347:f7259.
51. Bou-Karroum L, El-Harakeh A, Kassamany I, et al. Health care workers in conflict and post-conflict settings: systematic mapping of the evidence. *PLoS One*. 2020;15(5):e0233757.
52. Alsabri M, Cole J, Alhadheri A, et al. Conflict, Covid-19 and Yemen. *Crisis Response Journal*. 2021;16(1):73–5.
53. Brinkerhoff DW. From Humanitarian and post-conflict assistance to health system strengthening in fragile states: clarifying the transition and the role of NGOs. 2008. Available at: https://www.hfgproject.org/humanitarian-post-conflict-assistance-health-system-strengthening-fragile-states-clarifying-transition-role-ngos/. Accessed July 17, 2021.
54. World Health Organization. Toolkit for assessing health-system capacity for crisis management. 2012. Available at: https://www.euro.who.int/__data/assets/pdf_file/0008/157886/e96187.pdf. Accessed May 27, 2021.

COP26 and Health: Some Progress, But Too Slow and Not Enough

Laurie Laybourn-Langton, Senior Adviser UK Health Alliance on Climate Change, London, United Kingdom
Richard Smith, Chair

Section Editor: Mark I. Langdorf, MD, MHPE
Submission history: Submitted February 9, 2022; Revision received February 9, 2022; Accepted February 9, 2022
Electronically published February 28, 2022
Full text available through open access at http://escholarship.org/uc/uciem_westjem
DOI: 10.5811/westjem.2022.2.56422
Abstract [West J Emerg Med. 2022;23(2)285–287.]

The health community must step up its efforts to hold countries accountable for reducing greenhouse emissions and promoting adaptation

The editorial on climate change and biodiversity published in over 220 health journals in September had two main demands: 1) keep global temperature increases below 1.5°C above pre-industrial levels to avoid catastrophic damage to health; and 2) accept that this can be achieved only by rich countries making bigger cuts in greenhouse gas emissions and transferring substantial resources to the countries most vulnerable to the effects of climate change.[1] Neither demand was fully met at the "conference of parties" (COP)26 in Glasgow. The editorial was also aiming to make the voice of the health community more prominent in global discussions on climate change and environmental destruction. Some progress was made with this aim, but again not enough.

Although the mantra of COP26 was "keep 1.5C alive," the pledges made by countries to reduce emissions are insufficient to keep the temperature rise to below 1.5°C. Before COP26, the United Nations (UN) estimated that current pledges will lead to an increase of 2.7°C, a level that would lead to devastating effects on health through extreme weather events, crop failure, water shortages, forced migration, conflict, and a rise in sea level that will mean the disappearance of some island countries.[2] Even with the additional pledges made at COP26, temperatures are expected to rise well above 2°C.[3]

Christina Figueres, the head of the UN climate change convention in 2015 that achieved the Paris agreement, argues, however, that COP26 has made the aim of 1.5°C widely accepted, removing the aim of "below 2C" that emerged in Paris.[4] Countries are now required to review their pledges—called Nationally Declared Contributions (NDC) in UN speak—every year rather than every five years as at present. There is, however, no system of enforcement, and countries often fail to meet the pledges they make. Promises are easy; implementation is hard.

For the first time the final COP26 agreement mentioned fossil fuels, the source of most of the greenhouse gases.[5] Countries agreed to accelerate "efforts towards the phasedown of unabated coal power and phase-out of inefficient fossil fuel subsidies." Countries like India and China that depend heavily on coal for their energy supply insisted on the word "phasedown" of coal rather than the original "phase out."[6] It is a small success to have coal and fossil fuels mentioned in the final agreement, but at the same time the weak wording is a sign of the absolute failure of the world to adequately address the crisis.

The $100 billion (bn) support for low income and other vulnerable countries, which was promised back in Paris, did not materialise in Glasgow. It is now expected by 2023, deepening antagonisms between rich and vulnerable countries over the inequity of the global response to phasing out fossil fuels. There was, however, a greater emphasis on the need for more adaptation funding, as the editorial in the journals requested. Countries and their people are recognising that climate change is here now, not in the future. Vulnerable countries wanted a "Glasgow loss and damage facility," which would see funds passing from rich countries to vulnerable countries as compensation for the damage the rich countries have caused and continue to cause. Rich countries squashed this facility, greatly angering the vulnerable countries.

The editorial in the health journals sought to connect the climate element of the environmental crisis with other damage to nature, including biodiversity loss, deforestation, harm to the oceans, and soil destruction. COP26 did see $20 bn committed for forest protection, and more than 100 countries, including those with the largest forests, pledged to reverse deforestation by 2030 at the latest – though a similar pledge had already been made in 2014. Generally, however, broader damage to nature did not feature, which is partly because the UN process largely creates a separation between climate change, the focus of COP26, and biodiversity, which is being considered next year at a conference in China.

Business featured prominently at COP26. If the world is to reach net zero, then business—like every other activity—will have to play its part. Many businesses have committed to reach net zero and, perhaps more importantly, investors have discovered that there is money to be made from investing in genuinely green projects and money to be lost by investing in fossil fuels, which are rapidly becoming stranded assets. However, net-zero pledges made by businesses have attracted considerable doubts—and many remain full of loopholes, including allowing for continued investment in fossil fuels—leading the climate activist Greta Thunberg to call the conference "a global north greenwash festival, a two-week long celebration of business as usual and blah blah blah."[7] In response, the UN Secretary General has committed to establishing a "greenwashing" watchdog.[8]

Health was more prominent in COP26 than in any previous COPs in that the World Health Organisation had a health pavilion for the first time and health had an hour-long session with ministers in the main part of the meeting. The health pavilion featured dozens of sessions, most of which are available online.

Patricia Espinosa, the executive secretary of the UN Framework Convention on Climate Change, was expected to appear alongside the UK's senior health minister at the health session in the main part of the meeting, but neither attended. The meeting did, however, feature two British ministers, representatives of thr governments of Fiji and Egypt, a former British prime minister, a senior official from the US government, the chief executive of GlaxoSmithKline, and others. The representative from Fiji said that in his region more people are already dying from climate change that from any other cause, and the US representative told the audience that the US accounts for a quarter of all global emissions from health systems, which if they were a country would be the fifth largest emitter of greenhouse gases. Most health systems currently have rising emissions.[9]

Fifty countries committed at COP26 to "take concrete steps towards creating climate-resilient health systems."[10] Argentina, Fiji, Malawi, Spain, the United Arab Emirates, the US, and 39 other nations will achieve low-carbon, sustainable health systems, while Bangladesh, Ethiopia, the Maldives, the Netherlands, and 45 others have committed to enhance the climate resilience of their health systems.

Nobody knows how to achieve net zero within a health system, but we do know that everything, including clinical practice, will have to change; about two-thirds of the emissions come from suppliers, meaning that they too will have to reach net zero; and research and innovation will be essential. Funding for research on climate change and health has been small, but the UK minister announced a new fund for research on climate change and health.

Despite greater attention to health, the word "health" appeared only once in the final document agreed to at the meeting: "[countries,] when taking action to address climate change, respect, promote and consider their respective obligations on…the right to health." https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf

John Kerry, the US climate envoy who was at the original earth summit in Rio de Janeiro in 1992 and deeply involved in negotiating the agreement at the Paris COP, acknowledged that COP26 was never going to solve the climate crisis completely. But, he said, "Paris built the arena, Glasgow starts the race…When we leave Glasgow, our password will be implementation, follow up and follow up." https://awsforwp.com/2021/11/14/john-kerry-cop26-brings-us-closer-than-ever-to-avoiding-climate-chaos-policeman-26/

His words ring true for the health community. Restricting the rise in global temperature to 1.5°C is still possible with emergency action, and we must continue to emphasise the extreme danger to health from temperatures rising above 1.5°C and the great benefits to health that can result from countries decarbonising their economies. We must encourage countries to be bolder in cutting emissions, promoting adaptation, supporting vulnerable countries—and do more to hold them to account. We must also concentrate on implementation, particularly within health systems where we have the most influence.

Address for Correspondence: Laurie Laybourn-Langton, Senior Adviser, UK Health Alliance on Climate Change, C/O BMJ Publishing Group, Tavistock Square, London, WC1H 9JR. Email: laurie.laybourn@ukhealthalliance.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. Atwoli L, Baqui A H, Benfield T, et al. Call for emergency action to limit global temperature increases, restore biodiversity, and protect health. *West J Emerg Med*. 2021;22(5):1025-7.
2. UN Environment Programme. Addendum to the Emissions Gap Report 2021. 2021. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/37350/AddEGR21.pdf. Accessed December 7, 2021.
3. Climate Action Tracker. Glasgow's 2030 credibility gap: net zero's lip service to climate action. 2021. Available at: https://climateactiontracker.org/publications/glasgows-2030-credibility-gap-net-zeros-lip-service-to-climate-action/. Accessed December 7, 2021.
4. Figueres C. Cop26 took us one step closer to combating the

climate crisis. 2021. Available at: https://www.theguardian.com/commentisfree/2021/nov/15/cop-26-agreement-victories-global-economy-climate-crisis. Accessed December 7, 2021.

5. United Nations Conference of the Parties. Glasgow Climate Pact. 2021. Available at: https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf. Accessed December 7, 2021.
6. Khadka NS. COP26: Did India betray vulnerable nations? 2021. Available at: https://www.bbc.co.uk/news/world-asia-india-59286790. Accessed December 7, 2021.
7. Eden T. COP26: Greta Thunberg dismisses summit as 'greenwash festival of empty promises.' 2021. Available at: https://www.standard.co.uk/news/uk/greta-thunberg-speech-protests-glasgow-cop26-greenwash-festival-b964695.html. Accessed December 7, 2021.
8. Spencer B. Firms to be named and shamed for 'greenwashing' their climate record. 2021. Available at: https://www.thetimes.co.uk/article/firms-to-be-named-and-shamed-for-greenwashing-their-climate-record-nxdhd0t3j. Accessed December 7, 2021.
9. Lancet Countdown on Climate Change and Health. Healthcare sector greenhouse gas emissions. 2021. Available at: https://www.lancetcountdown.org/data-platform/mitigation-actions-and-health-co-benefits/3-6-mitigation-in-the-healthcare-sector. Accessed December 7, 2021.
10. World Health Organisation. Countries commit to develop climate-smart health care at COP26 UN climate conference. 2021. Available at: https://www.who.int/news/item/09-11-2021-countries-commit-to-develop-climate-smart-health-care-at-cop26-un-climate-conference. Accessed December 7, 2021.
11. Kerry J. COP26: 'Paris built the arena, Glasgow starts the race' – Kerry. 2021. Available at: https://www.bbc.co.uk/news/av/world-59278509. Accessed December 7, 2021.

This Article Corrects: "Toxicologic Exposures in California Emergency Departments in 2011 and Its Risk Factors"

Shahram Lotfipour, MD*†
Connie Au, BS‡
Soheil Saadat, MD, MPH, PhD*
Tim Bruckner, BS§
Parvati Singh, BS§
Bharath Chakravarthy, MD, MPH*

*University of California, Irvine, Department of Emergency Medicine, Irvine, California
†Eisenhower Health, Department of Emergency Medicine, Rancho Mirage, California
‡University of California, Irvine, School of Medicine, Irvine, California
§University of California, Irvine, Program in Public Health, Irvine, California

Electronically published March 3, 2022
Full text available through open access at http://escholarship.org/uc/uciem_cpcem
DOI: 10.5811/westjem.2022.2.56586

West J Emerg Med. 2021;22(5):1139–1145.
Toxicologic Exposures in California Emergency Departments in 2011 and Its Risk Factors
Lotfipour S, Au C, Saadat S, Bruckner T, Singh P, Chakravarthy B

[West J Emerg Med. 2022;23(2)288.] This article corrects the first author's name, Shahram Lotfipour, MD.

This Article Corrects: "Persistent and Widespread Pain Among Blacks Six Weeks after MVC: Emergency Department-based Cohort Study"

Francesca L. Beaudoin, MD, MS, PhD*
Wanting Zhai, ScM†
Roland C. Merchant, MD‡
Melissa A. Clark, PhD§
Michael C. Kurz, MD¶
Phyllis Hendry, MD‖
Robert A. Swor, DO#
David Peak, MD**
Claire Pearson, MD††
Robert Domeier, MD‡‡
Christine Ortiz, MD§§
Samuel A. McLean, MD¶¶

*Warren Alpert Medical School of Brown University, Department of Emergency Medicine, Providence, Rhode Island
†Warren Alpert Medical School of Brown University, Department of Biostatistics, Providence, Rhode Island
‡Harvard Medical School, Department of Emergency Medicine, Boston, Massachusetts
§Warren Alpert Medical School of Brown University, Department of Obstetrics and Gynecology, Providence, Rhode Island
¶University of Alabama School of Medicine, Department of Emergency Medicine, Birmingham, Alabama
‖University of Florida College of Medicine – Jacksonville, Department of Emergency Medicine, Jacksonville, Florida
#Oakland University William Beaumont School of Medicine, Department of Emergency Medicine, Royal Oak, Michigan
**Harvard Medical School, Department of Emergency Medicine, Boston, Massachusetts
††Wayne State University School of Medicine, Department of Emergency Medicine, Detroit, Michigan
‡‡St. Joseph Mercy Hospital, Department of Emergency Medicine, Ypsilanti, Michigan
§§Rhode Island Hospital, Department of Emergency Medicine, Providence, Rhode Island
¶¶University of North Carolina – Chapel Hill, Department of Anesthesiology and Emergency Medicine, Chapel Hill, North Carolina

Electronically published March 3, 2022
Full text available through open access at http://escholarship.org/uc/uciem_cpcem
DOI: 10.5811/westjem.2022.2.56585

West J Emerg Med. 2021;22(1)139–147.
Persistent and Widespread Pain Among Blacks Six Weeks after MVC: Emergency Department-based Cohort Study
Merchant RC, Beaudoin FL, Zhai W, Clark, MC Kurz MA, Hendry P, Swor RA, Peak D, Pearson C, Domeier R, Ortiz C, McLean SA

[West J Emerg Med. 2022;23(2)289.] This article corrects the misuse of the term "Blacks" in place of "African American" in the title and throughout the manuscript.

This Article Corrects: "Gender-based Barriers in the Advancement of Women Leaders in Emergency Medicine: A Multi-institutional Qualitative Study"

Emily M. Graham, BSN*
Meganne N. Ferrel, BS*
Katie M. Wells, MD, MPH[†]
Daniel J. Egan, MD[‡]
Casey Z. MacVane, MD, MPH[§]
Michael A. Gisondi, MD[¶]
Boyd D. Burns, DO[‖]
Troy E. Madsen, MD[#]
Megan L. Fix, MD[#]

*University of Utah School of Medicine, Salt Lake City, Utah
[†]University of Vermont, Division of Emergency Medicine, Department of Surgery, Burlington, Vermont
[‡]Massachusetts General Hospital/Brigham and Women's Hospital, Departments of Emergency Medicine, Boston, Massachusetts
[§]Maine Medical Center, Department of Emergency Medicine, Portland, Maine
[¶]Stanford University, Department of Emergency Medicine, Palo Alto, California
[‖]University of Oklahoma School of Community Medicine, Department of Emergency Medicine, Tulsa, Oklahoma
[#]University of Utah, Division of Emergency Medicine, Department of Surgery, Salt Lake City, Utah

Electronically published March 3, 2022
Full text available through open access at http://escholarship.org/uc/uciem_cpcem
DOI: 10.5811/westjem.2022.2.56587

West J Emerg Med. 2021;22(6)1355–1359.
Gender-based Barriers in the Advancement of Women Leaders in Emergency Medicine: A Multi-institutional Qualitative Study
Graham EM, Ferrel M, Wells KM, Egan DJ, MacVane CZ, Gisondi MA, Burns BD, Madsen TE, Fix ML

[West J Emerg Med. 2022;23(2)290.] This article corrects the title to "Gender-based Barriers to the Advancement of Women in Academic Emergency Medicine: A Multi-Institutional Survey Study.

This Article Corrects: "Sources of Distress and Coping Strategies Among Emergency Physicians During COVID-19"

Erin Dehon, PhD*
Kori S. Zachrison, MD, MSc†
Jennifer Peltzer-Jones, PsyD, RN‡
Ramin R. Tabatabai, MD§
Elizabeth Clair, DO*
Michael A. Puskarich, MD¶
Amy Ondeyka, MD‖
Katherine Dixon-Gordon, PhD#
Lauren A. Walter, MD**
Elaine H. Situ-LaCasse, MD††
Megan L. Fix, MD‡‡

*University of Mississippi Medical Center, Department of Emergency Medicine, Jackson, Mississippi
†Massachusetts General Hospital, Department of Emergency Medicine, Boston, Massachusetts
‡Henry Ford Health System, Department of Emergency Medicine, Detroit, Michigan
§Keck School of Medicine of USC, Department of Emergency Medicine, Los Angeles, California
¶Hennepin Healthcare, Department of Emergency Medicine, Minneapolis, Minnesota
‖Inspira Health Network, Department of Emergency Medicine, Vineland, New Jersey
#University of Massachusetts, Psychological and Brain Sciences, Amherst, Massachusetts
**University of Alabama at Birmingham, Department of Emergency Medicine, Birmingham, Alabama
††Banner University Medical Center – Tucson, Department of Emergency Medicine, Tucson, Arizona
‡‡University of Utah School of Medicine, Department of Emergency Medicine, Salt Lake City, Utah

Electronically published March 3, 2022
Full text available through open access at http://escholarship.org/uc/uciem_cpcem
DOI: 10.5811/westjem.2022.2.56588

West J Emerg Med. 2021;22(6)1240–1252.
Dehon E, Zachrison KS, Peltzer-Jones J, Tabatabai RR, Clair E, Puskarich MA, Ondeyka A, Dixon-Gordon K, Walter LA, Situ-Lacasse EH, Fix ML

[West J Emerg Med. 2022;23(2)291.] This article corrects the number of emergency physicians who completed the survey in the abstract.

CALL FOR SUBMISSIONS

Team Based Learning ▪ Podcasts ▪ Lectures ▪ Small Group Learning and Workshops ▪ Oral Boards ▪ Simulation ▪ Curricula ▪ Innovations

CALL FOR REVIEWERS

JETem is an online, open access, peer-reviewed journal-repository for EM educators.

VISIT JETem.org to learn more about submissions or if you're interested in being a JETem reviewer.

JETem

Journal of Education & Teaching in Emergency Medicine

A Journal of CORD

Call for Submissions

The Mediterranean Journal of Emergency Medicine & Acute Care

MedJEM

MedJEM aims to promote emergency medicine and acute care in the mediterranean region where the field and the specialty of emergency medicine remain in an early or middle phase of development.

Mediterranean Academy of Emergency Medicine

MAEM

www.medjem.me

Official publication of the Mediterranean Academy of Emergency Medicine (MAEM), regional chapter of the American Academy of Emergency Medicine

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

50

ANNIVERSARY