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Integrating Emergency Care with Population Health

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A Pilot Study Assessing Left Ventricle Diastolic Function in the Parasternal Long-axis View

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Introduction: Spectral Doppler echocardiography is used to evaluate diastolic dysfunction of the heart. However, it is difficult to assess diastolic function with this modality in emergency department (ED) settings. Based on the hypothesis that E-point septal separation (EPSS) measured by M-mode in the parasternal long-axis (PSLA) view may facilitate the assessment of diastolic function in emergency patient care, we aimed to investigate whether EPSS measured by M-mode in the PSLA view correlates with spectral Doppler assessment in patients with grade 1 diastolic dysfunction.

Methods: We performed this prospective, observational, single-center study was performed in the ED of a tertiary training and research hospital. All patients who presented to the emergency critical care unit with symptoms of heart failure were evaluated by the cardiology department, had grade 1 diastolic dysfunction confirmed by the cardiology department, and did not meet any of the study's exclusion criteria. The study population of 40 (included rate 14%) was formed after the exclusion criteria were applied to 285 patients who met these conditions. Patients included in the study underwent spectral Doppler measurements in the apical four-chamber (A4C) view followed by M-mode measurements in the PSLA view. We then compared the measurements.

Results: The correlation between the early diastolic velocity of the mitral inflow to the late diastolic velocity (E/A) ratio in spectral Doppler measurements and the EPSS/ A-point septal separation (APSS) ratio in M-mode was strong (correlation coefficient 0.677, $P = 0.001$). Similarly, the correlation between E in spectral Doppler measurements and the EPSS/APSS ratio in M-mode measurements was also moderately strong (correlation coefficient 0.557, $P = 0.001$).

Conclusion: A significant correlation exists between the M-mode EPSS/APSS ratio measurement in the PSLA view and the spectral Doppler E/A ratio measurement in the A4C window to evaluate grade 1 diastolic dysfunction. This association suggests that M-mode measurements in the PSLA may be used in diastolic dysfunction. [West J Emerg Med. 2025;26(1)1–9.]

INTRODUCTION

Point-of-care ultrasound (POCUS) is of vital importance for assessing heart functions in the emergency department (ED).[1–3] Bedside echocardiography, a component of POCUS, is a non-invasive imaging technique used to obtain real-time images of the heart. In this way, systolic and diastolic cardiac function can be evaluated in the ED.[4,5] Although there are many echocardiographic methods for assessing systolic function, the E-point septal separation (EPSS) method, which measures the distance between the

ventricular septal wall and the anterior leaflet of the mitral valve (MV) in the parasternal long axis (PSLA) view, is used in the ED to assess the systolic function of the heart. The EPSS method is reliable and simple and does not require specialized equipment or complex calculations. It is particularly useful in emergency patient care.[6–8]

The bedside use of the American Society of Echocardiography (ASE) and European Association of Cardiovascular Imaging (EACI) guidelines for the assessment of diastolic function using echocardiography is difficult in in the ED setting is difficult and challenging in many respects.[9] In spectral Doppler echocardiography various parameters, such as the ratio of the early diastolic velocity of the mitral inflow to the late diastolic velocity (E/A), the E deceleration time, and the ratio of the early diastolic velocity of the mitral inflow to the early diastolic velocity of the mitral annulus (E/e′), are evaluated in the apical four-chamber view (A4C) to assess the diastolic function of the heart.[10,11] Evaluating diastolic function using this spectral Doppler method is simply not practical in emergency patient care.

Various studies have examined the evaluation of diastolic dysfunction by emergency physicians using spectral Doppler echocardiography.[12,13] Some researchers have observed that the E/A pattern evaluated with pulsed wave (PW) Doppler in the A4C view is similar to the motion pattern of the MV anterior leaflet seen when measuring EPSS with M-mode in the PSLA view.[14,15] Based on the hypothesis that this similarity may facilitate the assessment of diastolic function in emergency patient care, we aimed to investigate whether EPSS measured with M-mode in PSLA view correlates with spectral Doppler assessment in patients with grade 1 diastolic dysfunction.

Population Health Research Capsule

What do we already know about this issue?
The use of Doppler measurements in the evaluation of diastolic function in the ED is difficult. Therefore, it is necessary to assess diastolic function by a practical method.

What was the research question?
Do measurements made by E-point septal separation (EPSS) assessment with M-mode in parasternal long-axis (PSLA) view correlate with those made by spectral Doppler in patients with grade 1 diastolic dysfunction?

What was the major finding of the study?
The correlation between the early diastolic velocity of mitral inflow to late diastolic velocity (E/A) ratio in spectral Doppler and the EPSS/ A-point septal separation (APSS) ratio in M-mode was strong (correlation coefficient 0.677, P = 0.001. This suggests that M-mode measurements in the PSLA may be used in diastolic dysfunction.

How does this improve population health?
The ability to use M-mode measurements in PSLA for diastolic dysfunction enables rapid diagnosis and prompt treatment of patients in the ED.

METHODS

Study Design and Setting

This prospective, observational, single-center study was performed in the emergency department of a tertiary training and research hospital in Türkiye between December 1, 2023–March 31, 2024. Local ethical committee approval was granted prior to commencement (decision no. 2023/259). All patients we planned to include in the study were told how and for what purpose bedside ultrasonography would be performed, and written informed consent was obtained from all patients who consented to be included in the study.

Patient Selection and Data Collection

All patients who presented to the emergency critical care unit with symptoms of heart failure were evaluated by the cardiology department, had grade 1 diastolic dysfunction confirmed by cardiology, and did not meet any of the study's exclusion criteria. The following patients were excluded: two who were <18 years of age; 75 with tachycardia or bradycardia at presentation; 47 with a history of mitral stenosis or mitral regurgitation; 44 with arrhythmia; 24 with a history of mitral valve surgery; four who refused diagnosis and treatment; 14 who did not have a cardiologist-approved new echocardiography report; 29 for whom ultrasound measurements could not be performed; and six who were brought to the ED because of cardiac arrest. The study population of 40 patients (included rate 14%) was formed after the exclusion criteria were applied to 285 patients who met these conditions. The patient flow chart is shown in Figure 1.

Study Protocol

Initial patient evaluations in the ED were performed by emergency medicine residents. The study's patient population was formed primarily based on grade 1 diastolic dysfunction confirmed by a cardiologist, resulting in a group of standardized patients. In the next step, patients with a history of mitral stenosis or mitral regurgitation and a history of mitral valve surgery in echocardiography results who did not have a cardiologist-approved new echocardiography

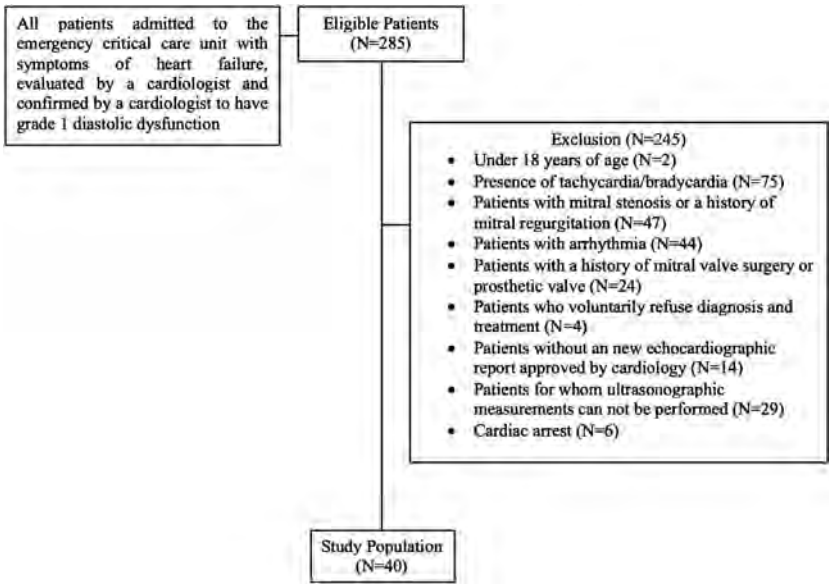

Figure 1. Patient flow chart for enrollment and evaluation of patients with diastolic heart failure with bedside echocardiography in the emergency department.

report were excluded. Then, other exclusion criteria were applied. Finally, we excluded patients for whom ultrasonographic measurements were not appropriate and who refused diagnosis and treatment.

The emergency medicine resident performing the initial evaluation recorded all vital and physical examination findings during presentation. The resident also recorded the demographic characteristics, comorbid diseases, and cardiologist-confirmed echocardiography results of the patient he included in the study via the hospital's automaed system. Primary diagnoses and treatments were made and administered by the emergency medicine resident performing the initial evaluation.

Two emergency physicians who had no responsibility for the patients' primary care performed the POCUS examinations. Both had participated in and successfully completed ultrasound courses (basic and advanced) that were certified by professional emergency medicine associations (five years of experience in POCUS with an average of 500 ultrasounds per year). They were blinded to the study patients' laboratory parameters, vital findings, diagnoses, and treatments.

POCUS Protocol

Sonographic examinations were performed on a Fujifilm-Sonosite-FC1 (FUJIFILM SonoSite Inc, Bothell, WA) 2015 model US device. All measurements were made with 1–5 megahertz sector (cardiac) probe. The study protocol included pulsed-wave (PW) Doppler measurements for diastolic function evaluation in A4C view, followed by M-mode measurements via PSLA view scans of the MV anterior leaflet. At sonographic examination, E, A, and E descent time (EDT) measurements were first performed with PW Doppler in A4C view. Then EPSS, A-point septal separation (APSS), A-point opening length (APOL), and E-point opening length (EPOL) were measured with M-mode evaluation at the level of the mitral valve in the PSLA view. The ejection fraction (EF) was calculated using the EPSS method. Measurement time was recorded for both A4C view measurements and PSLA view measurements. The recording procedure commenced once the ultrasonographic windows provided by the images were clearly visible, and it was concluded when the desired measurements had finished. All measurements are summarized in Figures 2 and 3.

Endpoints

The primary endpoint in this study was to evaluate the correlation between measurements performed with PW Doppler in the A4C view and M-mode measurements in the PSLA view in patients with grade 1 diastolic dysfunction. The secondary outcome point was to compare the time elapsing between the measurements.

Statistical Analysis

We performed all analyses using Jamovi version 1.6 statistical software (the Jamovi Project 2021, Sydney, Australia). Categorical data were expressed as frequency (n) and percentage. Normally distributed continuous variables were presented as mean plus standard deviation, and non-normally distributed data as median and interquartile range (IQR). Normality of distribution was evaluated using the Shapiro-Wilk test. We compared continuous variables in dependent groups using the paired *t*-test in case of normal distribution and the Wilcoxon test in case of non-normal distribution. The Pearson correlation for normally distributed variables and Spearman correlation analysis for

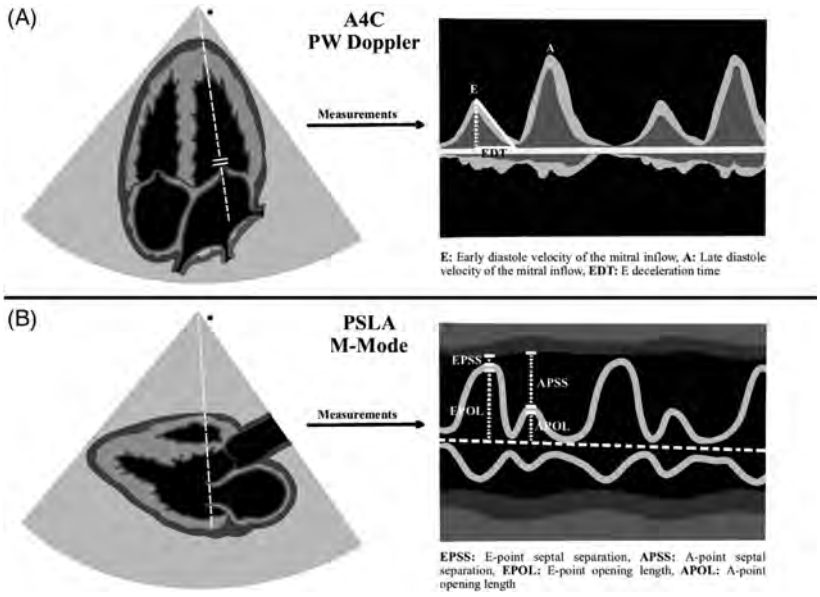

Figure 2. Illustration of measurements.
PSLA, parasternal long axis; *A4C*, apical four-chamber; *PW*, pulsed wave.

non-normally distributed variables were performed to evaluate the relationships between MV measurements in PSLA view and PW Doppler measurements in A4C view. Since the relationship between MV anterior leaflet M-mode measurements in the PSLA view and Doppler inflow velocity MV measurements had not yet been determined, we did ot perform sample size calculation. *P*-values <0.05 were considered significant for all analyses.

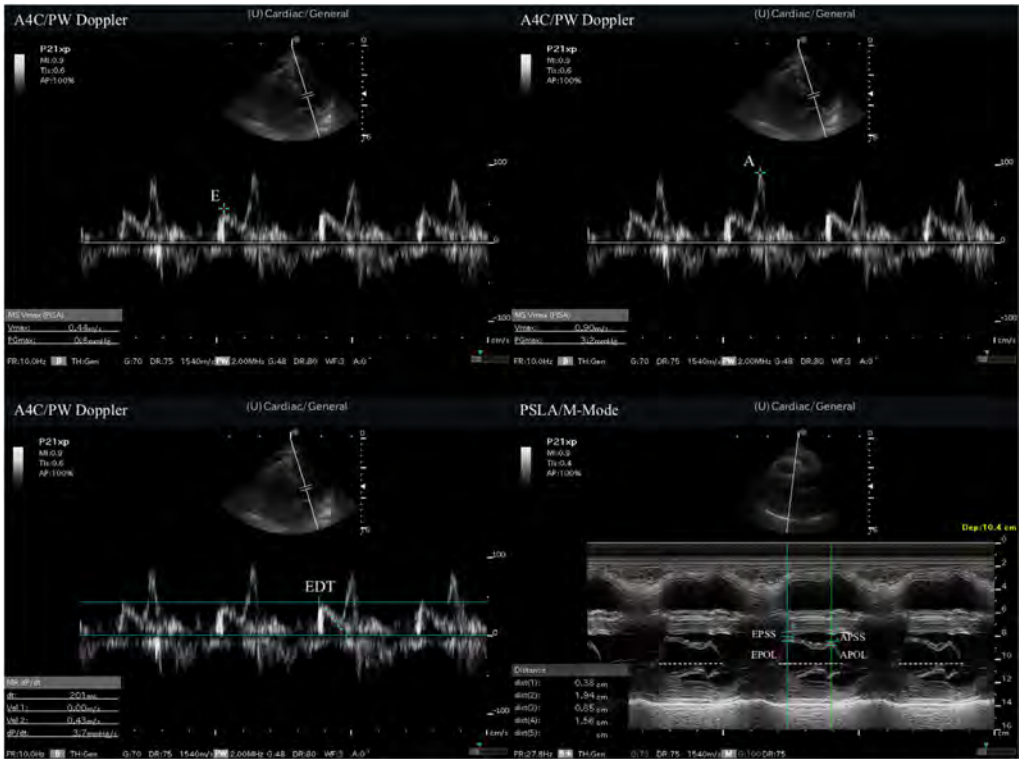

Figure 3. Measurements of point-of-care ultrasound.
A, late diastole velocity of the mitral inflow; *A4C*, apical 4-chamber; *APOL*, A-point opening length; *APSS*, A-point septal separation; *E*, early diastole velocity of the mitral inflow; *EDT*, E deceleration time; *EPOL*, E-point opening length; *EPSS*, E-point septal separation; *PSLA*, parasternal long axis; *PW*, pulsed wave.

RESULTS

The study population of 40 patients was constituted following application of the inclusion and exclusion criteria. The study population was formed after all exclusion steps, and ultrasonographic evaluations were performed on all 40 patients. Considering 29 patients evaluated by cardiologists but excluded because of the inability to perform measurements by sonographers, sonographers were able to perform measurements in 40 of 69 patients (58.0%). Twenty-six (65%) of the patients enrolled were men, and 14 (35%) were women. The patients' mean age was 76.6 years, ranging between 35–97. Hypertension (HT) and coronary artery disease (CAD) were the most common accompanying comorbid diseases.

Analysis of measurements using PW Doppler in the A4C revealed a median E value of 0.5 meters per second (m/s), with an IQR of 0.4–0.6 m/s, median A 0.7 m/s, IQR 0.6–0.8 m/s, and median EDT 258 m/s, IQR 233–279 m/s. Similarly, analysis of measurements taken with M-mode in the PSLA view revealed a median EPSS value of 0.77 centimeters (cm), with an IQR of 0.54–0.89 cm, median APSS 1.10 cm, IQR 0.79–1.31 cm, median EPOL 1.51 cm, IQR 1.23–1.74 cm, and median APOL 1.31 cm, IQR 1.10–1.57 cm. Measurement time was evaluated for both A4C view measurements and PSLA view measurements. The A4C view measurements mean was 70.3 ± 5.4 seconds (sec) to complete, while the PSLA view measurements mean was 44.1 ± 3.8 sec to complete. The patients' demographic data, initial vital findings, all measurement data, and measurement time are shown in Table 1.

The correlation between the E/A ratio in PW Doppler measurements and the EPSS/APSS ratio in M-mode was strong (correlation coefficient 0.677, $P = 0.001$). Similarly, the correlation between E in PW Doppler measurements and the EPSS/APSS ratio in M-mode measurements was also moderately strong (correlation coefficient 0.557, $P = 0.001$). No other statistically significant correlations were observed between PW and M-mode measurements. Correlation analysis and graphics between measurements in the PSLA and A4C views is summarized in Table 2 and Figure 4.

DISCUSSION

Echocardiography plays an important role in the evaluation of the systolic and diastolic functions of the left ventricle. It is, therefore, employed in the ED for evaluating both the systolic and diastolic functions of the heart.[12,13] It represents a rapid, repeatable, and non-invasive diagnostic tool for emergency physicians.

Diastolic dysfunction can be seen in conditions such as HT, CAD, and diabetes and can represent a determinant of morbidity and mortality in such diseases.[16–18] The ASE and EACI published updated guidelines to the evaluation of diastolic dysfunction in 2016.[10] The guidelines recommended the evaluation of four parameters for the diagnosis of diastolic dysfunction: the E/E′ ratio; septal e′ or lateral e′ velocity; tricuspid regurgitation velocity; and the left atrial volume index. It suggested that abnormality should be present in three or four of these parameters for a diagnosis of diastolic dysfunction. These recommendations entail difficulties for the evaluation of patients in the ED setting, one of these being that emergency physicians should be trained in the use of POCUS. The measurements recommended in the guidelines involve complex parameters and measurements for POCUS under ED conditions. More practical diastolic dysfunction evaluation with E, A, and EDT measurement using the PW Doppler method is, therefore, employed in the ED.[11,19,20] However, it is also difficult to perform these focused Doppler measurements under ED conditions.

In light of these difficulties, we undertook this study to investigate alternative measurement methods. A different measurement method for evaluating grade 1 diastolic dysfunction was tried by applying M-mode evaluation of MV anterior movement in PSLA view. A statistically strong correlation was thus observed between grade 1 diastolic dysfunction patients' EPSS/APSS ratios from M-mode measurements in the PSLA view and E/A ratios from PW Doppler measurements in the A4C view (correlation coefficient 0.677, $P = 0.001$). These findings suggest that EPSS and APSS values measured in the ED via M-mode evaluation of MV anterior leaflet movement in the PSLA view may represent a practical approach for diastolic function estimation, similarly to the EPSS method used for systolic function estimation.

Park et al evaluated the relationship between MV anterior leaflet motion in the PSLA view with M-mode measurements and PW Doppler measurements in the A4C view in healthy humans. Those authors determined a significant correlation between the APSS/EPSS ratio and E values (correlation coefficient = 0.4). They concluded that visual evaluation of the M-mode pattern on the MV anterior leaflet in the PSLA view might represent a practical approach toward estimating diastolic function in the ED.[15] In the present study we evaluated the relationship between M-mode measurements of MV anterior leaflet motion in the PSLA view and PW Doppler measurements in the A4C view in patients with grade 1 diastolic dysfunction. In contrast to the correlation reported by Park et al, we observed positive correlations between the E/A ratio and EPSS/APSS ratio and between E and the EPSS/APSS ratio.

We attribute this discrepancy to the presence of an opposite relationship in the E/A ratio between normal healthy individuals and patients with grade 1 diastolic dysfunction. This contrast may be due to the E/A ratio typically being >1 in healthy individuals, while it falls to <1 with the development of diastolic dysfunction (grade 1). We also think that the positive correlation between the E/A ratio and the EPSS/APSS ratio is associated with physiological

Table 1. The patients' demographic data and baseline characteristics.

Characteristics, N = 40	Value
Gender	
Male, n (%)	26 (65.0%)
Female, n (%)	14 (35.0%)
Age (years), mean ± SD	67.6 ± 13.5
Comorbidities	
Hypertension, n (%)	36 (90.0%)
Diabetes, n (%)	13 (32.5%)
CAD, n (%)	17 (42.5%)
Stroke, n (%)	1 (2.5%)
Dementia, n (%)	3 (7.5%)
Neoplasia, n (%)	7 (17.5%)
CHF, n (%)	1 (2.5%)
Vital signs	
Systolic blood pressure (mmHg), median (IQR)	133 (IQR 130–140)
Diastolic blood pressure (mmHg), median (IQR)	80 (IQR 70–90)
Pulse (/min), median (IQR)	78.5 (IQR 71.8–84)
Measurements	
E (m/s), median (IQR)	0.5 (IQR 0.4–0.6)
A (m/s), median (IQR)	0.7 (IQR 0.6–0.8)
EDT (ms), median (IQR)	258 (IQR 233–279)
EPSS (cm), median (IQR)	0.77 (IQR 0.54–0.89)
APSS (cm), median (IQR)	1.10 (IQR 0.79–1.31)
EPOL (cm), median (IQR)	1.51 (IQR 1.23–1.74)
APOL (cm), median (IQR)	1.31 (IQR 1.10–1.57)
EF (%), median (IQR)	55 (IQR 51.5–60.5)
EPSS/APSS (ratio), median (IQR)	0.70 (IQR 0.64–0.75)
EPOL/APOL (ratio), median (IQR)	1.19 (IQR 1.10–1.29)
E/A (ratio), median (IQR)	0.72 (IQR 0.64–0.78)
Measurement times	
PSLA measurements time (sec), mean ± sd	44.1 ± 3.8
A4C measurements (sec), mean ± sd	70.3 ± 5.4

A, late diastole velocity of the mitral inflow; *A4C*, apical 4-chamber; *APOL*, A-point opening length; APSS, A-point septal separation; *IQR*, interquartile range (25p, 75p); *CAD*, coronary artery disease; *CHF*, congestive heart failure; *E*, early diastole velocity of the mitral inflow; *EDT*, E-point deceleration time; *EF*, ejection fraction; *EPSS*, E-point septal separation; *EPOL*, E-point opening length; *PSLA*, parasternal long axis.

compensation developing in grade 1 diastolic dysfunction. This is because in grade 1 diastolic dysfunction, the left ventricular (LV) inflow velocity (E) decreases (passive filling) in early diastole due to impaired LV relaxation, which can lead to an increase in EPSS and a decrease in EPOL. Subsequently, during late diastole, the LV filling rate (A) increases (filling with active propulsion), thus causing an increase in the EPSS/APSS ratio by producing a decrease in APSS. The EPSS/APSS ratio may have exhibited a positive correlation with the E/A ratio as a result of this physiological compensation.

Heart failure remains a major cause of morbidity and mortality. Symptomatic heart failure is due to systolic dysfunction but is also commonly due to diastolic dysfunction.[21,22] The assessment of diastolic dysfunction is of great importance as it is a common cause of symptomatic heart failure. Many emergency physicians do not find the detailed measurements included in the ASE guidelines applicable to POCUS in the ED setting. This is due to multiple factors. For example, if the patient has dyspnea or hypoxemia, they may not be able to lie flat or be properly positioned for the sonographer to obtain an adequate four-

Table 2. Correlation between measurements in the parasternal long axis view and measurements in the apical four-chamber view.

	Correlation coefficient (*P*-value)			
	E	A	EDT	E/A
EPSS*	−0.036 (0.825)	−0.042 (0.798)	−0.060 (0.711)	0.022 (0.895)
APSS*	−0.277 (0.084)	−0.092 (0.573)	−0.060 (0.712)	−0.236 (0.142)
EPOL*	−0.011 (0.946)	−0.172 (0.288)	−0.034 (0.835)	0.158 (0.331)
APOL*	−0.086 (0.596)	−0.212 (0.189)	0.021 (0.898)	0.074 (0.650)
EPSS/APSS*	0.557 (0.001)	0.090 (0.581)	−0.003 (0.986)	0.677 (0.001)
EPOL/APOL*	−0.079 (0.628)	−0.020 (0.904)	−0.265 (0.098)	−0.033 (0.840)
EF*	0.043 (0.791)	0.081 (0.620)	0.050 (0.759)	−0.053 (0.747)

*Spearman's correlation analysis.
APOL, A-point opening length; *APSS*, A-point septal separation; *E*, early diastole velocity of the mitral inflow; *EDT*, early deceleration time; *EF*, ejection fraction; *EPSS,* E-point septal separation; *EPOL,* E-point opening length; diastole velocity of the mitral inflow.

chamber view. In addition, many emergency physicians may not have advanced echocardiographic training to perform these measurements. Considering these limitations we thought that a simple method to assess diastolic dysfunction is important for the ED.

We performed this pilot study to demonstrate that a rapid and practical method can be applied in the ED. Our study included only patients with grade 1 diastolic dysfunction, which made it difficult to generalize our study. Considering that grade 1 diastolic dysfunction can be easily affected by the current clinical conception and treatment, among other factors, it suggests that our study should be conducted to include all subgroups of diastolic dysfunction. In addition, because our study included only grade 1 diastolic dysfunction, it included a single-group evaluation. This makes it impossible to calculate the sensitivity or specificity of the M-mode EPSS/APSS ratio measurement. Accordingly, more evidence is needed for the general use of the M-mode EPSS/APSS ratio measurements for grade 1 diastolic dysfunction.

This study also evaluated the time taken for M-mode measurements of the MV anterior leaflet in the PSLA view and PW Doppler measurements in the A4C view. The mean time taken for measurements in the PSLA view was shorter than the mean time taken for measurements in the A4C view. Adopting the time measured after the image window was provided as the starting point eliminated the time difference in finding the appropriate window. The shorter PSLA measurement time suggests that this may be advantageous for diastolic assessment.

LIMITATIONS

There are a number of limitations to this study. The first is the small study population and the single-center nature of the research. The second is that since the relationship between M-mode measurements of the MV anterior leaflet in the PSLA

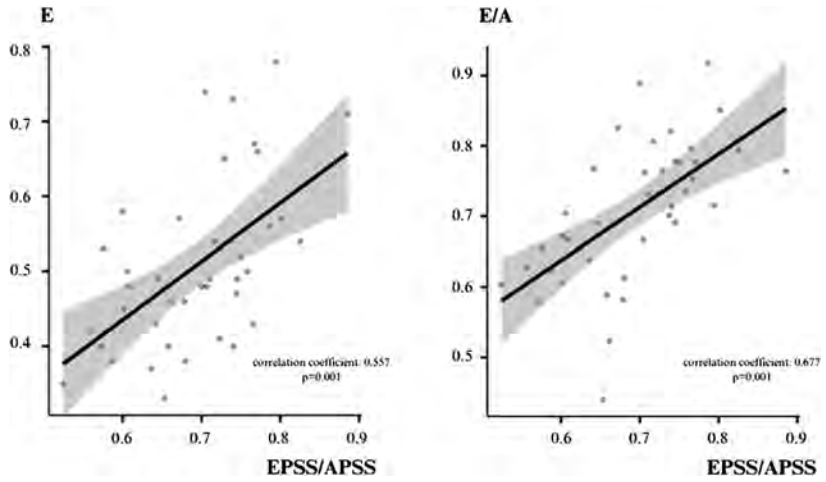

Figure 4. Correlation graphics between measurements in parasternal long axis PSLA view and measurements in apical four-chamber view. *APSS*, A-point septal separation; *E*, early diastole velocity of the mitral inflow; *E/A*, early diastolic velocity of the mitral inflow to the late diastolic velocity ratio; *EPSS*, E-point septal separation.

view and Doppler measurements of the MV inflow velocity in the A4C view is still unclear, sample size calculation could not be performed. It is, therefore, difficult to generalize our results to the wider population. However, we focused on M-mode measurements in the PSLA view and E, A, and EDT measurements in the A4C view, which also permitted a simplified evaluation. Despite the advantages of this approach, it represents another limitation of this study as it does not cover the entire spectrum of diastolic function evaluation. Care was taken to ensure that there was no time between the US evaluation performed by the emergency physicians and the echocardiography evaluation performed by the cardiologists for patient selection, which could have affected the clinical parameters (eg, vital signs) for worsening/improvement. However, the fact that this was not evaluated in terms of time is another limitation of our study. Finally, POCUS was applied by two emergency physicians with experience in ultrasound, and inter-observer agreement was not evaluated. These factors may have affected our results. Further studies with a larger population, including the evaluation of interobserver agreement, are needed to increase the reproducibility and reliability of the diastolic function evaluation method.

CONCLUSION

When evaluating grade 1 diastolic dysfunction, we found a significant correlation between the M-mode E-point septal separation/A-point septal separation ratio measurement in the parasternal long-axis view and the PW Doppler ratio of the early diastolic velocity of the mitral inflow to the late diastolic velocity measurement in the apical four-chamber window. This association suggests that M-mode measurements in the PSLA may be used in diastolic dysfunction.

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Association Between Fentanyl Use and Post-Intubation Mean Arterial Pressure During Rapid Sequence Intubation: Prospective Observational Study

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Introduction: The choice of medications used in rapid sequence intubation (RSI) can result in the difference between an acceptable outcome and a lethal one. When executed properly, RSI is a lifesaving intervention. Nonetheless, RSI may result in fatal complications such as peri-intubation cardiac arrest. The risk of peri-intubation cardiac arrest reportedly increases in patients who are profoundly hypoxic or hypotensive prior to endotracheal intubation. Medication choice for RSI may either optimize or deoptimize hemodynamic parameters, thereby impacting patient outcomes. Therefore, our study aimed to examine the association of change in mean arterial pressure (MAP) with and without the use of a predetermined dose of 50 micrograms (μg) intravenous fentanyl as a pretreatment agent during RSI.

Methods: This prospective observational study included patients undergoing RSI at an academic emergency department (ED) over a three-year period between January 1, 2018–January 1, 2021. Average hemodynamic parameters were measured at the time of induction (prior to medication administration) and 10 minutes after induction. We categorized patients into fentanyl and non-fentanyl groups for analysis, and we compared data using chi-square and *t*-test as appropriate. Logistic regression analysis was conducted to account for potential confounding factors.

Results: A total of 278 patients were included in the analysis, of whom 160 received fentanyl and 118 did not. The majority of the patients underwent RSI by trainees 95.0% of the time. The first-pass success rate was 77.7% in our sample and did not differ significantly between the two groups ($P = 0.84$). Unadjusted analysis showed a larger decrease in hemodynamic parameters in the fentanyl group compared to the non-fentanyl group; systolic blood pressure decreased by 11.2% vs 1.6%, diastolic blood pressure decreased by 13.7% vs 3.8%, and MAP decreased by 12.7% vs 3.2%. After adjusting for potential confounders, fentanyl was 2.14 times more likely to lower MAP by 10%.

Conclusion: The use of 50 μg fentanyl for rapid sequence intubation in an ED is associated with higher odds of decreasing mean arterial pressure by at least 10% at 10 minutes from the time of induction. Therefore, it should be carefully dosed, and its use in clinical practice should be justified to avoid unnecessary complications. [West J Emerg Med. 2025;26(1)10–19.]

INTRODUCTION

Rapid sequence intubation (RSI) is the cornerstone of airway management in the emergency department (ED).[1] The process involves the administration of an induction agent and a neuromuscular blocking agent to facilitate endotracheal intubation. The primary aim of RSI is to provide optimal tracheal intubation conditions and reduce gastric regurgitation.[2] Critically ill patients presenting to an ED generally have profound physiological derangements, which are often paired with a rapid decline. The choice of pharmacological agents may optimize or exacerbate the underlying physiology. Therefore, the ideal technique should provide rapid optimal intubation conditions, allowing a high rate of first-pass intubation success while reliably attenuating excessive hemodynamic changes.[3]

When executed properly, RSI is a lifesaving intervention. However, it has been associated with a peri-intubation cardiac arrest rate of 0.9–2.7%.[4,5] In particular, patients with pre-intubation oxygen saturation <90% or pre-intubation systolic blood pressure (SBP) <100 millimeters of mercury (mm Hg) have been reported to have a higher likelihood of peri-intubation cardiac arrest.[5] Factors related to patient characteristics and procedure technique have a remarkable impact on the rate of occurrence of adverse events. Astute clinicians optimize patient physiology before undertaking RSI to limit complications.

Medications used for RSI have a significant impact on patient outcomes. Fentanyl, an ultra-short-acting pretreatment agent, is used to blunt the catecholamine surge due to α-receptor stimulation from endotracheal intubation. The typical dose is 3–5 micrograms per kilogram (μg/kg) administered intravenously (IV) three minutes prior to intubation.[6] It is traditionally advocated for patients in whom hypertension can be dangerous, such as those with intracranial hemorrhage, elevated intracranial pressure, ischemic heart disease, and aortic aneurysm/dissection.[6] We could not find studies reporting the use of fentanyl as pretreatment during RSI by emergency physicians for non-trauma victims. The use of fentanyl, however, is reported in the anesthesiology literature and limited to trauma victims.[7,8] Nonetheless, previous studies have reported that the use of fentanyl as a pretreatment agent is associated with an increased risk of adverse events, such as post-intubation hypotension.[9,10] In fact, post-intubation hypotension is a known risk factor for higher in-hospital mortality rates and prolonged duration of intensive care unit stays.[11,12,13]

A multicenter, randomized controlled trial compared the use of fentanyl vs placebo with ketamine and rocuronium in patients undergoing RSI in an ED.[14] The trial's secondary outcome revealed that 29% of patients in the fentanyl group had at least one SBP measurement <100 mm Hg compared to 16% in the placebo group.[14] In another study researchers conducted a secondary analysis of data from a multicenter, prospective study of 14 Japanese EDs. They found that patients who received fentanyl had a higher risk of post-intubation hypotension in comparison to those who did not receive the drug.[15] Previous studies investigated the use of fentanyl with a defined cutoff SBP value. In the present study, we sought to examine the use of 50 μg of IV fentanyl as a pretreatment agent before RSI and its association with percent change in post-intubation mean arterial pressure (MAP).

Population Health Research Capsule

What do we already know about this issue?
Peri-intubation hypotension with the use of fentanyl has previously been seen in trauma patients and in the anesthesiology literature.

What was the research question?
Was the use of fentanyl as a pretreatment agent during rapid sequence intubation in the ED associated with a change in mean arterial pressure (MAP)?

What was the major finding of the study?
Fentanyl was associated with reduced MAP (−12.7% vs −3.2%; $P < 0.01$), compared to those without fentanyl.

How does this improve population health?
Emergency physicians should be aware of the complications associated with fentanyl use in the ED. Careful dosing and clinical justification is advised.

METHODS

Study Design

This single-center, prospective observational study included patients undergoing RSI at an academic ED during a three-year period between January 1, 2018–January 1, 2021. The study protocol was approved by the Unit of Biomedical Ethics at the institution (reg. no.: HA-02-J-008) and was conducted in accordance with the tenets of the Declaration of Helsinki. The need for informed consent was waived due to the observational nature of the study.

Study Setting

We conducted the study at an academic ED with an annual census of approximately 60,000 including adult,

pediatric, and pregnant patients. The ED has an accredited four-year emergency medicine residency training program with a total capacity of 32 residents. Upon acceptance into the program, all residents are required to participate in an airway management workshop. Moreover, residents rotate through the anesthesia department with a focus on elective airway management. The majority of intubations were performed by ED residents under the supervision of board-certified emergency physicians with expertise in RSI. All patients requiring RSI were screened for eligibility. The inclusion criteria were as follows: patients aged ≥18 years; those who were administered both induction and neuromuscular blockades; and those who required emergent tracheal intubation at the discretion of the emergency physician. Patients who did not receive neuromuscular blockades, were <18 years, had received vasopressors for hypotension prior to intubation, and those in whom intubation was performed in settings other than the ED were excluded from the study.

All treatment decisions were made at the discretion of the treating physician and were not influenced by the study. Once the decision to perform RSI was made, patients were prepared in accordance with the following departmental protocol:

1. Non-invasive monitoring of heart rate, systolic, diastolic, mean arterial blood pressure, respiratory rate, 3-lead electrocardiogram, and oxygen saturation using CARESCAPE B650 (GE Healthcare, Chicago, IL) monitors.
2. Placement of two large-bore IV catheters at the level of the antecubital fossa or above.
3. Selection of IV fentanyl (fixed dose of 50 μg) as a pretreatment agent was optional at the discretion of the physician.
4. Selection of an IV induction agent (etomidate 0.3 milligrams per kilogram (mg/kg), ketamine 1 mg/kg, propofol 1 mg/kg, or midazolam 0.3 mg/kg) and an IV neuromuscular blocking agent (succinylcholine 1.5 mg/kg or rocuronium 1.2 mg/kg) based on the physician's preference. (Dosing may be reduced in hypotension based on physician discretion.)
   - *All medications were administered at the same time using the following sequence: pretreatment – induction – neuromuscular blockade, when pretreatment was given; and induction – neuromuscular blockade, when pretreatment was not given.*
5. Optimization of the hemodynamic status to achieve a SBP of at least 100 mm Hg.
6. Optimization of pre-induction oxygen saturation to at least 98% (either via non-rebreather mask at 15 liters per minute or positive pressure ventilation using bag valve mask (BVM) when oxygen saturation dropped below 90%).
7. Placement of the patient in a 20–30° upright position during preoxygenation.
8. Preparation of a suction canister with a Yankauer catheter.
9. Preparation of an intubating device based on the physician's preference (either direct laryngoscopy using a size 3 or 4 Macintosh blade or video laryngoscopy using a hyperangulated laryngoscope). All endotracheal tubes were loaded with a stylet appropriate for the device used. Adjuncts and backup devices were also prepared, including nasopharyngeal airways, oropharyngeal airways, laryngeal mask airways, and gum-elastic bougies.
10. Confirmation of the position of the endotracheal tube using capnometry or continuous capnography.

Upon completion of a successful endotracheal intubation, the treating physician was required to complete an airway procedure note. At least two registered nurses were to be present during the procedure; one performed documentation, while the other prepared medications. Ultimately, the treating physician was required to enter all the procedure details in the patient's electronic health record. When entering an electronic procedure note, it was mandatory that the physician include all the details or it might have resulted in the inability to continue patient care via electronic medical records system. This led to a data capture rate of 100%.

An attempt was defined as a laryngoscope blade placed into the oropharynx regardless of whether an endotracheal tube was passed. When oxygen saturation measurements dropped below 90%, the operator removed the laryngoscope blade and provided positive pressure ventilation via a BVM until oxygen saturation reached at least 98%. Modifications in subsequent attempts were made at the discretion of the treating clinician.

Definition of Post-Intubation Hypotension

Previous studies have defined hypotension as an absolute SBP <90 mm Hg or MAP <65 mm Hg.[16] It is, however, crucial to note that binary definitions are not always applicable in clinical practice.[17] Classical anesthesia practice suggests maintaining blood pressure within a relative 20% of the preoperative values.[17] This is based on the theory that patients with hypertension require higher than normal pressure to adequately perfuse organs that are habituated to high pressure.[17] In fact, a systematic review[18] examined the definitions of intraoperative hypotension and found that it could be either based on absolute values (ie, MAP <50 mm Hg, <55 mm Hg, <60 mm Hg, <65 mm Hg, <70 mm Hg, <75 mm Hg) or thresholds relative to baseline preoperative values (ie, decrease in MAP by >10% from baseline, decrease in MAP by >15% from baseline, decrease in MAP by >20% from baseline, decrease in MAP by >25% from baseline, decrease in MAP >30% from baseline). Based on the

aforementioned findings, we defined post-intubation hypotension as a decrease in MAP by >10% within 10 minutes of induction.[18]

Measurements

Once the treating physician decided to proceed with RSI, all patients underwent continuous monitoring of vital signs (heart rate, blood pressure, oxygen saturation, respiratory rate) via non-invasive measures. Blood pressure was measured using a cuff placed around the upper arm and cycled every two minutes. An average of three vital sign readings was obtained at the time of induction (immediately prior to the administration of pretreatment or induction) as a pre-induction value, and 10 minutes after the administration of the first medication in the sequence as a post-intubation value. Adverse events were documented if they occurred within 60 minutes after induction. An individual was assigned to measure the hemodynamic parameters and the time using a stopwatch. Pulmonary aspiration was documented based on chest radiograph evidence of aspiration within 14 days of induction.

Statistical Analysis

We present categorical variables as frequencies and percentages, while continuous variables are presented as median and interquartile ranges. Patients were categorized into two groups: fentanyl and non-fentanyl. We performed comparisons using chi-square for categorical data and *t*-test for continuous data. We measured percent change in hemodynamic parameters (at induction and 10 minutes after induction) using the following formula: [(post-intubation value – pre-induction value)/pre-induction value] × 100.

We compared percent change in hemodynamic parameters between the two categories using the *t*-test. Binary logistic regression analysis was performed to adjust for potential confounding factors. The dependent variable was at least a 10% reduction in MAP (yes/no), while independent variables included age (in years); weight (in kg); indication for intubation (airway protection [yes/no]); respiratory failure [yes/no]); anticipated deterioration [yes/no]); clinical diagnosis (pulmonary diseases [yes/no]; cardiovascular diseases [yes/no]; hepatic diseases [yes/no]; renal diseases [yes/no]; neurological diseases [yes/no]; endocrine disorders [yes/no]; infectious diseases [yes/no]; toxicity [yes/no]); and choice of medication (fentanyl [yes/no]; etomidate [yes/no]; ketamine [yes/no]; propofol [yes/no]; succinylcholine [yes/no]; rocuronium [yes/no]). Independent variables were selected a priori to avoid overfitting the model.

We categorized presenting conditions into the following: pulmonary diseases (including acute respiratory distress syndrome, pulmonary edema, pulmonary embolism, acute asthma exacerbation, chronic obstructive pulmonary disease exacerbation, pneumothorax, pleural effusion, interstitial lung disease, and hemoptysis); cardiovascular diseases (including acute coronary syndrome, aortic syndromes, dysrhythmias, and circulatory shock due to any cause); hepatic diseases (including acute and chronic liver failure and hematemesis due to liver failure); renal diseases (including end-stage renal disease requiring dialysis and obstructive uropathy); neurological diseases (including status epilepticus, hepatic encephalopathy, uremic encephalopathy, hypertensive encephalopathy, acute ischemic stroke, intracranial hemorrhage, neuromuscular weakness, and altered mental status due to any cause); endocrine disorders (including diabetic ketoacidosis, decompensated hypothyroidism, thyroid storm, and adrenal insufficiency); infectious diseases (including meningitis, encephalitis, cerebral abscess, pyelonephritis, pneumonia, spontaneous bacterial peritonitis, and sepsis from any cause); and toxicity (including opioid toxicity, benzodiazepine toxicity, cocaine toxicity, and alcohol intoxication).

The primary endpoint was at least a 10% change in MAP measured 10 minutes from the time of induction. Level of significance was set at $P < 0.05$.

RESULTS

During the three-year study period, we collected data from 361 intubation encounters. Of these, only 278 patients met our inclusion criteria (Figure 1). A total of 160 patients received fentanyl as pretreatment, whereas 118 did not receive fentanyl as pretreatment for RSI. Baseline

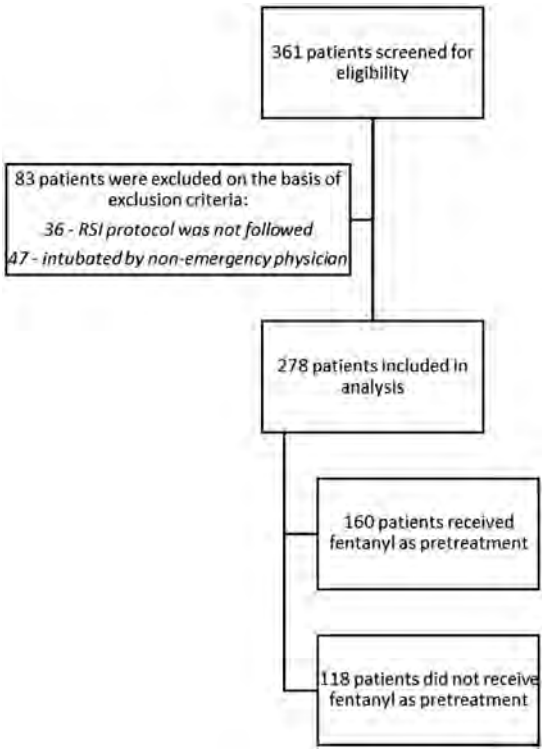

Figure 1. Flow diagram for study participants.
RSI, rapid sequence intubation.

Table 1. Characteristics of patients undergoing rapid sequence intubation stratified by use of fentanyl.

	All (n = 278)	Pretreatment with fentanyl (n = 160)	No fentanyl (n = 118)	*P*-value
Age (median [IQR])	61 (54–68)	62 (50–71)	60 (56–66)	0.64
Weight (kg) (median [IQR])	78 (73–84)	78.5 (74–85)	77 (71–80)	0.77
Gender Male	160 (57.6%)	89 (55.6%)	71 (60.2%)	0.44
Female	118 (42.4%)	71 (44.4%)	47 (39.8%)	
Presenting condition				
Neurologic diseases	85 (30.6%)	53 (33.1%)	32 (27.1%)	0.28
Pulmonary diseases	119 (42.8%)	64 (40%)	55 (46.6%)	0.27
Cardiovascular diseases	38 (13.7%)	24 (15%)	14 (11.9%)	0.45
Hepatic diseases	24 (8.6%)	11 (6.9%)	13 (11%)	0.22
Renal diseases	39 (14.0%)	22 (13.8%)	17 (14.4%)	0.87
Endocrine disorders	25 (9.0%)	14 (8.8%)	11 (9.3%)	0.86
Infectious diseases	71 (25.5%)	39 (24.4%)	32 (27.1%)	0.60
Toxicological causes	3 (1.1%)	1 (0.6%)	2 (1.7%)	0.39
Indication for RSI				
Respiratory failure	120 (43.2%)	64 (40%)	56 (47.5%)	0.21
Airway protection	45 (16.1%)	30 (18.8%)	15 (12.7%)	0.17
Anticipated deterioration	114 (41.0%)	66 (41.3%)	48 (40.7%)	0.92
Pre-induction vital signs				
Pre-induction SBP	122 (106–138)	124 (100–140)	121 (110–131)	0.83
Pre-induction DBP	80 (61–88)	80 (60–87)	78 (62–88)	0.69
Pre-induction MAP	93 (77–102)	94 (73–102)	92 (79–100)	0.75
Pre-induction HR	107 (100–114)	106 (99–112)	107 (100–119)	0.15
Pre-induction RR	24 (22–28)	24 (22–28)	25 (21–29)	0.74
Pre-induction SpO_2	93 (88–97)	95 (88–97)	91 (88–95)	0.15
Pre-induction GCS	14 (11–15)	13 (10–15)	14 (12–15)	0.09
Post-intubation vital signs				
Post-intubation SBP	115 (96–129)	110 (88–128)	119 (106–129)	0.01
Post-intubation DBP	70 (55–80)	69 (49–75)	75 (60–87)	<0.01
Post-intubation MAP	84 (70–96)	82 (62–92)	89 (77–100)	<0.01
Post-intubation HR	101 (92–116)	93 (88–100)	111 (107–124)	<0.01
Induction agent				
Etomidate	263 (94.6%)	149 (93.1%)	114 (96.6%)	0.20
Ketamine	14 (5.0%)	11 (6.9%)	3 (2.5%)	0.10
Propofol	2 (0.7%)	1 (0.6%)	1 (0.8%)	0.82
Paralytic agent				
Succinylcholine	252 (90.6%)	142 (88.8%)	110 (93.2%)	0.20
Rocuronium	26 (9.4%)	18 (11.3%)	8 (6.8%)	0.20
Cormack-Lehane grade				
Good	235 (84.5%)	137 (85.6%)	98 (83.1%)	0.55
Poor	43 (15.5%)	23 (14.4%)	20 (16.9%)	
First pass success	216 (77.7%)	125 (78.1%)	91 (77.1%)	0.84

(*Continued on next page*)

Table 1. Continued.

	All (n = 278)	Pretreatment with fentanyl (n = 160)	No fentanyl (n = 118)	*P*-value
Device used				
Direct laryngoscopy	29 (10.9%)	19 (11.9%)	10 (8.5%)	0.35
Video laryngoscopy	249 (89.6%)	141 (88.1%)	108 (91.5%)	0.35
Operator				
Physician	14 (5.0%)	12 (7.5%)	2 (1.7%)	0.02
Trainee	264 (95.0%)	148 (92.5%)	116 (98.3%)	
Post-induction adverse events				
Cardiac arrest	5 (1.8%)	4 (2.5%)	1 (0.8%)	0.30
Severe hypoxia	14 (5.0%)	10 (6.3%)	4 (3.4%)	0.28
Vasopressor requirement	21 (7.6%)	15 (9.4%)	6 (5.1%)	0.18
Aspiration	5 (1.8%)	2 (1.3%)	3 (2.5%)	0.42
Esophageal intubation	9 (3.2%)	6 (3.8%)	3 (2.5%)	0.57
Right mainstem intubation	7 (2.5%)	3 (1.9%)	4 (3.4%)	0.42
Dental trauma	3 (1.1%)	2 (1.3%)	1 (0.8%)	0.74
Pneumothorax	1 (0.4%)	1 (0.6%)	0 (0%)	0.39
Outcome				
Mortality	20 (7.2%)	12 (7.5%)	8 (6.8%)	0.81

RSI, rapid sequence intubation; *IQR*, interquartile range; *SBP*, systolic blood pressure; *DBP*, diastolic blood pressure; *MAP*, mean arterial pressure; *HR*, heart rate; *RR*, respiratory rate; SpO_2, oxygen saturation; *GCS*, Glasgow Coma Scale.

characteristics of the participants (including age, weight, gender, presenting condition, pre-induction vital signs, induction agents, Cormack-Lehane grade, first-pass success rates, device used, and post-induction adverse events) were mostly similar between the two groups (Table 1). However, operators and post-intubation hemodynamic parameters were significantly different between the two groups. A total of 264 (95.0%) patients underwent intubation by trainees. Post-induction median SBP (110 mm Hg [88–128] vs 119 mm Hg [106–129]; $P = 0.01$), diastolic blood pressure (DBP) (69 mmHg [49–75] vs 75 mmHg [60–87]); $P = < 0.01$), and MAP (82 mm Hg [62–95] vs 89 mm Hg [77–100]); $P < 0.01$) were significantly lower in the fentanyl group than in the non-fentanyl group (Table 1 and Figure 2).

Upon examining percent change in hemodynamic parameters between the two groups (Table 2), we found significantly larger differences in the fentanyl group in SBP (−11.2 vs −1.6%; $P < 0.01$), DBP (−13.7 vs +3.8%; $P < 0.01$), MAP (−12.7% vs −3.2%; $P < 0.01$), and heart rate (12.2% vs +3.7%; $P < 0.01$). [Table 2]

We performed logistic regression analysis (Table 3) to ascertain the association of confounding factors on the likelihood that study participants would sustain at least a 10% reduction in MAP. The model explained 77.1% (Nagelkerke R2) of the variance in post-induction hypotension and correctly classified 88.1% of the cases. Our model showed that the use of fentanyl was 2.14 times (95% confidence interval [CI] 1.34–4.11) more likely to be associated with at least 10% reduction in MAP post-intubation. The remaining predictors did not reveal any association. Based on our post hoc power analysis, the sample size had 86.9% ($\alpha = 0.05$) power to detect a change in MAP of at least 10%.

DISCUSSION

In this single-center ED study, we found that a decrease in MAP by at least 10% was associated with the use of 50 μg of fentanyl as a pretreatment agent in RSI. This reduction was also seen in SBP and DBP. The reduction in MAP was observed even after adjusting for potential confounding factors. Induction agents have been previously reported to be associated with peri-intubation hypotension.[18,19] Etomidate is least likely to be associated with this outcome.[19,20,21] Fentanyl is an optional pretreatment agent; although studies on its use are scant, it is an available option as a pretreatment agent for RSI in some parts of the world and in certain conditions such as trauma.[8] Studies examining the association between fentanyl use and peri-intubation hypotension are limited.[14,15] While the aforementioned studies defined hypotension based on a cutoff SBP value, in

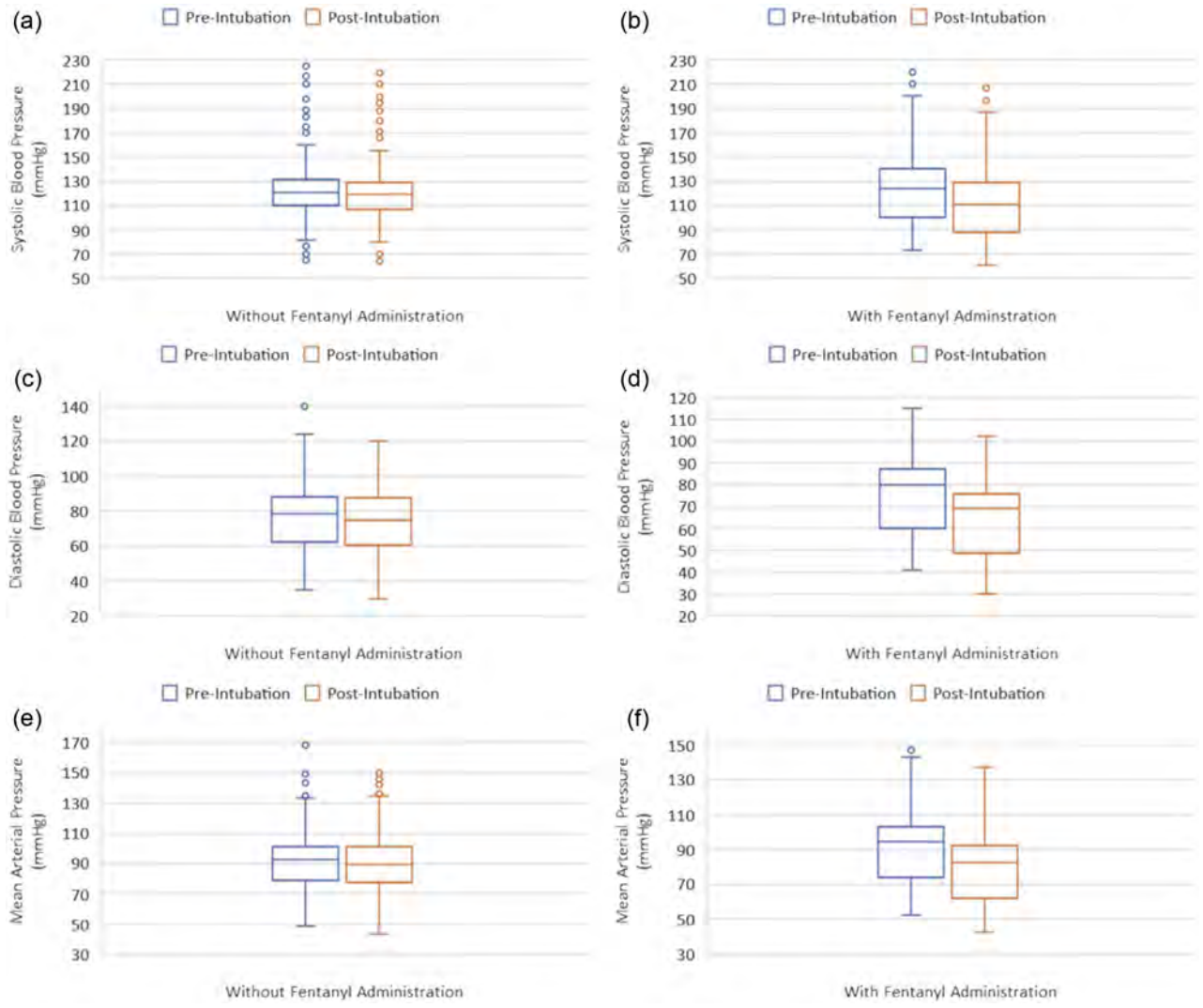

Figure 2. Hemodynamic parameters at the time of induction (pre-intubation) and at 10 minutes after induction (post-intubation) stratified by fentanyl administration: (a) change in systolic blood pressure (SBP) without fentanyl; (b) change in SBP with fentanyl; (c) change in diastolic blood pressure (DBP) without fentanyl; (d) change in DBP with fentanyl; (e) change in mean arterial pressure (MAP) without fentanyl; (f) change in MAP with fentanyl.

this study we sought to examine the change in hemodynamic parameters from the time of induction until 10 minutes after induction in relation to the use of fentanyl. This approach provides a more dynamic definition of hypotension. Our analysis found at least a 10% reduction in SBP, DBP, and MAP associated with the use of fentanyl.

The purpose of fentanyl is to blunt the sympathetic surge induced by laryngoscopy; thus, dosing should be decided with caution. While lower doses may achieve fentanyl's purpose, higher doses may introduce unwanted adverse events such as hypotension. We used a standard dose of 50 µg that was administered immediately before the induction agent, and it showed an association with at least 10% reduction in hemodynamic parameters. While in our study we used dosing well below what is described in the literature, a previous study that examined the impact of dose-dependent effects on hemodynamic parameters did not reveal a significant difference between the full and lower dose regimens.[23] Blood pressure decreased an average of 12 mm Hg (95% CI 7–16) in the full-dose group and by 6 mm Hg (95% CI 1–11) in the reduced-dose group ($P = 0.10$).[22] Although not significantly different, it is critical to note that hemodynamic parameters showed lower trends in the full-dose group. Therefore, the use of fentanyl should be clinically justified and carefully dosed, especially for critically ill patients who are dependent on their sympathetic drive for survival. Furthermore, its preparation and administration are additional steps in a multistep procedure.

We found a significant difference between operators in terms of the use of fentanyl. While the majority of intubations were performed by trainees, our study showed that attending physicians used fentanyl as a pretreatment

Table 2. Change in hemodynamic parameters (between pre-induction and post-intubation values) stratified by use of fentanyl.

	Fentanyl group	Non-fentanyl group	*P*-value
Systolic blood pressure			
Absolute change	−14 mm Hg	−2 mm Hg	<0.01
Percent change	11.2%	1.6%	
Diastolic blood pressure			
Absolute change	−11 mm Hg	−3 mm Hg	<0.01
Percent change	13.7%	3.8%	
Mean arterial pressure			
Absolute change	−12 mm Hg	−3 mm Hg	<0.01
Percent change	12.7%	3.2%	
Heart rate			
Absolute change	−13 BPM	+4 BPM	<0.01
Percent change	12.2%	3.7%	

mm Hg, millimeters of mercury; *BPM*, beats per minute.

agent before RSI more frequently than trainees. This can be attributed to clinical practices developed by attending physicians over their training period. While the physicians staffing our department have been trained in emergency medicine, the majority were trained in the Middle East and some in North American institutions. This may suggest that the use of fentanyl as a pretreatment agent for RSI is variable based on training and practice.

Table 3. Factors predicting 10% reduction in mean arterial pressure from the time of pretreatment (or induction) until 10 minutes after induction.

	Adjusted odds ratio	95% CI
Age	1.00	*0.98–1.02*
Weight	0.92	*0.73–0.98*
Gender	0.69	*0.40–1.19*
Airway protection	0.40	*0.11–1.41*
Respiratory failure	0.77	*0.33–1.83*
Anticipated deterioration	0.20	*0.11–2.77*
Pulmonary diseases	1.84	*0.83–4.05*
Cardiovascular diseases	1.10	*0.81–3.98*
Hepatic diseases	0.99	*0.39–2.51*
Renal diseases	1.52	*0.71–3.24*
Neurological diseases	1.79	*0.80–3.89*
Endocrine disorders	1.07	*0.42–2.73*
Infectious diseases	1.12	*0.59–2.12*
Toxicological causes	4.36	*0.34–7.70*
Fentanyl	2.14	*1.34–4.11*
Etomidate	1.21	*0.83–1.24*
Ketamine	0.81	*0.76–1.89*
Propofol	1.67	*0.87–2.33*
Midazolam	1.12	*0.91–4.01*
Succinylcholine	0.71	*0.54–2.32*
Rocuronium	0.61	*0.43–1.78*

CI, confidence interval.

Since the literature does not show a strong benefit in outcomes, (ie, higher first-pass success, reduced mortality rates, reduced esophageal intubation, or reduced hypoxia), we question the use of fentanyl in routine clinical practice. We emphasize the importance of optimizing hemodynamic parameters before RSI and aiming for first-pass success. Therefore, the selection of induction agents that attenuate peri-intubation hypotension during RSI is desirable. A major advantage of etomidate compared with other induction agents is that it preserves cardiovascular stability. It typically does not cause significant hypotension upon induction at a dose of 0.3 μg/kg.[23,24] This is because etomidate does not significantly inhibit sympathetic tone and preserves autonomic reflexes. It is thought that etomidate has this property because it acts as an agonist at the α-2 adrenoreceptors responsible for the peripheral vasoconstriction response to hypotensive effects.[24] However, there are concerns with its use in critically ill patients because it is known to inhibit adrenal enzymes but is clinically insignificant from a single bolus dose. Other reported side effects include nausea, vomiting, laryngospasm, and myoclonus, all of which can be attenuated by neuromuscular blockade.[23]

Importantly, etomidate did not show increased mortality when compared with other induction agents.[23] Ketamine may be a reasonable option for RSI because of its quick onset and short duration of action, its preservation of respiratory drive, and its sympathomimetic properties. However, in critically ill patients with depleted catecholamine stores,

there is concern for hypotension and cardiac arrest.[23] Propofol, although having a quick onset and short duration of action, has the most profound effect on blood pressure, which may limit its use in critically ill patients.[23] Midazolam may be less desirable for RSI as it has a longer onset of action compared with etomidate and ketamine and is a potent venodilator at RSI doses.[23]

Taken as a whole, there was no significant difference between etomidate and other induction agents in the most serious outcome, mortality. In addition, most studies demonstrated favorable peri-intubation hemodynamics with etomidate. Because etomidate is often readily available, clinicians have experience with its use, and its cost is low, it is a reasonable RSI induction agent for critically ill patients.[23] However, in settings where physicians may not have access to hemodynamically neutral agents such as etomidate for RSI, it would be prudent to optimize patient physiology and hemodynamic parameters during airway management.

LIMITATIONS

Our study had a few limitations that need consideration. First, this single-center study was conducted in the ED, which limits its generalizability to other settings and institutions. Second, hemodynamic parameters were measured using non-invasive methods, which might have lowered the accuracy of the results. However, this reflects real-world practice due to limited time and resources when performing an arterial line in patients requiring emergent airway intervention. Third, our study lacks valuable hemodynamic data beyond the 10-minute time frame. Fourth, this was an observational study that allowed physician's discretion. However, a departmental protocol exists for RSI to standardize the procedure.

Fifth, our department protocol allows a maximum dose of 50 μg of IV fentanyl. The dose used in this study is well below the dosing described (3–5 μg/kg) in the literature. Therefore, we were unable to determine the association of hemodynamic parameters with different dosing strategies. Sixth, although data was collected in real time, it was typically entered manually after the procedure, which may have resulted in recall bias. Seventh, the inclusion of induction agent dosing and its association with post-intubation hypotension would add valuable information, but it is not reported in our study due to the variability in dosing between physicians and the extremely low use of certain induction agents such as propofol. Finally, while we performed a logistic regression analysis to account for confounding factors, other unmeasured confounders may still exist given the observational nature of the study.

CONCLUSION

In this prospective, single-center ED study, we found that the use of 50 μg fentanyl is associated with higher odds of reduction in mean arterial pressure by at least 10%. While fentanyl is an ultra-short-acting agent that could be beneficial for certain conditions, it should be carefully dosed, and its use should be justified in clinical practice to avoid unnecessary complications arising from blood pressure reduction.

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Beirut Port Blast: Use of Electronic Health Record System During a Mass Casualty Event

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Introduction: Emergency departments (ED) play a central role in defining the effectiveness and quality of the overall hospital's mass casualty incident (MCI) response. The use of electronic health records (EHR) in hospital settings has been rapidly growing globally. There is, however, a paucity of literature on the use and performance of EHR during MCIs.

Methods: In this study we aimed to describe EHR use, as well as the challenges and lessons learnt in response to the 2020 explosion in the Port of Beirut, Lebanon, during which the hospital received over 360 casualties.

Results: Information technology support, reducing EHR system restrictions, cross-function training, focus on registration and patient identification, patient flow and tracking, mobility and bedside access, and alternate sites of care are all important areas to focus on during emergency/disaster response planning.

Conclusion: Innovative solutions that help address logistical challenges for different aspects of the disaster response are needed. [West J Emerg Med. 2025;26(1)20–29.]

INTRODUCTION

Emergency departments (ED) play a central role in responding to mass casualty incidents (MCI) and define the effectiveness and quality of the overall hospital response.[1,2] Hospitals must be prepared to respond to a large influx of patients and coordinate resources accordingly. This becomes particularly challenging in systems that lack a national or regional emergency medical services (EMS) plan and a disaster response framework.

Preparedness for MCIs is multifaceted and entails a multidisciplinary and integrated approach to develop a response plan that allows for prompt activation of a disaster code and notification of staff, expansion of triage and clinical areas, quick registration, rapid disposition, patient tracking, resources coordination, crowd control, efficient internal and external communication, and effective leadership and governance. Numerous previous studies have examined MCI responses; however, limited data exists on the performance of electronic health records (EHR) during MCIs.[3–5]

The adoption of EHRs by healthcare organizations has seen rapid growth globally, fueled by data supporting their positive impact on safety, quality and efficiency. The EHR offers valuable advantages in terms of strengthening patient tracking capabilities, improving clinician efficiency through quick access to medical records, and improving clinical decision-making through best practice advisories, as well as empowering healthcare systems with analytical and reporting capabilities.[6–13] At the same time, some studies

have raised concerns around declining throughput, lengthy documentation requirements, increasing complexity of work, and challenges with user-friendliness, as well as the level of available technical support for clinicians.[14–21] This is particularly relevant to ED settings where time constraints and complex processes pose additional challenges.

Use of EHRs in MCIs requires the development of specialized disaster modules that involve pre-registered records that can be quickly accessed and activated in a disaster. Given the time constraints in MCIs, where routine processes might not keep up with the flow of patients, specialized workflows around documentation, financial clearance, computerized physician order entry (CPOE), medication management, patient tracking, and admission and discharge are required.[12,22] To our knowledge there are no peer-reviewed publications documenting the use and performance of EHRs during live MCIs.

On August 4, 2020, during the COVID-19 pandemic, Lebanon witnessed its largest non-conflict-related MCI, the Beirut port blast, which left behind ≈200 dead and 6,500 injured.[23] In this study we aimed to describe EHR use during the MCI response, as well as highlight the challenges and lessons learnt in response to the Beirut port blast, one of the largest non-nuclear explosions in history.

Population Health Research Capsule

What do we already know about this issue?
Hospitals and EDs face major operational challenges during mass casualty incidents (MCI). Research on the use of electronic health records (EHR) during MCIs is limited.

What was the research question?
This study examines EHR use during the Beirut port blast (August 2020) and highlights challenges and lessons learnt from this MCI.

What was the major finding of the study?
Opportunities identified for improved EHR use during MCIs included staff training and scaling up routine workflows to enhance efficiency of response.

How does this improve population health?
Hospitals adopting proposed EHR changes can better respond to MCIs, enhancing efficiency and leading to improved patient outcomes.

METHODS

Design

This is a case report with a review of the literature. We searched both Pubmed and MEDLINE using the following keywords: electronic medical record; disaster planning; mass casualty incident; hospital emergency preparedness; and medical informatics. This resulted in the identification of three manuscripts. All three involved limited use of information technology (IT) in a MCI, and only one involved a live activation.[24–26] The search did not yield any manuscripts on MCI response with a fully integrated EHR system.

Facility

The American University of Beirut Medical Center (AUBMC) is the largest academic, tertiary-care center in Beirut with over 57,000 ED visits annually. In the past 17 years, AUBMC-ED has been at the forefront of responding to over 15 MCIs. As a result, AUBMC regularly assessed and modified both its ED and hospital emergency preparedness plan (EPP). The AUBMC established its own EPP in July 2000. Yearly drills and modifications to the existing plan were conducted to ensure better communication, coordination, and availability of resources during MCIs. In 2019, AUBMC became an HIMSS Stage 6 Emergency Medical Record/EHR institution with the implementation of the Epic EHR (Epic Systems Corporation, Verona, WI).

The Event

On August 4, 2020, at 6:07 PM, an estimated 2,750 tons of stored ammonium nitrate exploded at the Port of Beirut less than 2.5 miles from AUBMC.[27] The Beirut port blast was reported to be one of the largest non-nuclear explosions in history leaving behind more than 6,500 people injured, approximately 300,000 displaced, and 204 fatalities.[27] Casualties immediately flooded nearby hospitals, which had already been partly destroyed by the blast.

The AUBMC ED started receiving casualties from within the institution and from its neighborhood less than three minutes after the explosion due to its proximity to the blast site. The highest EPP notification level "Code D-Full Activation level" was immediately activated at AUBMC, where all hospital staff were notified to respond. During the three-hour interval following the explosion, over 360 victims were treated in the ED, of whom 87 required admission (52 regular bed admissions, 19 critical care cases, and 16 immediately operated on) and 12 reported dead upon arrival.

Description of the Emergency Preparedness Plan

The disaster plan at AUBMC consists of two levels of MCI response (Code D): partial and full activation. Activation usually follows an alert notification "Code D Alert."

"Code D – Partial activation" requires all essential staff to report to their corresponding departments including the ED. "Code D – Full Activation" requires all active staff to report to their corresponding departments. Activation of the disaster plan and its corresponding response level is traditionally based on the geographical location of the incident and on the number of casualties expected to present to the ED.

The hospital director or administrator on call is in charge of announcing the level of hospital response. Code D Alert is usually announced by the ED director, chair, or delegate for MCIs located in a predefined geographical area surrounding AUBMC. Activation levels are communicated through short text message (SMS), paging and WhatsApp messages to pre-prepared disaster lists of hospital staff. This ensures redundancy of communication since cellular networks usually experience delays in SMS delivery during MCIs due to infrastructure damage and call overload on landlines and mobile networks.

Upon activation of the EPP, initial steps of the response consist of quickly transforming the ED physical space to designated color coded "surge areas," with deployment of pre-prepared supplies and medication carts to different sections. A mobile triage area is set up and existing ED patients are discharged or sent to inpatient units to improve surge capacity and prepare for the first wave of casualties. The MCI patients are color tagged upon arrival to the ED and directed from triage to designated areas based on a color-coded triage system. Patient triage shifts from Emergency Severity Index scoring to the modified care-flight system. A detailed description of the plan has been previously published.[1]

Emergency Preparedness Plan Post Implementation of an Electronic Health Record

During the implementation of Epic in 2018, scoping and adoption phases focused on including a streamlined disaster module because of the high frequency of MCIs in Lebanon. The foundational Epic disaster module that is part of the standard implementation package was modified for alignment with existing workflows. Final workflows that were integrated into the disaster module are summarized in Table 1. With the implementation of the EHR, the response plan shifted from pre-prepared manual charts to a full electronic system using pre-printed bracelets containing pre-assigned mass casualty record (MCR) numbers and requiring barcode scanning for activation. The MCR numbers are unique identifiers that allow identification and tracking of casualties during the disaster response phase.

Smart groups of preferred orders (laboratory, medication, radiology, admissions, procedures, etc) were built into the disaster module based on previous data from MCIs. These would be requested electronically in Epic when the disaster module is activated. Results are viewed electronically when available, which would allow physicians to access real-time patient data.

Tracking and identification of casualties also shifted from a paper-based system to an electronic system whereby staff and caregivers can track casualties at any point in time on "disaster view" using the EHR disaster navigator. Moreover, charging and financial clearance in the disaster module are performed automatically instead of manually. Documentation within the disaster module included a simplified trauma template. The EHR implementation plan also included allocation of additional workstations on wheels that can be deployed into the surge areas for use by front-liners. Additional areas were designated for workstation deployment and included triage and the low-acuity "green area," as well as the discharge area.

Debriefing

After the MCI, several debriefing sessions were held to review strengths and areas for improvement in our response protocols. Psychological debriefing sessions were conducted within 72 hours of the event with all team members who actively participated in the incident including faculty, residents, and nursing teams. These initial debriefings were led by the chair of the department. They were carried out immediately after the incident for staff who were involved directly in the MCI response and focused on emotional support, leaning on principles outlined in the MCI CORD (Council of Residency Directors in Emergency Medicine) Survival Package for psychological debriefs.[28] The psychological debriefing sessions were subsequently followed by technical debriefs conducted around three weeks post event by a multidisciplinary team including clinical and non-clinical staff from the ED (chair of ED, ED medical director, ED nurse manager, ED quality officer), surgical department (chair of surgery, director of trauma), medical informatics team (director of medical center applications, and chief medical information officer), risk management (director of quality safety and risk management, and safety officer), nursing team (director of nursing), and patient registration team (director of patient registration).

The technical debriefs were led by the director of quality safety and risk management and followed the after-action review framework, including a review of the incident, an analysis of both the successes and challenges encountered, as well as an identification of root causes of any shortcomings.[29] Minutes of the debrief sessions were recorded by the quality team and sent to participants for review, comments, and approval prior to finalization. These minutes were then analyzed by two of the authors following the six-stage process for thematic analysis.[30] This included data familiarization, initial code generation, reviewing themes, defining and naming themes, and completion of write-up. Through this process, we identified several key focus areas. Key findings and discussion points raised in our debriefing sessions were used to modify the plan for future responses. Since this event was the first to test the EHR component of

Table 1. Changes done to emergency preparedness planning after introduction of an electronic health record.

Elements	Pre-EHR	Post-EHR
Communication display of a disaster status on the dashboard	Not available	ED nurse manager and/or ED charge nurse and/or ED clerks activate the ED department status to "Disaster" on the ED dashboard.
Registration of casualties	Registration is performed manually. Pre-labeled emergency wristbands are used at the triage area.	Pre-printed identification bracelets available with the PA team, are used during partial and/or full activation of the disaster. Pre-printed bracelets contain preassigned MCR numbers and patient hospital number. PAOs provide each casualty with a bracelet, scan it, and activate the chart in EPIC. Once the casualty is registered, the record appears in the Disaster section, the triage RN then completes the triage using the Disaster Navigator and assigns the casualty to an ED section.
Identification of casualties	MCR numbers are used as the only tracking reference for all concerned departments. The patient's name, if identified, is shown in another field visible to ED and PA staff.	MCR numbers are the only tracking reference for all concerned departments. Patient's name when identified is added to Aliases and not to the primary name field.
Tracking of casualties	Casualty tracking checklists are used. These included: • MCR number • Chief complaint • Entry/exit to/from the color-coded areas • Comments • Patient disposition	The "disaster view" is used to track casualties' movements during disaster, using EPIC disaster navigator. Disaster reports are generated at any point in time during a disaster to track casualties.
Discharge process	Pre-labeled discharge form is used to document diagnosis and follow-up instructions.	Full demographic data are collected by PAOs before discharge. PAOs collect the information included in the ED disaster discharge checklist (MCR number, patient triple name and phone number), to ensure that the patient is registered in the EHR and to provide the patient with the discharge instructions.
Documentation	A pre-labeled kit system is used in the triage area. These kits contain pre-labeled emergency paper charts and preassigned MCR numbers.	During a disaster, the EHR is used by the medical and nursing teams. Nurses and physicians use "disaster navigator" with minimal documentation.
Ordering	Pre-labeled emergency studies' requests are used in the color-coded areas.	All orders required during disaster (laboratory, medications, radiology, procedures, admissions, etc), are ordered through the disaster orders navigator. An admission order is also placed by the medical team for casualties requiring admission.
Radiology process	Pre-labeled emergency studies' requests are used. A radiologist reports the major findings of the radiograph, or CT requests handwritten.	All radiology studies are ordered through the disaster orders navigator, and results are reported on the AGFA/EHR system.
Laboratory process	Pre-labeled emergency paper orders are used. Lab results are communicated verbally to the ED team by phone with read back or handwritten on the lab requests and sent to ED by pneumatic tube.	Rainbow draws are ordered by the RNs on all patients admitted to red and yellow areas, unless the MD already placed orders for these patients. ED EMTs /RN print labels, collect the samples using rainbow draw process, and send them to receiving area using pneumatic tube. MDs, in parallel, order the required tests using the EHR. Laboratory then proceeds with testing, and the results appear electronically on the patient's chart.

(*Continued on next page*)

Table 1. Continued.

Elements	Pre-EHR	Post-EHR
Charging and financial clearance	Charging is performed manually. Casualties are assigned a specific guarantor (070). All charging documents are given by the ED team, at the end of the disaster to the ED cashier. The ED cashier logs them on the billing system (AS400) after the patient's discharge.	Casualties are automatically assigned a specific guarantor (070), thereby allowing automatic clearance of ED registration. Charging is performed electronically using the EHR, during or after the patient's stay. All charges are cleared by the cashier on the billing system (AS400).
Recovery process	Upon disaster termination, all casualties are manually entered on the dashboard, to complete their registration on AS400, placing the necessary charges, and admission orders, if needed, and discharging them.	Upon disaster termination, a recovery process is initiated to update information about each casualty in the EHR (registration status, location, and disposition).
Medication dispensing during disaster	Emergency medication carts are used (Pyxis did not exist).	Emergency medication carts are used. Medications are also dispensed using the ED Pyxis machine. Pyxis is replenished from the central pharmacy.
Equipment	Paper system (workstation wheel [WOWs] did not exist).	ED and PAO staff use WOWs in the triage area, inside the ED, and at discharge

ED, emergency department; *EHR*, electronic health record; *PA*, patient access; *PAO*, patient access officer; *Pyxis*, automated medication dispensing system; *RN*, registered nurse; *MCR*, mass casualty record; *CT*, computed tomography; *MD*, medical doctor; *EMT*, emergency department technician; *WOW*, workstation on wheels.

the EPP plan, a major part of the debriefings focused on EHR-specific issues including workflows and the performance of the EHR'a different features.

RESULTS

Emergency Preparedness Plan Response

We identified several effective elements of EPP response. The actual treatment areas rapidly expanded to designated "surge areas" within and outside the ED. Patient triage rapidly shifted to the modified care-flight system. Non-critical casualties were directed to pre-designated low-acuity or green surge areas with adequate medical teams and supply carts. The influx of patients in terms of rate and number presenting to the ED within the first hour was, however, much higher than expected due the proximity of AUBMC to the explosion site. Casualties were treated in hallways and at the ED entrance on stretchers, chairs, and floors. Treatment of patients proceeded in a quick manner as in previous MCIs with most hospital staff responding immediately upon activation.

Challenges

Numerous issues were, however, faced with the EHR during the response.

Workflow Related

An initial delay occurred in activating the disaster status on Epic since it needed to be activated manually by specifically trained members who were not present physically in the ED at the time of the explosion. This prevented the appearance of the disaster navigator on the dashboard and delayed information relay to different stakeholders in the ED.

Patient registration was another main challenge. The EPP planned for 200 pre-prepared disaster e-records/wristbands. The number of casualties exceeded this within the first hour. Calling in additional registration staff caused delay in registration and inability to capture demographic information for patients who were discharged early, in addition to delays in ordering tests and placing orders on other patients. Creating additional records was logistically challenging since it required both registration staff and IT support. Loading all the records within a short time interval also slowed the system in terms of response. Back-up manual charts were, therefore, used until additional wristbands were printed and corresponding electronic records were created. While MCRs were used as unique identifiers, this prevented easy identification of casualties since registration staff were not collecting patients' names or demographic data when handing out MCR bracelets.

Issues with patient flow and with financial workflows were also identified. Beyond operational difficulty in managing the high number of admissions to hospital, the staff experienced additional challenges related to complex workflows that required following routine admission process for every patient. This proved to be difficult especially for physicians responding in the ED since they were focused on patient care rather than completing steps in admission workflows to allow for patients to transition electronically to inpatient units. Eighty-seven patients required admission, and most of them were physically sent to inpatient units prior to completing the extensive admission electronic process. Financial constraints were also identified for patients during their transition to inpatient status despite previous modification of financial

workflows for the ED in the EPP. Charges were not automatically waived in the operating room or inpatient for patients, similar to what happened at the level of the ED, which required cashiers to manually clear charges during the event.

Medications and supplies were dispatched immediately to different treatment areas in the ED as planned in the EPP. Carts were managed by pharmacists, nurses and store staff who used paper logs while helping dispense different items. Routine medication from Pyxis (the automated medication dispensing system) and supplies workflows were, therefore, bypassed during the event.

Real-time Operations

Patient tracking was also another challenge faced during this MCI response. Several clinical and administrative staff were tracking the number of casualties arriving to the ED; however, moving patients on the dashboard between different sections was delayed, which resulted in difficulties in tracking casualties and in identifying their exact physical location.

Training Related

Clinical documentation was suboptimal during the event. Despite introducing a streamlined one-page "express lane" disaster-documentation module, limited clinical documentation occurred for casualties treated in the ED. Key challenges were related to available workstations, as nearly all areas in the ED were transformed into clinical areas given the high number of casualties. Despite previous training, physicians from other units were not familiar enough with the documentation process on ED patients during EPP. Many patients were discharged physically from the ED with minimal or no documentation.

Recovery Process

Once CODE-D was deactivated, recovery operations resumed. These consisted of cleanup of ED clinical areas, reconciliation of different casualty lists and fatality management/identification, in addition to resupplying essential equipment and restocking ED medications. The Epic dashboard recovery process was not previously planned; therefore, this required setting up a clinical/IT group to help clean up the ED dashboard and to resolve tickets related to patient flow, CPOE, and disposition-related issues (Table 2).

DISCUSSION

This review describes EHR challenges and lessons learned at an academic, tertiary-care center in Lebanon during the response to the Beirut port blast, which was one of the largest non-nuclear modern explosions in history, and reviews the literature on EHR use in a MCI. The main challenges in this case experience were related to complex workflows, training on EHR workflows, and the recovery process. Translatable lessons include improving workflows to streamline patient registration, identification, and care during MCIs. Cross-training of staff on patient-registration disaster modules is also important to capture the large influx of patients. In addition, having members of the IT staff on the ground addressing acute issues during an MCI is an important part of EPP preparedness using EHRs. While a few studies have reported on the use of technology in MCI, these have been limited to specific aspects of IT, such as radiology order entry and tracking systems. No studies to our knowledge have reported on the use and performance of a comprehensive EHR during an MCI.

Non-EHR essential concepts during MCIs focus on external and internal communication. External communication with EMS agencies, command centers, and other neighboring hospitals is needed to coordinate response and provide status updates on capacity and on dynamic readiness of hospitals to accept additional casualties when near a disaster event. Most hospitals in Beirut were affected to varying degrees by the explosion, and some became non-functional because of the damage. Two large hospitals very close to the explosion site needed to coordinate with EMS transfer of their patients who were already inpatients to other hospitals outside the Beirut area. Several casualties walked directly from areas near the explosion sites to the closest hospitals and found them to be non-functional.

Internal communication was also key and used various methods to notify all essential staff. Notification of staff and dispatch of resources and personnel was effective. Alerts used redundant communication SMS, paging, and WhatsApp notifications of members of pre-prepared disaster lists. As in prior events, infrastructure damage delayed SMS delivery in Beirut; however, pager messages and WI-FI messaging systems alerts were promptly received. This allowed for immediate dispatch of staff to the ED as well as the opening of additional treatment areas with distribution of pre-prepared supply and medication carts to all sections. This is in line with previous literature showing that effective intraorganizational communication is critical for crisis planning.[31]

The EHR-specific workflow challenges such as patient registration, identification, and tracking during MCI remain challenging. Ready bracelets with unique identifiers allow for quick activation of records once patients arrive to the ED. They allow for ease of ordering/results management during MCIs. They can also help with patient tracking and patient flow between the ED and various departments. However, patient identification can be difficult if demographic information is not collected immediately. Communication with search-and-rescue teams, media, and relatives of casualties required immediate identification of patients and

Table 2. Summary of challenges and lessons learned during the response.

Process	Events and challenges	Lessons learned
Workflow related	Disaster plan activation on the EHR was delayed as it needed to be manually activated by specific trained members: • Prevented the appearance of disaster navigator • Delayed information relay to different stakeholders in ED Delay in Patient Registration: • The number of casualties arriving to the ED exceeded the number of pre-printed disaster wristbands (200). This required additional printing of wristbands, which was logistically non-workable. • Calling in the registration staff delayed patients' registration caused delay in registration and inability to capture demographic information for patients who were discharged early in addition to delays in ordering tests and placing orders on other patients. • Creating additional records delayed as it required both registration staff and IT support. • Use of MCRs prevented easy identification of casualties since registration staff were not collecting patients' names or demographic data when handing out MCR bracelets. • Printing of MCR wristbands delayed due to limited number of patient access users. Delay in patient admission on the system: • Patients were sent to inpatient units prior to completing the extensive admission electronic process. Financial constraints identified for patients during their transition to inpatient status: • Admission financial clearances were not automatically overridden in the operating room or inpatient for patients, similar to what happens at the level of the ED, which required patient access to manually clear the admission requests during the event.	• Ready bracelets with unique identifiers allow for quick activation of records once patients arrive to ED. • Improved workflows on handheld devices to help streamline patient registration/ identification/ care during MCI events. • Alternative methods of health records activation should be implemented, which include using dormant records with unique identifiers activated by scanning wristbands, as well as pre-printed back up manual charts. • Activation of these records can be done by registration and by nursing staff at triage and at bedside if needed until the registration staff scale up in terms of response. • Training on activating disaster status on the EHR should be done for different ED staff and not limited to nurse managers during MCIs. • All staff should be cross trained on performing different tasks related to EHR interface during MCIs. • Having members of the IT staff on the ground relaying the technical issues back to the complete IT team is more effective. • Access/roles limitations present in routine workflows should be addressed and bypassed if needed during an MCI. • Throughput restrictions related to financial clearance, patient admission/discharge/flow through phases of care should be reviewed and restrictions lifted to allow seamless patient transfer across the hospital.
Real-time operations	Inefficient patients tracking during and post disaster: • Delay in patient registration led to inconsistency in the number of patients registered on system with those registered on paper. • Several clinical and administrative staff were tracking the number of casualties arriving to the ED. This caused delay in moving patients on dashboard between different sections which resulted in difficulties in tracking casualties and in identifying their exact physical location.	• Triage in non-clinical areas, bedside registration by registration staff and nurses, collecting and recording information, CPOE and access to results are all important functions that can be done at bedside. • Maximize the use of handheld devices to help streamline patient care/ flow during MCI events.
Training related	• Despite previous training, physicians from other units were not very familiar with the documentation process on ED patients during EPP. • Many patients were discharged physically from the ED with minimal or no documentation.	• Recording the MCR numbers and demographics from patients prior to them physically leaving the ED is important to reconcile lists. • Unified electronic reports that show casualty lists with clear identifiers and demographic data should also be available to administrative and clinical staff in charge during the MCI response.
Recovery process	• Recovery process was not previously thoroughly planned. • It required setting up a clinical/IT group to help clean up the ED dashboard and to resolve tickets related to patient flow, CPOE and disposition related issues.	• Assess system responsiveness, address tickets related to workflows, onsite help with registration/CPOE/ reconciliation issues. • Establish a trained multidisciplinary team to address tickets/resolve pending issues.

ED, emergency department; *EHR*, electronic health record; *EPP*, emergency preparedness plan; *IT*, information technology; *MCR*, mass casualty record; *MCI*, mass casualty incident; *CPOE*, computerized physician order entry.

their location (inside the hospital and at other hospitals) during the event; this proved to be initially very difficult especially for unconscious patients since identifying patients was a step previously assigned to the inpatient/pre-discharge phase of care. Casualty reports did not initially identify patients, which resulted in communication challenges. Additionally, closing the loop during the discharge process by recording the MCR numbers and demographics from patients prior to them physically leaving the ED is important to reconcile lists. Unified electronic reports that show casualty lists with clear identifiers and demographic data should also be available to administrative and clinical staff in charge during the MCI response. These enhancements can help close gaps in EHR adoption in the context of MCIs and address previously reported difficulties in this setting.[32]

Another EHR-related challenge was mobility during MCIs; use of handheld devices can help improve mobility of staff during response. Fixed workstations work during routine operations; however, with the need to expand treatment areas, the influx of casualties and medical staff responding to event, bedside access to EHRs is key. Triage in non-clinical areas, bedside registration by registration staff and nurses, collecting and recording information, CPOE, and access to results are all important functions that can be done at bedside. With the increasing number of casualties, dedicated staff were assigned to accompany and care for patients during their ED stay and to handoff essential information to other treatment teams. Such models of care require maximizing the use of handheld devices to help streamline patient care/flow during MCI events. Disaster-related plan for equipment/handheld devices should also be part of an emergency/disaster response plan.

The EHR access workflows need to be tailored to the MCI response. Addressing access and role limitations that are present in routine workflows for different provider types is also important. Routine quick registration and full registration workflows are not effective during a high influx of patients. Limitations are related to immediately available registration staff and to information collection requirements. Planning should be done for alternative methods of health records activation, which include using dormant records with unique identifiers activated by scanning wristbands, as well as pre-printed, back-up manual charts. While the EHR-based response within our institution had integrated these features, registration staff were the only team members trained on this step and were not able to keep up.

Cross-training of nursing staff at triage and at bedside if needed until the registration staff scale up in terms of response is essential. Moreover, training on activating disaster status on Epic should be done for different ED staff and not limited to nurse managers during MCIs. This step is key to activating a disaster module with corresponding disaster documentation. Additionally, cross-training all staff on performing different tasks related to EHR interface during MCIs is crucial. This should be accompanied by addressing access/roles limitations present in routine workflows and bypassing them if needed during an MCI. Examples would be to allow physicians or nurses to activate a patient registration event. Similarly moving patients electronically from one area to the next can be done by different clinician types. This role fluidity can enhance previously suggested models to optimize the management of patient flow and medical resources during MCIs.[33]

Testing admission/flow/discharge workflows in planning for MCIs is also key. Throughput restrictions related to financial clearance and patient admission/discharge/flow through phases of care should be reviewed and restrictions lifted for allowing seamless patient transfer across the hospital. With the high number of complex events occurring during an MCI, routine EHR-related required steps in different units/departments become very cumbersome and may result in unnecessary complications. For example, routine sequential steps do not allow a patient to be admitted to the intensive care unit (ICU) and for clinicians to initiate CPOE of care bundles in the ICU before a physician places an admission order in the ED.

The IT-related activities become extremely complex during MCIs. Scaling up quickly in terms of IT helpdesk and support is key during an MCI. Assessing overall system status, creating new records, addressing tickets related to workflows, and providing onsite help with registration/CPOE/reconciliation issues are very important. Setting up additional new treatment areas also requires IT support. The recovery phase also entails having a trained multidisciplinary team to address tickets/resolve pending issues. Business continuity activities (BCA) plans that are usually put in place do not account for operations during MCIs. During the Beirut port blast, the IT infrastructure remained intact. However, in the event where IT infrastructure is affected, EHR systems might be impacted, and institutions should resort to alternative BCA measures. Literature on IT support in such critical situations is limited. Future research will shed more insights on this aspect of MCIs.

LIMITATIONS

This study has several limitations. The results reflect the experience of a single center using a specific EHR, limiting generalizability of our findings. At the same time, this is the largest medical center in Lebanon with one of the largest catchment areas. In addition, the EHR adopted at this center is one of the most widely used across the United States with a growing presence globally.[34] Recall bias of participants during the debriefs and transcribing biases are additional limitations that may have impacted the findings that were documented in the minutes. However, the practice of sending minutes to all meeting participants for comments and approvals prior to finalization mitigates the latter.

CONCLUSION

We have outlined the challenges of using an electronic health record system in a large-scale mass casualty event. The main improvement opportunities were related to staff training, failure to address the recovery process in the initial plan, and complex EHR workflows that failed to effectively scale up to the rapid influx of patients. In particular, streamlining EHR workflows related to patient registration, patient identification/ tracking, and patient admission is critical to handling the scale of patient flow during large-scale MCIs, as is staff training on time-sensitive registration processes. Addressing these challenges a priori in settings that rely on EHR use and incorporating on-the-ground IT support as part of the response team is essential to an effective hospital MCI response.

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Integrating Disaster Response Tools for Clinical Leadership

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Background: Disastrous situations in the emergency department (ED) or community can overwhelm even the best-prepared teams due to their complexity and dynamic nature. In this paper we propose an integrated approach to disaster management, combining six theoretical and practical frameworks to enhance decision-making and operational effectiveness.

Discussion: The approach begins with "sensemaking," an instinctive process that helps leaders quickly gain situational awareness, a crucial foundation for the recognition-primed decision process (RPD). RPD enables swift, experience-based decisions without exhaustive analysis, aligning them with the appropriate domain in the Cynefin framework to guide subsequent interventions. In chaotic situations, rapid action is necessary, and the edge-of-chaos theory guides leaders to balance order and chaos for optimal adaptability. Complexity theory aids in managing the unpredictable elements of a crisis, highlighting the need for flexible responses. Finally, the Incident Command System ensures effective implementation by providing a standardized approach to command, control, and coordination. This cohesive strategy equips emergency physicians and incident commanders to manage both internal ED crises and broader community disasters effectively, with an emphasis on the importance of training in these frameworks to enhance the resilience of emergency medical services.

Conclusion: This multifaceted approach should improve disaster management by better preparing responders for the unpredictable nature of emergencies, enabling effective evaluation and management of complex scenarios, and leading to a more rapid restoration of order. [West J Emerg Med. 2025;26(1)30–39.]

INTRODUCTION

Disasters, both natural and man-made, vary widely in scope and scale. They involve complex interactions between patients, the environment, and healthcare systems. Such incidents pose significant challenges to the entire emergency medical system (EMS) continuum, including emergency departments (ED), prehospital care systems, and disaster response teams.[1] While emergency physicians (EP) are prepared to manage crises, their training may not extend to situations that lack available resources or that go beyond their knowledge or experiences.[2]

Disasters can be internal or external.[3] Healthcare facilities may face internal disaster when treating patients with unusual or complex life threats, or when their normal functions are disrupted. Disruptions may result from the loss of essential resources such as water, power, computer systems, or staff; a sudden increase in patient numbers or severity; or imminent threats like fires, bomb threats, or active shooters. External disasters occur outside healthcare facilities and may be simple—typically short-lived and manageable using local resources or extended—causing widespread damage and injuries that necessitate external assistance to support the surviving local services, including healthcare facilities. Widespread disasters are long-term situations arising from pandemics, drought, famine, and war.[4] Despite their differences, all disasters and disordered clinical situations share common elements that can inform effective management (Table 1). Managing a disordered situation as an EP or as a prehospital care or disaster team incident commander (IC) requires a comprehensive approach that addresses all these elements.

Table 1. Elements to address in all types of disasters.[5,6]

1. Strategic planning: Developing a comprehensive and flexible plan to address different types of disasters and disordered clinical situations.
2. Hazard assessment: Identifying potential hazards and assessing their potential impact to prioritize resources and develop appropriate responses.
3. Risk management: Identifying, assessing, and implementing measures to reduce risks.
4. Mitigation: Taking steps to reduce a disaster's effect.
5. Preparedness: Ensuring that resources, systems and staff are ready to respond effectively when disasters occur.
6. Response: Taking measures to promptly evacuate people, provide medical care, and coordinate resources in a disaster situation.
7. Recovery: Making provisions to restore normalcy following a disaster.

BACKGROUND

Problem

This paper addresses the inadequacy of current disaster management approaches, which often rely on weak or inflexible evaluation and management tools. When used individually, these tools are often too rigid to adequately plan for, manage, and recuperate from the complex and unpredictable challenges posed by large-scale disasters. Most traditional disaster planning generates detailed plans that may fail when confronted by real-world scenarios. Since "no plan survives contact with the enemy,"[7] disaster management fails when leaders rigidly follow a single method or plan that lacks the scope and flexibility offered by integrating multiple approaches.

Educational programs for disaster preparedness have been specifically designed for EPs, surgeons, intensivists, anesthesiologists, and similar medical specialties.[8] These have included simulations, online games, case studies, and shared experiences with seasoned professionals. Yet it is unclear whether current systems to educate professionals about disaster management provide them with the adequate tools to deal with internal and external disasters.[9–11] The integrated approach proposed in this paper equips EPs and ICs with comprehensive tools for managing both internal ED crises and wider community disasters. It has the flexibility to enhance decision-making in high-pressure situations and improve their coordination.

While already a small element of medical education, use of the methods that comprise the integrated approach should be expanded and integrated into residency and continuing medical education programs, as well as into training for potential ICs in EMS or fire services. Through experiential learning and scenario-based training, future leaders can develop the RPD skills necessary to navigate the complexities of disaster management, boosting their confidence and agility in emergencies.[12]

OBJECTIVE

Proposed Solution

In this paper we propose combining six disaster evaluation and management methods into a novel integrated approach that provides a structured methodology adaptable to changing circumstances. This fusion of multiple theoretical and practical frameworks provides flexibility and enhances emergency decision-making and operational effectiveness. The proposed framework includes, in order, the following:

1. Sensemaking
2. Recognition-primed decision-making (RPD)
3. Cynefin framework
4. Edge-of-chaos theory
5. Complexity theory
6. Incident Command System (ICS)

While several of the disaster assessment and management elements described in this paper are taught individually in disaster-oriented courses, others, such as the edge-of-chaos and complexity theories, have rarely been discussed in the healthcare literature.[13,14]

Interconnections and Effectiveness

Each component in crisis management is interconnected, collectively contributing to the overall effectiveness of the process. The proposed sequence begins with sensemaking, which equips leaders with the situational awareness needed to quickly identify familiar patterns or cues. This awareness is crucial for RPD, a process that allows leaders to draw on past experiences to swiftly determine a course of action without exhaustively analyzing every possible option.

The decisions made through RPD are then aligned with the appropriate domain in the Cynefin framework, which helps determine the most effective approach to managing the crisis. If a situation falls into the chaotic domain, leaders must act rapidly to stabilize the environment. This is where leaders can use the edge-of-chaos theory to rapidly act at the brink of chaos, allowing for innovation and adaptability. Complexity theory then allows leaders to better understand and manage the unpredictable and interconnected elements of a crisis. Finally, the ICS ensures that these strategies are executed effectively by providing a standardized approach to command, control, and coordination. The ICS enables leaders to manage complex situations by organizing teams, delegating tasks, and ensuring clear communication.

Each component builds on the previous one, contributing to a cohesive and adaptive approach to managing critical, time-sensitive situations. The interplay between these theories and frameworks allows leaders to evaluate and manage complex scenarios effectively in crisis and disasters.

Limitations of this Construct

The balance of this paper describes a logical progression of six assessment and managerial tools that EPs and ICs can use when dealing with ill-defined problems under high-stress conditions. Despite the presentation of these decision-making elements in sequential order, they are distinct components of a theoretical flowchart designed for disaster assessment and decision-making. This structured pattern will not always apply, since the real world is unpredictable and messy. Some steps may need to be used simultaneously; in other cases, previous steps will need to be revisited and adjusted as new information clarifies the situation.

DISCUSSION

The following sections describe the six components of this proposed system in more detail, with information on how they build on each other to influence outcomes, whether they are currently taught, and best ways to introduce them into a curriculum.

Component 1: Sensemaking in emergency medicine: initial assessment and situational awareness

In emergency medicine (EM) and disaster situations when information is often incomplete or rapidly evolving, the ability to quickly interpret confusing or unclear situations—known as sensemaking—is essential. Emergency physicians and ICs must swiftly collect information, identify patterns, formulate and then continually update plausible narratives based on direct observations and inputs from initial responders. Such input is essential for grasping the nature and scale of an event, since early misunderstandings can lead to ineffective or dangerous decisions.

Sensemaking is triggered when people encounter unexpected situations, those that contradict their expectations (eg, counterfactuals), or a significantly ambiguous event or issue.[15] These situations may disrupt normal routines, leading individuals to question fundamental assumptions about how they should act. Emergency physicians typically engage in sensemaking when faced with diagnostic challenges where symptoms may not clearly indicate a specific disease, or in disaster management scenarios where information is inconsistent or incomplete. By asking appropriate questions (Table 2), they can construct a mental model from available data, begin to understand the unfolding situation, evaluate available resources, and specify immediate goals.[12,16]

When a leader arrives at an emergency site, individuals such as nurses, housestaff, and first responders might already be working to stabilize the situation. These individuals often have a better understanding of the current circumstances than the newly arrived leader. It is important for leaders to acknowledge the value of the actions already in progress and to avoid interrupting the team's momentum by stopping their activities for detailed briefings, if possible.[12]

Table 2. Sensemaking questions. Used to identify key stakeholders, evaluate available resources, and specify immediate goals in an unclear situation.

- Who is affected?
- What are the immediate threats to life and safety?
- What is the primary goal of the response effort (eg, rescue, evacuation, treatment)?
- What equipment, personnel, and supplies are on hand?
- What other resources are available?
- What more do we need to know to move forward?

After addressing these questions, the IC can then decide:

- What do I want to do?
- What do I have to do?
- What can I do?
- What am I trying to achieve?

IC, incident commander.

Sensemaking emphasizes flexibility, allowing leaders to navigate the delicate balance between rigid adherence to protocols and the need for real-time adaptation. A key strategy within sensemaking is to initiate decision-making in disordered situations with targeted questions rather than immediately defaulting to established protocols like the ICS.[17] This approach helps teams build a coherent narrative amid chaotic ambiguity (eg, multiple potential interpretations of a situation) and uncertainty (eg, a lack of interpretations that leaves individuals unsure of the next steps).

To address rapidly deteriorating situations, leaders must remain flexible and understand that traditional emergency response protocols, while valuable, may be difficult to adapt to the unpredictable nature of disasters. Continuing the sensemaking process enables leaders to shift their objectives as the situation develops (eg, from resuscitation to stabilization, rescue to recovery, search to evacuation). Sensemaking also aids in categorizing the situation using the Cynefin framework, a tool for managing complexity and uncertainty (Table 3).

Component 2: Recognition-primed decision-making in emergency and disaster management

Leaders with experience in emergency and disaster management can use RPD to quickly assess complex time-sensitive situations. They leverage their store of experiences and tactics from previous incidents and training to select effective courses of action.[18,19] Instinctively recognizing familiar elements, ie, sensemaking, they can use those insights to construct a reasonable understanding of the crisis.[19]

This pattern recognition enables them to make swift initial decisions to mitigate immediate threats. While not always

Table 3. Progression from sensemaking to recognition-primed decision-making (RPD) and the Cynefin framework in disasters.

- Assess the scope and consequences of the disaster, including immediate life-threatening concerns and property damage.
- Identify critical tasks and determine their priority.
- Establish an understanding of the situation, focusing on plausibility rather than absolute precision.
- Recognize familiar elements within a complex situation to begin imposing order on chaos and guide the situation toward normalization.

Table 4. Response strategies for five domains in the Cynefin framework.

- Simple/clear: Confirm rules or precedents, apply best practices.
- Complicated: Analyze the situation, apply expert knowledge.
- Complex: Experiment and adapt responses based on emergent patterns.
- Chaotic: Act immediately to stabilize, seek novel solutions.
- Disorder: Gather more information to categorize the situation correctly.

fully nuanced, these decisions are crucial for stabilizing the situation and allowing time for more comprehensive data-gathering. The decision-making process involves asking critical questions to assess the disaster type, casualty numbers, environmental hazards, and available resources, while also clarifying the primary objectives of the response effort. Such clarity is essential for directing actions and resources toward meaningful outcomes.

Component 3: Using the Cynefin framework in emergency and disaster management

The Cynefin framework, developed by Dave Snowden and Mary E. Boone, can enable EPs and ICs to quickly categorize and respond to situations based on their complexity and enhances their abilities to make swift, effective decisions under pressure.[20] This model (Figure) helps differentiate among clear/obvious, complicated/difficult, complex, chaotic, and disarray/confusion/disordered/ uncertain domains, each of which necessitates a specific response strategy (Table 4) to restore order. As such, it provides an essential tool for managing the diverse and unpredictable nature of emergency scenarios. Leaders in a variety of healthcare fields have modified this model for various scenarios.[21]

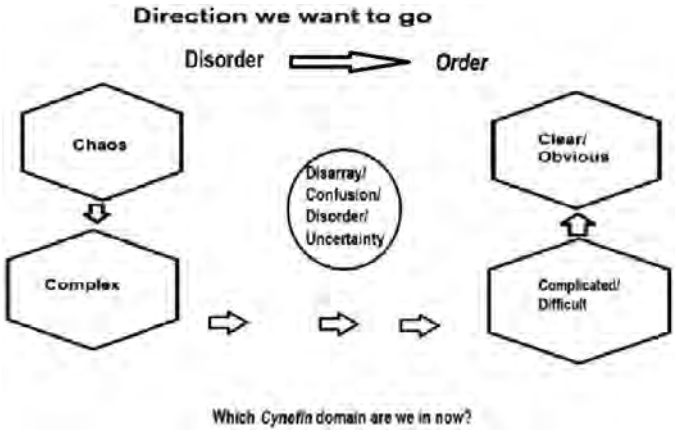

Figure. This Cynefin model illustrates the desired management flow from disorder to order. In disordered situations, the leader identifies the situation's domain (chaotic, complex, complicated, or clear) and uses the correct response strategy (Table 4).

Originating in the business world, the Cynefin model has been adapted to provide clinicians with "a taxonomy for categorizing the various types of uncertainty, as well as a framework to apply when navigating uncertainty during clinical challenges. These tools can help students make sense of uncertainty and determine actions in a complex health system."[22] In situations categorized as simple or clear, where the relationship between cause and effect is straightforward, the strategy involves making sense of the situation by gathering data, confirming the problem has clear rules or precedents, and responding with established protocols such as the ICS. Such clear, predictable problems with well-understood solutions are amenable to best practices and standard operating procedures. For example, a patient with an isolated fractured humerus or minor injuries from a motor vehicle accident would fit into the "simple" domain, where established medical protocols are directly applicable.

More complex or chaotic scenarios demand innovative and adaptive strategies due to their unpredictability and the opaque relationship between cause and effect. For instance, a patient presenting with a rare combination of symptoms or a catastrophic event like a building collapse with multiple casualties would fall into these domains. Such situations require exploratory approaches that emphasize experimentation rather than linear solutions, which often prove insufficient (see Appendix).

Karl Weick, an organizational theorist, emphasizes the importance of categorizing unclear or novel situations within the Cynefin framework to clarify and address them effectively. This structured approach allows practitioners to identify the domain a situation belongs to—be it simple, complicated, complex, chaotic, or disorder—and tailor their decision-making and actions accordingly. In more complex or chaotic domains, where uncertainty prevails, further information gathering is necessary to determine an appropriate response strategy. Here, the strategy shifts toward maintaining a balance between stability—using proven methods—and flexibility—adapting to the unique

challenges of the situation, as suggested by the edge-of-chaos paradigm.

Component 4: Navigating the edge-of-chaos paradigm in disaster response

The edge of chaos is a concept derived from complexity theory, which describes the precarious state existing between order and complete randomness.[23,24] Within the context of the Cynefin framework, this concept represents an initial state of disorder, confusion, and uncertainty, where the application of sensemaking and RPD is crucial. This concept can be visualized as an infinitesimally thin membrane marking the transition from chaotic disorder to an ordered, manageable scenario. In such conditions, EPs and ICs must navigate a delicate balance between maintaining stability (order) and adapting to new information (flexibility). The EPs and ICs need to identify when an incident is at or nearing the edge of chaos to foster effective, adaptive responses to rapidly evolving conditions. They should be able to recognize the situational characteristics that indicate that they are approaching the edge of chaos. These include the following:

Increasing information complexity

This may involve contradictory reports, escalating numbers of casualties, or conflicting operational directives, all of which complicate the response effort.

Decision-making difficulties

As uncertainties and complexities multiply, the decision-making process becomes more challenging. The decline in effectiveness of standard protocols may indicate the need for adaptive, creative solutions.

Increased communication breakdowns

Effective communication is essential for maintaining order. Failures in technology or misunderstandings among team members that cause communication breakdowns may necessitate a shift in management tactics.

Resource limitations

A decrease in available resources, whether personnel, equipment, or information, can signal movement toward chaotic conditions. Monitoring resource usage and forecasting future needs are critical for recognizing and responding to this shift.

The edge-of-chaos paradigm underscores the complexity of decision-making under conditions characterized by time pressure, dynamic changes, and challenging logistics. It serves as a bridge across various disaster leadership methodologies, emphasizing the need to maintain a balance to prevent the situation from tipping into chaos. This approach requires EPs and ICs to be exceptionally agile, using a blend of established protocols and innovative solutions to manage disasters effectively. By recognizing and responding to the signs of the edge of chaos, leaders can prevent further deterioration of the situation and guide their teams toward restoring order and stability.

Component 5: Complexity theory and its importance in emergency response

The EP often operates in conditions marked by high uncertainty and unpredictability, conditions that point to the need for an understanding of complexity theory. This theory, sometimes referred to as "high-dimensional chaos,"[25] is rooted in mathematics, physics, and cellular biology, and can help EPs[26] navigate the nature of emergencies, facilitating better long-term planning and resource allocation.[25] It is a vital framework for enhancing decision-making, efficiency, and adaptability in the dynamic, unpredictable environments with multiple interconnected components typical of emergency and disaster responses.[27,28]

Although defining complexity theory has proven elusive and has rarely been applied to healthcare,[29,30] it can help EPs discern whether a situation is complicated, with clear cause-and-effect relationships; complex, characterized by emergent behaviors; or chaotic, with unpredictable elements.

The core features of complexity theory in emergency response include unpredictability, self-organization, emergent behaviors, and feedback loops.

Unpredictability (nonlinearity)

In complex systems, the relationship between cause and effect is not linear, making outcomes hard to predict. Small changes can trigger disproportionately large effects, reflecting the system's sensitivity to initial conditions (the "butterfly effect").[27,28,31] This aspect is crucial in EM, where a small alteration in team dynamics or decision points can significantly shift the outcome.

Self-organization

Complex systems exhibit a capacity to organize spontaneously without external control.[32] In EM, this is observed when multidisciplinary teams (eg, a "flash mob") rapidly assemble in response to a trauma call. Although their communications, equipment, command structure, and goals may not initially gel, they quickly align to function as a single organic team. Some volunteer wilderness rescue groups also work like this; knowing each other's capabilities, they automatically place the most expert person at each stage in the lead role (eg, organizing the team, setting up technical gear, medical assessment/treatment, and evacuation) in what they term a "flowing command system." [Personal communication, from the Southern Arizona Rescue Association, Pima County, AZ; February 1, 2024.]

Emergent behaviors

These behaviors, which are not predictable from the system's initial conditions, often arise in complex situations.

They may manifest as new patterns of team interaction or the use of innovative problem-solving approaches when standard procedures prove insufficient.[33] As complex systems self-organize, they become more than the sum of their parts.[28] This makes it impossible to precisely determine outcomes from interventions (nonlinearity).[34]

Feedback loops

Feedback is essential for adapting to changing conditions within emergency responses. These self-regulating systems can amplify or dampen the effects of the system's behavior, enhancing adaptability and resilience.[35,36] Managing complex situations requires leaders to know which interventions have succeeded. This allows teams to rapidly implement alternative actions when necessary. Complexity theory not only provides a theoretical framework but also sets the stage for practical decision-making in emergency situations. It offers insights into the nature of disorder and reminds leaders that unexpected behaviors and outcomes are typical under complex conditions. Furthermore, the theory underscores the potential for order to emerge from chaos through self-organization and resilience.

Understanding the interactions among system components—individuals, teams, resources, and environmental factors—is key to managing overall system behavior. These interactions often give rise to new characteristics (ie, emergent properties) that cannot be predicted from the system's individual components alone. In essence, the sum of the parts is more than the whole. This requires managers to be both flexible and innovative.

Including complexity theory in emergency response training and operations enhances the ability of EPs and ICs to better manage disasters by preparing EPs to anticipate and respond to unexpected situations. Moreover, complexity theory supports the creation of networks that foster collaboration across various agencies and disciplines, optimizing the collective response effort. By embracing a flexible, adaptive mindset and implementing continuous learning and improvement, emergency professionals can navigate the evolving dynamics of emergencies more effectively (Table 5).

Component 6: Integration of the Incident Command System in EM and disaster response

After devasting wildfires in the 1970s, Southern California firefighters developed the ICS to respond to disasters in a coordinated manner and to request regional resources as the situation expanded. When the September 11 attacks showed that coordinating federal and state with local resources was vital, this was incorporated into the National Incident Management System.[40] The ICS is an essential structured approach that integrates sensemaking and the Cynefin framework to manage resources effectively across various emergency scenarios. This system provides EPs and ICs with a standardized method for incident management that remains consistent regardless of the complexity of the situation—be it simple, complicated, complex, or chaotic. It ensures clear lines of authority, effective communication, and coordinated resource allocation, making it indispensable for managing both resources and personnel.

The ICS promotes effective coordination and communication among all responders, medical personnel, and rescue teams through its unified terminology, modular organization, and clarity in communication channels. These features are crucial, especially in complex situations involving multiple agencies, when it is necessary to have all parties aligned and informed. Despite its strengths, the ICS can be restrictive during the initial phase of disasters. The system's reliance on checklists and tasks may lead first responders to prioritize procedural adherence over gaining a deeper understanding of the broader crisis. This adherence to protocol can limit the ability to address chaotic situations where no straightforward guide exists, as noted in the critique that "While everyone can be ... trained to follow a checklist during later stages of an event, there is no exact guide for how to work through chaos."[12,17]

As scenarios transition from chaotic and disordered states to more complex or complicated domains, the advantages of the ICS become more evident. In these stages, the structured nature of the ICS supports methodical decision-making, particularly in scenarios familiar to responders. It allows for deliberate actions based on thorough situational awareness and a factual understanding of the incident. Described as a

Table 5. How complexity theory has been used in mass disasters.

Incident	Complexity theory principle applied	Outcome
2017 Las Vegas shooting[37]	Feedback loops and interconnectivity	Rapid setup of coordinated triage areas led to efficient patient management despite overwhelming numbers.
Hurricane Katrina[38]	Emergence and adaptability	Ad-hoc medical hubs and trained leaders improved survival rates amidst infrastructure collapse and multiple leadership failures at all levels.
COVID-19 pandemic[39]	All principles of complexity theory	Dynamic response strategies like adaptable hospital zones and real-time data tracking helped manage patient loads effectively.

Table 6. Key outcomes of disaster management training for emergency physicians and incident commanders.

Outcome	Description	Impact on emergency care
Enhanced decision-making[44]	Ability to make informed decisions amidst chaos.	Leads to better patient outcomes and less confusion during crises.
Improved crisis management[45]	Effective management of sudden, unpredictable events.	Reduces errors and improves overall emergency response effectiveness.
Increased system resilience[46]	Strengthening of the emergency care system to withstand pressures.	Ensures sustainability and reliability of emergency medical services.
Proactive problem solving[47]	Anticipating and addressing complications before they escalate.	Decreases incident severity and improves patient recovery rates.
Team cohesion and dynamics[48]	Improved teamwork under stress through understanding of roles and dependencies.	Enhances operational efficiency and staff morale during emergencies.

military-type system emphasizing command, control, and coordination, the ICS is particularly suited for large-scale operations. Its structured approach is critical in guiding efforts in EM and disaster response, especially when combined with the principles of complexity theory. This integration acknowledges the dynamic and multifaceted nature of such environments, enhancing the system's effectiveness.

By recognizing the strengths and limitations of the ICS within the framework of complexity theory, emergency management can adapt the system to better meet the demands of diverse emergency situations. This adaptation allows for a balance between the need for structured responses in familiar scenarios and the flexibility required in unpredictable or novel emergencies.

Integrating educational methods for advanced decision-making frameworks into EM

Training EPs in advanced decision-making frameworks involves a structured approach to understanding and applying the various theories and systems crucial for effective emergency response. For the RPD model, scenario-based training is instrumental, allowing physicians to rapidly assimilate past experiences with current situations to make effective decisions under pressure. Integrating sensemaking into training involves scenario-based learning where physicians interpret complex or ambiguous information to construct a coherent understanding of evolving situations (Table 6).[41–43]

Rusnack et al described a workshop to prepare clinicians to use sensemaking and the Cynefin framework to work through complex clinical challenges. Participants learned to categorize problems into simple, complicated, complex, or chaotic domains, and to apply appropriate decision-making strategies based on the situation's nature.[39] Complexity theory and the edge-of-chaos theory should be integrated into the curriculum through interactive lectures and group discussions that explore the dynamics of complex systems and their implications on emergency management.

The ICS, essential for managing emergency responses, requires both knowledge-based learning and practical exercises. Training should include detailed modules on ICS protocols and roles, supplemented by drills that simulate multi-agency response scenarios to foster coordination and communication. Training that blends theoretical instruction with practical exercises provides EPs with the skills needed to handle a wide range of challenges in emergency situations. This training leverages a deep understanding of different decision-making frameworks to improve their effectiveness and adaptability during real-world crises.

CONCLUSION

This proposal to reformulate and integrate disaster evaluation methods will, hopefully, be a stimulus to emergency and disaster medicine to reconsider their approaches to crises because it does the following:

- Presents an innovative and integrated approach that addresses significant gaps in disaster management.
- Enhances decision-making, promotes comprehensive training, and improves emergency response effectiveness and outcomes.
- Significantly improves outcomes by preparing responders for the unpredictable nature of emergencies. By enhancing coordination, decision-making, and training, it builds more resilient EMS and optimizes resource allocation during crises.
- Lays the groundwork for future research to evaluate the combined framework's effectiveness in real-world disaster scenarios. By presenting this concept, we can stimulate discussion and collaboration among emergency clinicians, researchers, and policymakers to advance the field of disaster management.

This exploration of disaster-management tools demonstrates that integrating multiple theoretical frameworks and methodologies, such as sensemaking, the recognition-primed decision process, the Cynefin

framework, the edge-of-chaos theory, complexity theory, and the Incident Command System, can significantly enhance the decision-making process and operational efficiency in emergency and disaster management. This synthesis offers emergency physicians and incident commanders a robust toolset with which to navigate the multifaceted nature of disaster situations—whether these occur within healthcare facilities or in external environments.

By adopting this integrated approach, emergency management personnel can better address the inherent complexities of disaster scenarios, ensuring more rapid stabilization of chaotic situations and a more organized transition to recovery phases. The emphasis on dynamic and adaptable response strategies aids in managing emergencies where traditional, rigid command structures may fall short.

Furthermore, the paper highlights the critical role of continuous training and education in these integrated frameworks. It argues that well-prepared emergency teams, versed in these frameworks, are better equipped to manage the unforeseen and rapidly evolving challenges of disaster scenarios. The application of these comprehensive strategies not only enhances the capability of emergency personnel to perform under pressure but also improves overall patient outcomes and system resilience.

As disasters continue to present unique and complex challenges, ongoing research and adaptation of these frameworks will be essential. The evolving nature of global threats—ranging from natural disasters to technological and biological hazards—demands a progressive approach to emergency management education and practice. Integrating these diverse frameworks into a unified operational strategy ensures a well-rounded response capability, fostering a more resilient and effective EMS. This paper serves as a call to action for emergency response organizations and training institutions to embrace this multifaceted approach. It is vital for enhancing the preparedness and response effectiveness in the face of disasters.

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Practice Patterns of Graduates of a Rural Emergency Medicine Training Program

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Introduction: Rural communities continue to face a shortage of emergency physicians despite the growing number of emergency medicine (EM) residencies. In rural areas, emergency physicians tend to be older, male, and White, and are less likely to have completed EM residency training or have board certification. There is also currently a higher rate of rural physicians leaving clinical practice than in urban emergency departments (ED). In this cross-sectional study we sought to identify the work environments of graduates of a rural EM residency program, and the strengths and weaknesses of such a program.

Methods: We conducted a survey among 29 graduates of a community-based EM program to evaluate the effectiveness of a residency program in training physicians who will work in rural areas. The survey assessed the graduates' perceptions of their level of preparedness, further training, and practice location after completing the program. Results are reported using descriptive statistics.

Results: Twenty respondents completed the survey (69%). Most of them identified as male (60%), White (70%), and non-Hispanic or -Latino (80%). Seventy-five percent of the graduates work in counties with fewer than 1,000,000 inhabitants, and 70% work in community hospitals and EDs caring for fewer than 100,000 patients/year. Four (20%) declared to work in critical access hospitals. Overall, respondents felt confident in their residency training.

Conclusion: A community-based EM training program may be an effective strategy for producing emergency physicians who go on to work in rural and smaller communities.
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INTRODUCTION

Recent research has contributed to a greater understanding of the landscape of the emergency medicine (EM) workforce and training in the United States. In 2020, a cross-sectional study using the American Medical Association (AMA) Physician Masterfile database found that there were 48,835 clinically active emergency physicians in the US. Among them, 81% reported having EM training, and 69% were board certified in EM. The remaining 19%, who were neither EM trained nor certified, were divided among those who were family medicine- (33%), internal medicine- (24%), or surgery-trained (12%) physicians. According to the US Department of Agriculture (USDA) Urban Influence Codes (UIC) classification, 92% worked in urban areas, 6% in large rural areas, and 2% in small rural areas. Compared to urban areas, the survey found that large and small rural areas tended to be staffed by males (71% vs 80% and 81%, respectively) and older physicians (50 years of age vs 58 and 62 years, respectively), were less likely to have EM training (74% vs 52% and 37%, respectively) or board certification (70% vs 56% and 40%, respectively), and that the majority of rural emergency physicians had graduated at least 20 years before 2020.[1]

In parallel, data from the AMA Physician Masterfile and the Accreditation Council for Graduate Medical Education listing showed an increase of 105 EM residencies from 2013 to 2020. Most of these programs offer three years of training, with the median age of residents being 31 (29–33 years) and females representing 39% of the trainees. Unsurprisingly, a cross-sectional data analysis found that 98% of the 6,993 residents included in the study were receiving training in urban areas, with 77% being in places with over 1,000,000 inhabitants and 17% in areas with populations between 250,000–1,000,000 individuals. Less than 2% of the residents were training in large rural areas and 0.3% in small rural areas (urban-rural classification based on the USDA UIC).[2]

While the density of emergency physicians per 100,000 US population in urban areas has increased 1.4 times, both large and small rural areas showed a decrease of 0.4 and 3.7, respectively.[1] One of the explanations for this phenomenon is that rural areas have a higher rate of emergency physicians leaving practice compared to urban areas.[3] Another leading cause of this urban preference is that residents tend to practice in environments similar to where they trained and stay geographically close to their training programs, at least in the first three years after graduation.[2,4] Given the locations of most training programs in urban centers, this does not address the rural-urban disparity in emergency care.

In this study we hypothesized that training physicians in a rural environment will make them more likely to practice in a rural area. Prior studies have demonstrated the effectiveness of alumni surveys in identifying residency problem areas to drive targeted curricular improvement.[5–7] However, no previous studies have looked at a training program's location in relation to its graduates' practice patterns. As a secondary outcome, we sought to explore the specific benefits and challenges that training at a community-based program presented to its graduates.

Population Health Research Capsule

What do we already know about this issue?
Rural communities lack board-certified emergency physicians. Residency graduates tend to practice in environments like their training environment.

What was the research question?
Do graduates of a community-based EM program in a rural area practice in rural areas after completing their training?

What was the major finding of the study?
75% of the graduates were practicing in counties with fewer than 1 million residents; 70% work in hospitals caring for fewer than 100,000 patients per year.

How does this improve population health?
A community-based training program in a rural area graduates emergency physicians who work in underserved, rural communities.

METHODS

The study site is in the state of New York. It is home to an EM residency training program with a 34-bed emergency department (ED) that sees an average of 35,000 visits per year and serves a largely rural population of 84,148 individuals.[8] The first residency class began their training in 2015, and the program has graduated 29 residents in the intervening years. Due to the characteristics of the institution and residency program, its mission is to train physicians to work in rural communities with fewer than 250,000 inhabitants.

The study design was a cross-sectional anonymous survey delivered through the Survey Monkey platform (SurveyMonkey Inc, San Mateo, CA). The research protocol was reviewed by the institution's System Review Board and deemed exempt from institutional review board approval.

All 29 graduates of the EM residency program were eligible and received the invitation to participate in the survey via emails retrieved from our contact list. The survey, consisting of 23 questions, was reviewed and amended by EM program faculty and leadership. The email text and the survey cover page instructed participants about the content and goals of the study. Agreement to answer the survey implied consent to participate in the study. The data collected included general demographics (sex, race, ethnicity, and number of years since graduation), characteristics of the graduate's current practices (type of hospital, ED annual volume, county, if critical access), additional postgraduate training, and administrative and mentoring roles. Questions about the residency training program and how graduates feel prepared for their current practice were elaborated on a five-point Likert scale. Two open-ended questions asked about the program's strengths and weaknesses.

The most relevant questions were placed in the first half of the survey. The survey was available for six weeks (February and March 2023), and the graduates received three email reminders to encourage them to participate.

County Size and Urban and Rural Classifications

County sizes were reported according to the 2020 US Census Bureau.[8] We used the USDA rural-urban continuum codes (RUCC) to categorize counties based on the population size, degree of urbanization, and proximity to a metro area (Table 1).[9] The RUCC was suitable for this study because it has a better representation of counties smaller than

Table 1. Definition of metro/non-metro US counties according to the population size, degree of urbanization, and proximity to a metro area - US Department of Agriculture Rural-Urban Continuum Codes (RUCC) (2023).[9]

Code	Classification of US counties based on the definition of metro/non-metro areas
1	Metro – counties in metro areas of 1 million population or more
2	Metro – counties in metro areas of 250,000 to 1 million population
3	Metro – counties in metro areas of fewer than 250,000 population
4	Non-metro – urban population of 20,000 or more, adjacent to a metro area
5	Non-metro – urban population of 20,000 or more, not adjacent to a metro area
6	Non-metro – urban population of 5,000 to 20,000, adjacent to a metro area
7	Non-metro – urban population of 5,000 to 20,000, not adjacent to a metro area
8	Non-metro – urban population of fewer than 5,000, adjacent to a metro area
9	Non-metro – urban population of fewer than 5,000, not adjacent to a metro area

250,000 inhabitants when compared to the USDA Economic Research Service UIC used by other authors.[1]

The results of this study are reported using descriptive statistics represented in tables and graphs. The United States map (Figure 1) was created using MapChart (Creative Commons Attribution 4.0 international license, Mountain View, CA) and Power Point Microsoft 365 Apps Version 2407 (Microsoft Corp, Redmond, WA).

RESULTS

Twenty graduates completed the survey, corresponding to a 69% response rate. As presented in Table 2, most of the respondents identified themselves as male (60%), White (70%), and non-Hispanic or -Latino (80%). Nine respondents (45%) graduated after 2021 and 11 (55%) in the years before.

Current Practice

Overwhelmingly, respondents self-reported working in community hospitals (14, 70%), with five working in private hospitals (25%) and one in a university hospital. Most graduates work in EDs caring for fewer than 100,000 patients/year (70%), and of those, 64% (9/14) work in EDs caring for 50,000 or fewer patients/year. Three respondents who work in community hospitals didn't report their approximate ED annual volume. Four graduates (20%) work in critical access hospitals, according to the designation by the Centers for Medicare and Medicaid Services (Table 3).

According to 2020 US Census Bureau data, 75% of the respondents work in counties with fewer than 1,000,000 inhabitants. Most of those (10 of 15) practice in counties with fewer than 250,000 inhabitants (codes 3, 4, and 6) and with rural populations varying from 21–73%. Forty-five percent (9/20) of the respondents live and work in the Northeast and are within 90 miles of the study institution (Table 3),

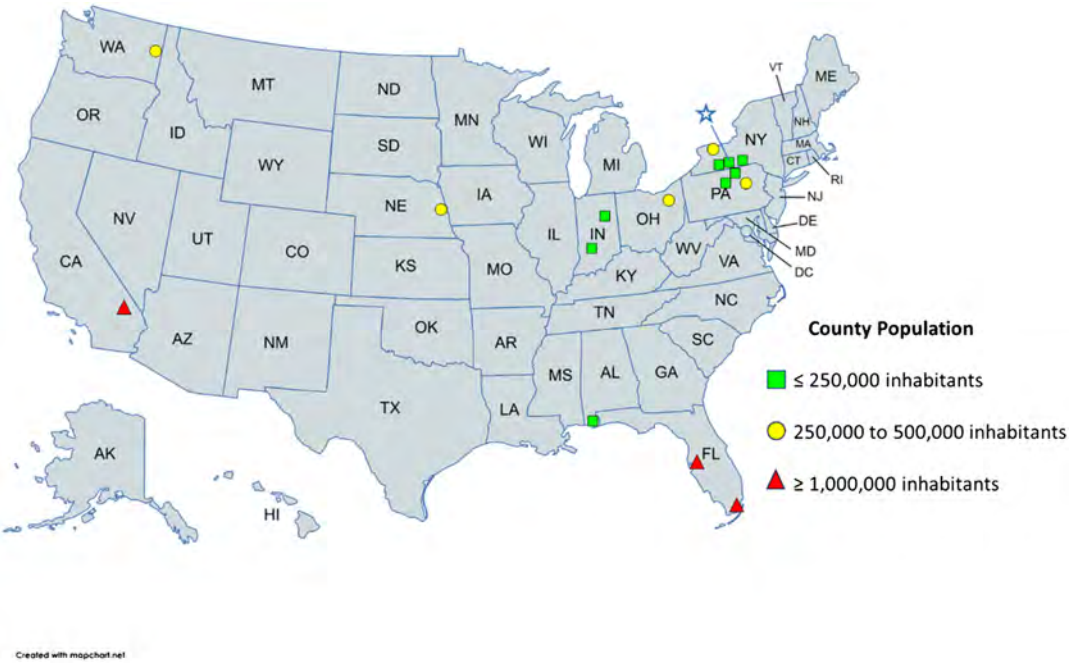

Figure 1. Current practices of emergency medicine graduates distributed by county population and geographic location. The blue star in the state of New York (NY) represents the study site location.

Table 2. Demographic information from the 20 residency graduates.

		Graduates	Percent
Sex	Female	7	35%
	Male	12	60%
	Other	1	5%
	Prefer not to say	0	0%
Race	White	14	70%
	Black	0	0%
	Asian	4	20%
	Native American/Alaska Native	0	0%
	Native Hawaiian/other Pacific Islander	0	0%
	Mixed Race	1	5%
	Other	1	5%
	Prefer not to say	0	0%
Ethnicity	Hispanic or Latino	1	5%
	Non-Hispanic or -Latino	16	80%
	Prefer not to say	3	15%
Years since graduation	0–2	9	45%
	> 2	11	55%

and two-thirds graduated more than two years before. The blue star in Figure 1 represents the study site location in the State of New York. One physician did not report his/her county.

Additional Training, Mentoring, and Administrative Roles

Respondents did not do another residency or change specialty areas. Three (15%) had gone on to further training, with two pursuing fellowships in addiction medicine and one pursuing fellowships in wilderness medicine and military EM, and a master's degree in public health. Although most respondents do not work in large academic centers, all but one (95%) reported some role in mentoring or teaching medical students (75%), residents (70%), or younger colleagues (25%) since graduation. Two have or had an administrative position in the hospital where they currently work or worked previously.

Graduates' Impressions of Residency Training

Figure 2 shows the responses to the six questions in Likert-scale format about how prepared graduates felt to take the board exams and work as emergency physicians. Overall, there were positive answers to all six questions. The respondents felt very well prepared to treat critically ill patients, and no neutral or disagreeing responses were observed. With questions regarding dealing with the healthcare system and preparedness for the board exams, the responses were mainly positive but with some neutral answers. Uncommonly, graduates reported feeling somewhat less prepared for procedures necessary for daily practice (1/20) and documentation in patients' charts (1/20). The area identified as the lowest performance of the program was related to preparing residents to manage the patient volume they need to see routinely, with two neutrals and two disagreements.

Main Positive and Negative Aspects of the Residency Training

From the graduates' point of view, the top three strengths and weaknesses of the EM residency program were as follows:

- Strengths: Autonomy with little competition for procedures; exposure to a good breadth of pathologies and critical care cases; one-on-one interaction with attendings.
- Weaknesses: Need for more exposure to rare procedures; more simulations/board preparation and practice with a higher volume of patients.

DISCUSSION

To our knowledge, this is the first study to examine whether residency training in a community-based EM program in a rural area produces graduates who practice in a rural environment after graduation. The results of this study suggest that this is so, although future research should expand on these findings to look at the breadth of EM-training programs to see whether this holds true across the country. As a secondary outcome, this study highlights the effectiveness and limitations of a small, community EM residency program in training emergency physicians in general and specifically to work in underserved rural environments.

The demographics indicate that the graduates of the study site residency program were predominantly male, White, and non-Hispanic or -Latino. This distribution is similar to data from residencies around the country, regardless of whether they are large or small training programs, reflecting the need for more diversity in the EM workforce.[1,2,10] Conscious efforts are being made to recruit residents and attendings from minorities to increase diversity and equity among emergency physicians.

Historically, emergency physicians tend to practice in environments similar to their training and to work close to their training site, at least in the first three years after graduation.[1,4] As most residencies are located in large urban areas, graduates may feel relatively uncomfortable considering jobs in more resource-limited locations.[11] Although the data presented here is limited, it suggests that the opposite might also be true—residents trained in small community hospitals tend to stay, and feel comfortable

Table 3. Characteristics of the counties and facilities where the resident graduates are currently practicing. The "*" signals respondents who declared to work in more than one type of hospital.

Study ID #	State	County of primary practice site	Type of primary practice site	Emergency department approximate annual volume	Critical access designation by the CMS	Total county population	County population living in rural areas (%)	RUCC	Distance from training site (miles)
1	NE	Douglas	University hospital/ academia	60,000		584,526	2	2	721
2	NY	Monroe	Community hospital*	100,000–130,000	NA	759,443	8	1	83
3	NY	Chemung	Community hospital	35,000	NA	84,148	26	3	0
4	FL	Miami Dade	Private hospital	65,000	Yes	2,701,767	1	1	1,154
5	CA	San Bernardino	Private hospital	150,000	NA	2,181,654	5	1	2,238
6	NY	Broome	Community hospital	55,000	NA	198,683	25	3	42
7	IN	Monroe	Community hospital	50,000	Yes	139,718	21	3	546
8	PA	Lycoming	Community hospital	Not sure	NA	114,188	40	3	64
9	PA	Luzerne	Community hospital	Not sure	No	325,594	22	2	90
10	NY	Chemung	Private hospital	37,000	No	84,148	26	3	0
11	IN	Grant County	Community hospital	50,000	No	66,674	39	4	472
12	FL	Hillsborough	Community hospital	37,000	NA	1,459,762	4	1	1,020
13	PA	Bradford	Community hospital	Not sure	Yes	59,967	73	6	17
14	OH	Summit	Community hospital	70,000	NA	540,428	4	2	246
15	CA	San Bernardino	Private hospital	130,000		2,181,654	5	1	2,238
16	AL	Baldwin	Community hospital	28,000–35,000	NA	231,767	38	3	1,014
17	WY	–	Community hospital	4,000	Yes	–	–	–	–
18	NY	Steuben	Community hospital	34,000	No	93,584	60	4	32
19	WA	Spokane	Community hospital*	60,000	NA	539,339	15	2	2,001
20	PA	Lycoming	Private hospital	45,000	No	114,188	40	3	64

CMS, Centers for Medicare and Medicaid Services; *RUCC*, Rural-Urban Continuum Codes – Metro/non-metro classification according to the US Department of Agriculture (2023).

working in that same environment. Besides increasing the availability of rural rotations during residency or giving incentives to attract physicians to underserved areas, creating new residency programs in small urban/rural areas may be another meaningful way to reverse the trend toward a rural EM desert around the country.[1,3,11]

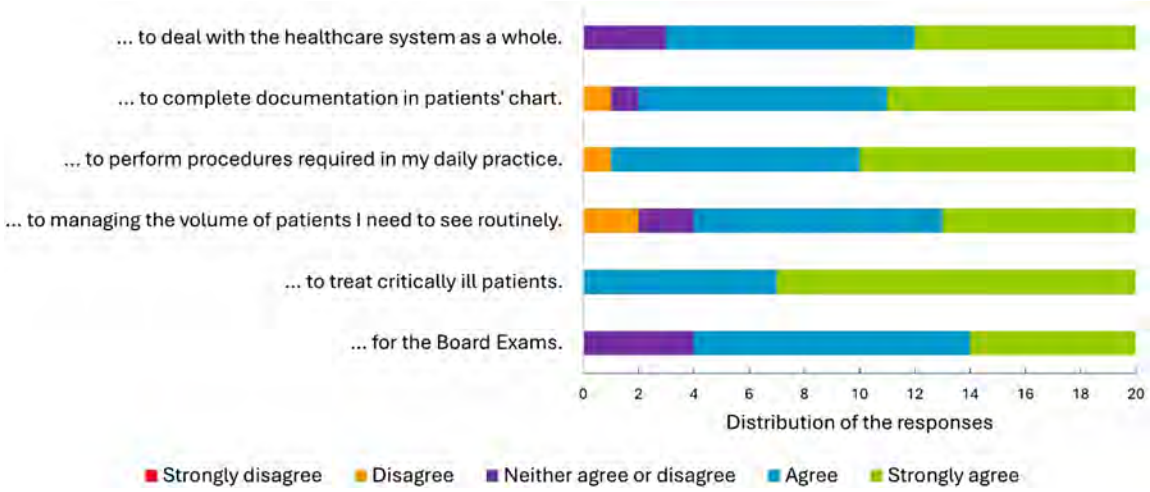

Figure 2. This graph represents the distribution and agreement of the 20 residents who responded to the survey with the statement, "The emergency medicine residency program prepared me well . . . "

Other factors that attract physicians to one determined area are family and spousal ties,[4] which can also be important for those choosing training in small programs. In this study, we did not observe a tendency of residents who graduated in the prior two years to work closer to the training program as described by other authors. This deviation could be attributed to the use of different time frames since graduation, or because of shifts in the job market since the onset of the COVID-19 pandemic.

As a secondary outcome, the survey identified areas for training improvement that could be addressed through curricular development. Overall, respondents felt confident in their residency training at this small institution. The strengths reported by the graduates were less competition for procedures, a sense of autonomy over patients, and the close resident-to-faculty relationship that had developed in a small community hospital. The main concern about training in small EDs is that residents are not exposed to sufficient volume and complex medical cases. However, a recent study comparing procedures done by second- and third-year residents training in urban vs rural centers reported a higher proportion of procedures done in large rural hospitals when data was standardized by hours worked. Residents who train with limited specialty backup learn valuable skills, such as relying on themselves to treat critically ill cases and stabilizing patients when transfers are necessary.[12] Overall, while it was not the primary goal of this study, the results support that residents graduating from this program felt well-prepared for their EM careers.

LIMITATIONS

The most important limitation of this study is its small sample size. The first class of graduates entered residency in 2015; therefore, the study site training program is relatively young, and the survey's sample size is still small. However, this study serves as a pilot for future research into the practice patterns of EM residency graduates. We look forward to expanding this work in the future.

Among other study limitations are the possibilities of survey fatigue, response bias, and non-response bias. The survey had primarily multiple-choice questions, and questions related to the main goal of this study (current practice locations) were presented in the first half of the questionnaire. Thirty percent of the eligible participants did not respond to the survey. It is possible that those who did not respond felt more negatively about their training and did not want to share those reflections. Finally, it is unknown to what extent the COVID-19 pandemic affected the perceived and/or real aspects of the residency.

CONCLUSION

The fact that 70% of the graduates of a residency program located in a rural area now work in community hospitals with an annual patient volume lower than 100,000 and 75% work in counties with fewer than 1,000,000 inhabitants suggests that this small community-based training program is succeeding in its mission. Because the nature of the program is emphasized in the recruiting material, it likely draws people with a pre-existing interest in working away from large urban areas. Access to high-quality emergency care is as critical in rural areas as it is everywhere else in the country, and this study supports that training clinicians in a rural environment fosters clinicians who are invested in the needs of rural, underserved communities.

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Substantial Variation Exists in Clinical Exposure to Chief Complaints Among Residents Within an Emergency Medicine Training Program

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Introduction: While many aspects of emergency medicine (EM) residency training are standardized among residents within a single residency program, there is no standard for the distribution of chief complaints (CC) that residents should see over the course of residency. This could result in substantial variability in each resident's clinical exposure. Our objective in this study was to explore EM residents' clinical exposure to CCs to determine whether substantial variation exists. If such variation exists, this could suggest the need for curricular reform to address gaps in resident clinical exposure during training.

Methods: This was a retrospective observational study of EM residents who graduated in the years 2016–2021 at a single, university-affiliated emergency department (ED) in the midwestern United States. All patient encounters where a CC was logged were included and categorized into 1 of 20 clinical domains based on the 2016 American Board of Emergency Medicine Model of Clinical Practice. We calculated descriptive statistics for the top 10 most encountered domains for comparison among residents.

Results: We included a total of 228,916 patient encounters from 69 residents in the analysis. Residents were involved in an average of 3,323 distinct patient encounters during the study period. The overall interquartile range for patient encounters was 523. The three CC domains with the broadest interquartile variation were abdominal and gastrointestinal disorders (116), musculoskeletal disorders (nontraumatic) (93), and traumatic disorders (86).

Conclusion: Within a single, three-year academic EM program, substantial variation existed among residents with regard to the variety of patient CCs seen during their residency training. [West J Emerg Med. 2025;26(1)47–52.]

INTRODUCTION

Medical residency training allows physicians to gain the cognitive and procedural skills necessary to practice independently. Based on experiential learning theory, patient encounters form the foundation upon which physicians in training begin to master the practice of medicine.[1] Additionally, the development of "illness scripts," or mental models for the classification of patient presentations, is crucial to the development of clinical skills and reasoning during residency training.[2] These models are developed over time by multiple exposures to presentations of similar disease states.[3,4] Emergency medicine (EM) trainees must be exposed to a variety of patient chief complaints (CC) throughout the course of residency to develop these scripts and become ready to begin independent practice.

Educators within EM have worked to define many aspects of EM residency training, including optimum number of shifts, on-shift educational goals/practices, and didactic content.[5] Despite this, the clinical experience of an individual resident may be highly variable and may be partially driven by self-selection of patients by the resident. Studies in pediatric EM suggest that there is significant variation in the overall number of patients and range in acuity among individual residents.[6,7] However, there is little adult EM literature that explores the variation in clinical experience seen by residents within a modern EM program. The literature that does exist in adult EM suggests there is substantial variation in clinical exposures among residents.[8] A study from 2006 found that the number of cases seen overall correlated with improved performance on a standardized test designed to assess clinical competence. However, the effect plateaued at around 200 cases.[9] Prior work by our group has shown that case volume in an individual domain did not correspond to performance within that domain on corresponding questions on the in-training exam.[10]

These studies suggest that individuals within a single training program may be gaining variable experience with certain types of patient presentations and lacking exposure (and therefore opportunities to develop mastery) to other complaints and pathology. However, this variability in clinical exposure during training has not been shown in adult EM for over three decades.[8] Since then, the number of annual visits to the ED as well as the complexity of medical care provided have substantially increased.[11,12] We, therefore, hypothesized that substantial differences in clinical exposure still exist among residents at the time of graduation. Understanding these differences is of critical importance for residency programs as considerable variation could push some residents below a threshold to develop robust illness scripts suitable for independent practice.

Population Health Research Capsule

What do we already know about this issue?
Studies from 30 years ago reported variation in the distribution of chief complaints seen by emergency medicine residents during training.

What was the research question?
We hypothesized that substantial differences in clinical exposure still exist among residents at the time of graduation.

What was the major finding of the study?
The three chief complaint domains with the most variability between individual resident experience, as measured by the greatest 25–75 interquartile ranges were abdominal and gastrointestinal disorders (median 594 patients per resident, IQR 116), nontraumatic musculoskeletal disorders (median 314, IQR 92), and traumatic disorders (median 525, IQR 86).

How does this improve population health?
Understanding these differences is important, as substantial variation could mean that some residents do not develop robust illness scripts suitable for independent practice.

METHODS

Study Design and Setting

We conducted this retrospective, observational study at a three-year EM residency program situated within an urban, academic emergency department (ED) in the Midwest. The ED for the primary clinical site has a total of 54 beds and sees an annual volume of approximately 60,000 patient visits. During the study period, the residency had 12 first postgraduate year one (PGY-1) positions available each year. The study ED divides its beds into two adult clinical areas and a pediatric clinical area. All three areas are physically connected on a single floor of the hospital. Residents from all three years are assigned to nine-hour shifts in each clinical area. Each shift includes 1–2 junior (PGY-1) residents, 1–2 senior (PGY-2 or PGY-3) residents, and one attending physician. Any resident can assign themselves to patients of any severity regardless of seniority. In Fall 2020, the study ED shifted from a "pod" model in which the two adult clinical areas would assign themselves predominately to patients in their clinical area to a "free-for-all" model in which either adult team could assign themselves to any adult patient regardless of the clinical area they were roomed in. During the study, physician assistants were employed in the ED and would occasionally take the place of a resident on shift (particularly during weekly resident didactics).

Data Acquisition

Residents were eligible for inclusion if they had completed residency within three consecutive years and graduated in the years 2016–2021 (therefore, the study period was from June 2013–June 2021). The electronic health record (EHR) was used to create a database of patient encounters; all encounters where eligible EM residents were the first resident assigned to the patient were analyzed. We used deidentified patient encounter data, listed by first CC. The CC was used to identify the nature of the patient encounter as this data was available at the time of patient presentation, often dictates the patient's ED workup, and would not have been affected by information discovered during the later stages of a

patient's hospital course. This approach is consistent with prior literature.[9,13] To maintain anonymity, only the senior author, a member of the residency leadership team, had access to each resident's individualized study identification number.

We excluded from analysis encounters where no CC was listed or no resident was assigned. In cases where multiple residents were assigned to a single encounter (e.g., a patient had been signed out to a different resident), we analyzed this encounter only for the initial resident assigned. This was done as they are typically the most involved in the cognitive workload of determining the patient's initial diagnostic and treatment plan. The CC for each encounter was selected and entered into the EHR by the primary nurse who cared for the patient in the ED initially. At our institution, this is nearly always selected from a list of common CCs, although it can be entered as free text. Encounters in which multiple CCs were listed were only coded into a single domain based on the first listed CC.

Data Analysis

A list of common CCs in EM has been categorized into a set of 20 content domains via a consensus process by two EM attendings using the 2016 American Board of Emergency Medicine (ABEM) Model of Clinical Practice as a framework.[14] For CCs identified in our data that were not already categorized by a previously described method,[13] we repeated the same categorization process in which each CC was assigned to a single domain by two board-certified EM attending physicians at our institution. Disagreements between the two reviewers were adjudicated by a third board-certified emergency physician. If a symptom was entered as the CC, such as "fever" (which could correspond to one of multiple domains), it was preferentially categorized into a domain based on what the coding physicians felt was the most likely to dictate the ED workup, rather than the "signs, symptoms, and presentations" domain. We used Excel (Microsoft Corp, Redmond, WA) to calculate descriptive statistics and create plots and tables. The top 10 most encountered domains overall were analyzed. We excluded less common domains given the low number of total encounters in each area, which would have been more vulnerable to random fluctuations in when these patients present to the ED.

This project was deemed exempt quality improvement by the University of Wisconsin Health Sciences Institutional Review Board.

RESULTS

A total of 315,614 encounters were initially identified from the EHR. Of these encounters 198 were excluded as no CC was listed. After excluding residents whose clinical experience was outside the study period and those who had left the training program prior to graduation or had a prolonged leave of absence, a total of 228,916 patient encounters from 69 residents were included in the analysis. Each resident was assigned to an average of 3,323 distinct patient encounters Assessment of the top 10 most common clinical exposure domains showed wide ranges in the case numbers of individual residents. The Table lists the mean, minimum, maximum, interquartile range (IQR) and 25th and 75th percentile for the 10 most common content domains. The Figure shows the range of exposure to the 10 most common domains in box-and-whisker format.

DISCUSSION

Our data suggests that residents within a single training program have substantial variation in their clinical experiences as measured by the variation in ABEM content

Table. Mean, 25th–75th percentile ranges, interquartile range, and minimum/maximum encounters for the 10 most encountered domains per resident.

	Mean	Median	25th, 75th percentile	IQR	Minimum, maximum
Total encounters	3323		3086, 3609	523	2595, 4053
Abdominal and gastrointestinal disorders	583	594	528, 644	116	416, 721
Traumatic disorders	529	525	484, 570	86	370, 725
Cardiovascular disorders	327	330	302, 356	54	233, 429
Nervous system disorders	319	319	301, 340	39	226, 402
Musculoskeletal disorders (non-traumatic)	314	314	269, 361	92	179, 460
Thoracic-respiratory disorders	280	281	246, 313	67	178, 383
Systemic infectious disorders	165	169	149, 179	30	115, 219
Head, ear, eye, nose, and throat disorders	150	151	136, 165	29	96, 196
Signs, symptoms, and presentations	129	130	120, 142	22	88, 170
Psycho-behavioral disorders	126	128	106, 139	34	67, 211

IQR, interquartile range.

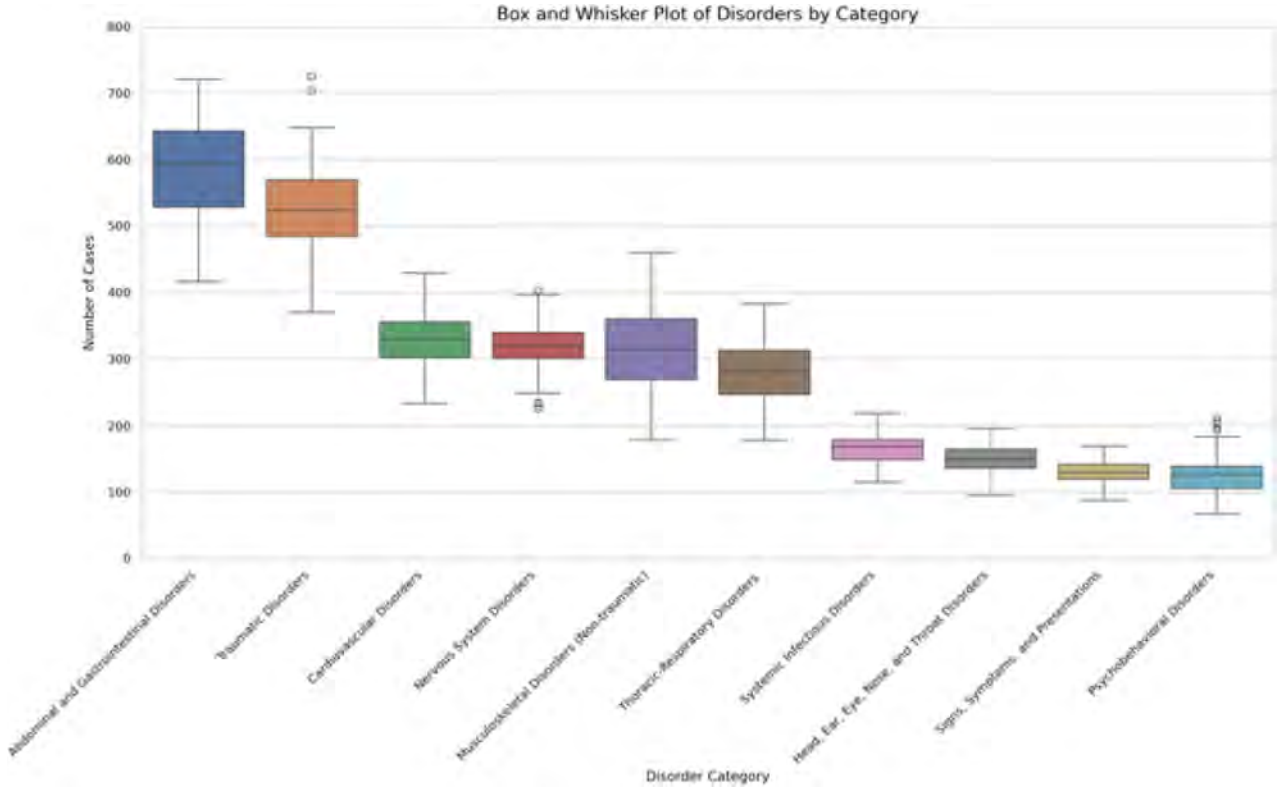

Figure. Top 10 most common clinical exposure domains seen by graduation per resident. Boxes illustrate the 25th–75th percentile of number of clinical exposures by residents in each domain, with whiskers representing the minima, maxima, and outliers.

domains seen by individual residents. This is similar to what was described by Langdorf et al. in 1990, despite the previous study being performed over three decades ago and the substantial subsequent differences in the utilization of the ED.[8] We found wide interquartile ranges between the maximum and minimum number of encounters among residents, suggesting that some residents saw substantially more patients within particular domains than others.

The magnitude of the educational significance of the exposure variability of residents is unclear. It is possible that a resident who sees twice as many musculoskeletal chief complaints as another resident by graduation is significantly more competent in that domain. Alternatively, it is also possible that they have both attained the minimal level of exposure to competently manage musculoskeletal complaints independently. The effects of clinical exposure on clinical competence, including the minimal number of encounters required to demonstrate competency in a particular domain, is an open question and an avenue for further research. However, the formation of illness scripts is continually modified by subsequent patient encounters.[3,4] Therefore, the identification of high degrees of variation among residents may prompt program leadership to institute changes in the curriculum or supplement clinical exposure with individualized learning plans. This is likely more important for domains that are encountered less frequently overall, such as psycho-behavioral disorders, where larger relative differences in exposure could result in greater deficits in illness script formation.

In addition to prompting changes made by the program, identification of high variability in clinical exposure may enhance resident self-assessment. As demonstrated previously, self-assessment when done in isolation, is an imperfect means of driving improvement but can be enhanced greatly when informed by additional information from a variety of sources.[15] Understanding the distribution of the patient encounters residents have during training, and the potential gaps in their clinical exposure, could be a potential means of allowing for informed self-assessment for a resident's clinical skills. This could be potentially further enhanced if facilitated under the supervision of faculty coaches within the program, a method that has become increasingly popular in medical education.[16,17] Future work could follow a cohort of residents who are able to track their own patient volumes more regularly than was possible in the current study and compare themselves to their peers throughout training and evaluate whether any differences in clinical competence are identified. This could also allow programs to determine the perceived value of this information to residents. Finally, residents could use this data to drive their patient selection while working in the ED.

Beyond the potential for shaping resident self-assessments, clinical exposure data may have important implications for residency program leadership as we move toward an era of competency-based medical education (CBME). Two of the pillars of CBME, "teaching tailored to competencies" and "effective programmatic assessment,"[18] lend themselves well to the identification of program clinical weaknesses as well as to the creation of new curricular experiences designed to address areas of limited clinical exposure identified by resident CC data. These experiences could potentially take the form of targeted readings or simulation sessions designed to supplement lower frequency clinical encounters.

LIMITATIONS

This was a single-center study in an urban, academic ED, and findings may not be generalizable to training programs in different environments. Additionally, the data was retrospective, making the educational utility of this information or any potential causes of variation difficult to determine.

Use of a CC to categorize each patient encounter into a clinical domain has an element of subjectivity and may have led to some encounters being miscategorized with respect to the workup done or final diagnosis. Some additional subjectivity may have been introduced by how we classified CCs that could potentially have been categorized into multiple different domains (such as "fever" or "ingestion"). This was done based on what was determined to be most likely to drive the initial workup in the department. For example, although a CC of "chest pain" could represent a cardiac or pulmonary etiology, in almost all cases, a cardiac etiology must be excluded. Therefore, it was felt that this would influence the formation and modification of the resident's illness script most heavily. It is also possible that encounters were mischaracterized due to only using the first CC listed and not considering the others if multiple CCs were listed. Like the prior limitation, it was felt that the first CC was most likely to dictate the initial ED workup. Using discharge or final diagnoses instead was considered for this study, but it was felt that the CC is more likely to drive the initial differential and diagnostic workup for the patient.

Additionally, ABEM domains may be too broad to capture important differences in exposure (e.g., two residents with the same exposure to "respiratory disorders" could have seen large numbers of pneumonia patients or, alternatively, many patients with asthma). Training is inherently variable as the EM environment differs by clinical site, day, shift, or even season. Therefore, there may have been slight differences in when individual residents were in the ED clinically or the number/type of overall ED shifts worked. It is important to note that some of the included residents' training occurred during the COVID-19 pandemic, which may have had an effect on both the variety and number of clinical exposures seen by these residents. Future work could also explore exposure based on sub-domains from the ABEM model to get a more granular look at individual resident clinical experiences rather than relying on the relatively broad domains.

Other clinical variables may also have an effect on a resident's clinical exposure, including the timing of months rotating in the ED. However, the ED did not undergo major changes in the staffing model of physicians (including residents) during this period. Also, while it is likely that more senior residents assign themselves to critically ill patients, this was felt to be unlikely to meaningfully impact our results given that data was obtained at the time of graduation. Therefore, each resident would have acted in a senior role for the same amount of time. Finally, our use of the EHR at the main clinical training site of the residency to generate the data did not capture the clinical experience at two other training sites for the residency that use a different EHR. This may have served to moderate or exacerbate the differences seen among residents. However, clinical experiences at these other sites comprised a total of only four months of the 36-month curriculum, and so it is likely that our overall findings would not have been substantially affected.

CONCLUSION

Within a single, three-year academic emergency medicine program, there was substantial variation among residents regarding the variety of patient chief complaints seen throughout residency when mapped to ABEM's Model of Clinical Practice.

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The Effect of Hospital Boarding on Emergency Medicine Residency Productivity

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Introduction: Emergency department boarding has escalated to a crisis, impacting patient care, hospital finances, and physician burnout, and contributing to error. No prior studies have examined the effects of boarding hours on resident productivity. If boarding reduces productivity, it may have negative educational impacts. We investigated the effect of boarding on resident productivity as measured by patients per hour and hypothesized that increased boarding leads to decreased productivity.

Methods: This was a retrospective study at a quaternary, urban, academic Level I trauma center from 2017–2021 with a three-year emergency medicine residency of 10–12 residents per year and annual volumes of 80,000–101,000. Boarding was defined as the time between an admission order and the patient leaving the ED. We created a multivariable mixed model with fixed covariates for year, month, day of week, resident experience, shift duration, total daily ED patients, and with residents as repeated measures. The effect of boarding was estimated after covarying out all other factors.

Results: All variables included in the model were significantly associated with changes in productivity. Resident experience has the largest effect such that for each month of residency experience, a resident adds 0.012 patients per hour (95% confidence interval [CI] 0.010–0.014). Isolating the effect of boarding demonstrated that for every additional 100 hours of boarding, a resident's productivity decreased by 0.022 patients per hour (95% CI 0.016–0.028). In the study, the median daily boarding was 261 hours; if this were eliminated (assuming a resident completes 100 10-hour shifts annually), a resident could be expected to see 56.9 more patients per year (95% CI 40.7–73.1).

Conclusion: Hospital boarding significantly reduces resident productivity as measured by patients per hour. Further studies are warranted to determine the educational impact. [West J Emerg Med. 2025;26(1)53–61.]

INTRODUCTION

Emergency department (ED) boarding (defined as patients admitted to the hospital but remaining in the ED) has reached critical levels and has been declared a crisis by the American College of Emergency Physicians.[1] The scope of the crisis is daunting with effects on patient care, errors, physician burnout, hospital economic stress, and ambulance diversion.[2] Increased ED boarding also leads to increases in

medication errors, time to antibiotics, time to percutaneous coronary intervention for patients with myocardial infarction, time to care for patients with acute stroke, patient mortality, and risk-adjusted hospital spending, and has effects on all levels of acuity.[3–10]

Within the context of boarding, EDs must also provide sound educational training involving both quality and quantity of patient experiences. Residency programs seek to improve efficiency and productivity in their residents throughout their training. Many variables have been associated with resident productivity including time of shift, shift length, and resident experience.[11–13] There are, however, few studies that evaluate the effect of ED crowding and boarding time on the effect of emergency medicine (EM) resident productivity.[14] If boarding decreases the number of patients seen during a residency, there may be an impact on resident education.

In this study we aimed to investigate the effect of boarding on EM resident productivity as measured by patients per hour. We hypothesized that increased hospital boarding would result in decreased resident productivity.

Population Health Research Capsule

What do we already know about this issue?
Emergency department boarding negatively impacts patient care, hospital efficiency, and physician well-being.

What was the research question?
Does increased ED boarding reduce emergency medicine resident productivity, as measured by patients per hour?

What was the major finding of the study?
For every additional 100 hours of ED boarding, a resident's productivity decreased by 0.022 patients per hour (95% CI 0.016–0.028); a resident sees 57 fewer patients per year due to boarding.

How does this improve population health?
Understanding the negative effects of boarding on productivity may help policy makers find solutions to improve patient flow, patient care, resident education, and overall health outcomes.

METHODS

Study Design and Setting

This was a retrospective study conducted at the Virginia Commonwealth University Health System, the only comprehensive Level I trauma center in Richmond, VA. During the study period from January 2017–June 2021, the total patient volumes ranged from 80,000–101,000 per year. On average, 30% of patients were admitted to the hospital, of whom 5% went to the intensive care unit. Patients <18 years of age constituted 22% of the total volume. The department is staffed with board-certified emergency physicians, and during the study period 81% of patients were seen by a resident. The remaining non-resident cases were seen by advanced practice practitioners (APP) in a low-acuity area of the ED or by attending physicians and were not included in the study. Throughout the study there was no change in this staffing model such that APPs were never competing for the same patients as residents. The department has 76 beds with 35 in an acute area, 10 in trauma/resuscitation, 10 in a mid-track area, 16 in a pediatric department, and five in a fast-track zone.

Our residency program is three years in length, and class sizes ranged from 10 residents in 2017 to 12 residents in 2021. During postgraduate years (PGY)-1, 2, and 3, residents work in the ED for 26 weeks, 29 weeks, and 35 weeks, respectively. Resident shift lengths varied from 9–12 hours with the most typical shift being 10 hours. On average, each 24-hour period had a total of 137 hours of resident coverage in overlapping shifts. The EM residents saw patients in all Emergency Severity Index (ESI) categories and were the primary physicians for all emergent patients (ESI 1 and 2). Residents cared for patients in all areas of the ED other than the low-acuity area. All residents staff patients directly with an attending physician without oversight by a more senior resident; therefore, the productivity numbers for residents in all three years of training are independent.

The study was granted exempt status by the Virginia Commonwealth University Institutional Review Board (HM20024717).

Selection of Participants

Data from all patients evaluated by an EM resident was captured in a database, and in conjunction with scheduling data it was used to determine the average number of patients per hour. Only EM residents were included. The study period was selected as this was the maximum amount of time for which data was available prior to the hospital switching to a new electronic health record. As the database was initially created to provide feedback to residents, certain data was removed and not available to us for analysis. Information from the first month of EM for each resident was not provided, and due to initial effects from the COVID-19 pandemic, data from April–July 2020 was not included.

Measurements

We combined three databases for analysis: the patient database of all ED encounters; the resident scheduling database; and the hospital boarding database.

During the study period, the EM residency program received monthly, system-generated reports listing the unique patient identifier, name of the resident assigned to care for the patient, the ESI acuity level, the date/time of first contact and check out, and the disposition. The resident assignment was derived from tracking board data, and in scenarios where multiple residents were assigned to a patient encounter, only the first resident assigned was credited for each unique patient encounter. The EM residents were scheduled for 9-hour, 10-hour, or 12-hour shifts during the study period. All non-EM residents and staff were excluded from the patient database.

Boarding data was reported daily from hospital analytics. The number of hours of boarding was defined as the time between an admission order and when the patient left the ED. Boarding hours was selected as this was the variable available to us from the hospital analytics database.

Outcomes

We designed a model to isolate the effects of ED boarding on resident productivity as measured by patients per hour. Patients per hour was defined as the total number of new patients seen during the shift divided by the duration of the shift in hours. The covariates were chosen from those found in previous studies to be related to resident productivity.[11,13,15,16] These included year, month, day of the week, cumulative residency months in training, shift duration, total patients per day, and boarding. Months in training was chosen as a continuous covariate to delineate resident experience rather than the rough classification of PGY-1, -2, or -3 based on the observation that resident productivity begins low in the PGY-1 year, increases in the PGY-2 year, and then plateaus. This monthly experience variable was modeled using cubic regression.

Analysis

We described the data using counts and percentages. Patients per hour was modeled using a multivariable mixed model, with covariates defined as fixed effects and residents as repeated measures. We used an autoregressive (AR1) covariance structure to account for the dependence between repeated measures. The fixed effects were year (reference = 2019), month (reference = 12), day of the week (reference = Thursday), resident month in training (centered on 18), total patients per day/100, shift duration, and daily boarding hours/100. We chose the year 2019 as a reference as it was the last full year of data prior to the start of the COVID-19 pandemic. December was chosen as it aligns with the 18th month of residency, which is when productivity plateaued in our model. Thursday was selected as it is thought to represent the day with the most ideal flow since it avoids weekends, Monday, and Friday patient surges, as well as Wednesday morning didactics when EM residents are not working clinically. The total patients per day, shift duration, and boarding hours were referenced at the median values in our dataset.

We estimated the effect of boarding from the marginal regression model after covarying out all other factors. Estimates are described using 95% confidence intervals. All data management and analysis were performed using SAS software (version 9.4 and JMP Pro version 17.2 (SAS Institute Inc, Cary, NC).

RESULTS

Characteristics of Study Subjects

During the study period, 263,058 patients were seen in the ED by 601 clinicians including the 80 EM residents studied. During the 49 months studied between 2017–2021, EM residents were scheduled to 16,949 shifts and were assigned 188,685 patients (Table 1). Total daily patient volume varied considerably during this time (mean 177, SD 26, range

Table 1. Characteristics of the emergency department residents' shifts and patients evaluated (January 2017–June 2021).

Characteristic	Shifts N	Patients N	(%)
Total	16,949	188,685	
Year			
2017	3,496	44,119	(23)
2018	3,955	47,569	(25)
2019 (11 months)*	4,053	47,035	(25)
2020 (8 months)†	3,101	29,191	(15)
2021 (6 months)	2,344	20,771	(11)
Month			
1- January	1,909	21,052	(11)
2- February	1,576	18,004	(10)
3- March	1,680	18,901	(10)
4†- April	1,302	15,229	(8)
5†- May	1,371	16,385	(9)
6†- June	1,337	15,191	(8)
7†- July	820	10,129	(5)
8- August	1,560	15,543	(8)
9- September	1,376	14,741	(8)
10- October	1,431	15,299	(8)
11*- November	1,062	11,639	(6)
12- December	1,525	16,572	(9)
Day of week			
Sunday	2,249	25,887	(14)
Monday	2,679	29,099	(15)
Tuesday	2,756	29,504	(16)
Wednesday‡	1,989	21,970	(12)
Thursday	2,601	27,874	(15)

(*Continued on next page*)

Table 1. Continued.

Characteristic	Shifts N	Patients N	(%)
Friday	2,525	28,785	(15)
Saturday	2,150	25,566	(14)
Shift			
7 AM to 5 PM	1,688	16,332	(9)
7 AM to 7 PM	180	2,512	(1)
9 AM to 7 PM	2,546	28,306	(15)
12 PM to 10 PM	3,386	38,586	(20)
2 PM to 12 AM	2,470	28,631	(15)
3 PM to 12 AM	3,553	41,138	(22)
9 PM to 7 AM	3,126	33,180	(18)
PGY			
PGY-1[§]	5,162	44,817	(24)
PGY-2	4,756	57,447	(30)
PGY-3	7,031	86,421	(46)
Disposition			
Admitted		74,663	(40)
Discharged		114,022	(60)

*November 2019 was excluded as the hospital information management system was down.
[†]April 2020 through July 2020 was excluded due to COVID-19 and hospital changes.
[‡]Wednesdays mornings are resident didactics.
[§]The first month of a residency was excluded (orientation month).
ESI, Emergency Severity Index; *PGY*, postgraduate year.

88–263). As indicated in the table, the ED experienced a patient count variability that changed across years, months, days of the week, shifts, and PGY level. Of all 188,167 patients seen by EM residents, 40% were admitted.

Boarding hours per day varied considerably (mean 281, SD 127, range 50.8–914.4; Figure 1). The hospital information system calculated boarding hours daily; however, across the 1,490 days studied, there were six impossible (negative) values and nine very low values. Low values were identified by large residuals in the multiple regression model. Rather than treating these as missing values, we used a multiple regression model to impute the 15 values in question.

Main Results

All the factors in the repeated-measures mixed-model were significant ($P < 0.001$). Table 2 shows the estimated effect of each term in the model. The joint effect of all the factors on resident productivity is shown in Figure 2. These profile plots show the marginal model predicted value of resident productivity on the vertical axis across all the covariates on the separate horizontal axes. The importance

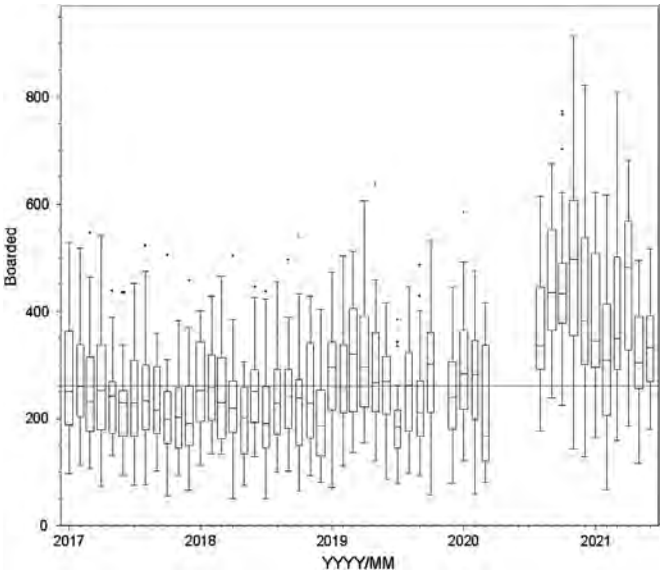

Figure 1. Boarding across study years.
Line set at median boarding hours across the entire study period (261 hours/day).
Each box plot represents a month (line = median, box = 25th to 75th quartile, whiskers = typical extremes, circles = outliers).
Note: April 2020–July 2020 hours are not available as they correspond to the beginning of the COVID-19 pandemic.

of a factor is visualized by the steepness of the prediction trace.

Isolating the effect of boarding demonstrated that for every additional 100 hours of daily departmental boarding, individual resident productivity decreased by 0.022 patients per hour (95% confidence interval [CI] 0.016–0.028, Table 2). In the reference standard scenario, a resident could be expected to see 1.10 patients per hour with boarding at the daily median (261 hours) but could see 1.15 patients per hour if boarding were eliminated (Figure 2, Panel C). Table 3 shows how resident productivity was degraded by boarding across the range of values seen at our institution. A resident would see 1.14 patients per hour when boarding was at the lowest in the study compared to 0.95 patients per hour at the maximum level of boarding seen in the study, which is a difference of 0.19 patients per hour (95% CI 0.15–0.22). Assuming a resident completes approximately 100 shifts a year that are of 10 hours duration and boarding was eliminated, then a resident could be expected to see 56.9 more patients per year (95% CI 40.7–73.1). This would represent a 5% increase in patient volume per resident annually.

Resident experience has the largest effect on resident productivity. Resident productivity was low initially at 0.5 patients per hour (95% CI 0.46–0.54) by the second month of training (Figure 2). Improvement was initially rapid to 0.75 patients per hour at seven months, then plateaued near the 18-month point (1.10 patients per hour) to finally reach 1.12 patients per hour at the end of the 36 months (95% CI 1.08–1.17). When evaluating our data by PGY level, our

Table 2. Multiple regression results predicting new patients per hour per resident for each variable.

Effect	Estimated new patients per hour	Standard error	95% CI
Intercept	1.0957	0.0173	1.0618 to 1.1297
Year			
2017	0.1501	0.0122	0.1262 to 0.1740
2018	0.0837	0.0117	0.0608 to 0.1065
2019	[reference]		
2020	−0.0641	0.0137	−0.0909 to −0.0373
2021	−0.1682	0.0156	−0.1987 to −0.1377
Month			
1- January	0.0635	0.0172	0.0298 to 0.0972
2- February	0.0776	0.0182	0.0420 to 0.1133
3- March	0.0498	0.0181	0.0144 to 0.0852
4- April	0.0840	0.0197	0.0453 to 0.1227
5- May	0.0750	0.0196	0.0366 to 0.1133
6- June	0.0585	0.0201	0.0191 to 0.0979
7- July	−0.0077	0.0219	−0.0507 to 0.0353
8- August	0.0550	0.0185	0.0188 to 0.0912
9- September	0.0654	0.0187	0.0288 to 0.1021
10- October	0.0487	0.0184	0.0127 to 0.0847
11- November	0.0486	0.0199	0.0095 to 0.0876
12- December	[reference]		
Day of the week			
Sunday	0.0587	0.0118	0.0357 to 0.0818
Monday	−0.0312	0.0118	−0.0542 to −0.0082
Tuesday	0.0122	0.0110	0.0094 to 0.0338
Wednesday	0.1094	0.0123	0.0854 to 0.1334
Thursday	[reference]		
Friday	0.0475	0.0109	0.0261 to 0.0688
Saturday	0.1182	0.0120	0.0948 to 0.1417
Resident months (linear)*	0.0122	0.0010	0.0101 to 0.0142
(quadratic)	−0.0011	0.0000	−0.0012 to −0.0010
(cubic)	0.00003	0.00001	0.00002 to 0.00004
Total patients per day (per 100 patients)*	0.4021	0.0165	0.3697 to 0.4344
Shift duration*	−0.1277	0.0070	−0.1413 to −0.1140
Boarded (per 100 hours)*	−0.0218	0.0032	−0.0280 to −0.0156

The mixed-model also included resident as a repeated-effect with an AR(1) covariance structure.
*Continuous covariates were referenced to the median value. Median resident month = 18, total patients per day/100 = 1.77, shift duration = 10 hours, boarded hours/100 = 2.61.
CI, confidence interval.

PGY-1 residents saw 0.75 per hour, PGY-2 residents saw 1.10 patients per hour, and PGY-3 residents saw 1.12 patients per hour.

Total patients per day presenting to the ED was the next most important factor in resident productivity. For every 100 new patients presenting to the ED, an individual resident would be expected to add 0.40 patients per hour (95% CI 0.37–0.43). The median value for daily total patient volume was 177 patients per day, but a low-volume day at the 10th percentile (143 total patients) resulted in a corresponding decrease in resident productivity to 0.96 patients per hour (95% CI 0.92–1.00). For a high-volume day at the 90th

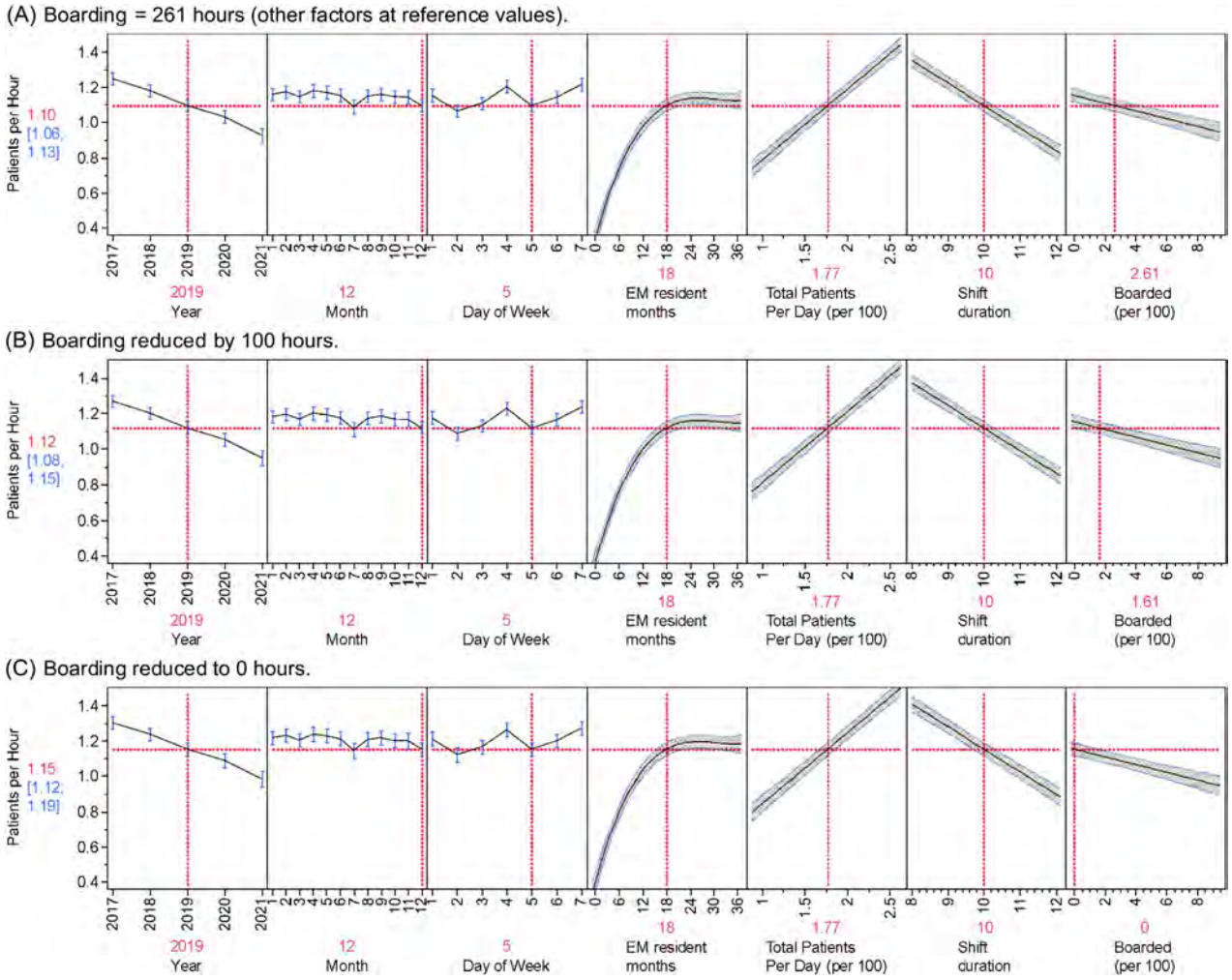

Figure 2. Multiple regression results predicting new patients per hour per resident for each variable.
All values (year, month, day of week, EM resident months, total patients, shift duration) in model held at reference standards with adjustments to boarding (last panel of each graph). Expected patients per hour in each scenario is indicated by the red number in the Y axis with 95% confidence intervals in blue. As boarded hours change (last panel of each graph) so do patients per hour (red number to left of each graph) in each of the three scenarios (A: Median boarding of 261 hours. B: Reducing boarding by 100 hours. C: Eliminating boarding hours.)

percentile (210 patients), resident productivity increased to 1.23 patients per hour (95% CI 1.19–1.26).

Resident productivity also changed based on the year, shift duration, and day of the week. Resident productivity was highest in 2017 at 1.25 patients per hour (95% CI 1.21–1.28) and steadily decreased to the 0.93 patients per hour seen in 2021. Resident productivity for a nine-hour shift was predicted to be 1.21 patients per hour

Table 3. Estimated resident productivity by boarding hours.

Cutoff	Boarded (hours)	Estimated patients per hour	Standard error	95% CI
Maximum	914	0.954	0.027	0.900 to 1.007
75th percentile	351	1.076	0.018	1.042 to 1.111
Median	261	1.096	0.017	1.062 to 1.130
25th percentile	189	1.111	0.017	1.077 to 1.146
Minimum	51	1.141	0.018	1.105 to 1.178
No boarding	0	1.153	0.019	1.115 to 1.190

Marginal estimates from the mixed model with the following factors held constant: year = 2019, month = 12, day of the week = 5 (Thursday), resident month in training = 18, total patients per day/100 = 1.77, shift duration = 10 hours.
CI, confidence interval.

(95% CI 1.19–1.26), whereas for a 12-hour shift it was predicted to be 0.84 patients per hour (95% CI 0.80–0.89). Saturdays and Wednesdays averaged approximately 1.21 patients per hour, Sundays, and Fridays approximately 1.15 per hour, and Mondays, Tuesdays, and Thursdays 1.10 patients per hour.

Month-to-month variability had the smallest effect on resident productivity. Compared with the other months, July and December had lower resident productivity (1.09 vs 1.16 patients per hour).

DISCUSSION

To our knowledge, this is the first study to demonstrate that there is a significant reduction in resident productivity (measured as patients per hour) due to hospital boarding in the ED. In our model, this resulted in a decrease of 0.022 patients per hour (95% CI 0.016–0.028) for every 100 hours of daily boarding. While performed at a single institution, our dataset broadly aligns with multiple studies previously completed regarding resident productivity. In our study, we analyzed resident experience as the number of months in training rather than divided into PGY level. This was based on our observation that productivity rapidly increased during the PGY-1 year and then plateaued in the middle of the PGY-2 year.

When evaluating our data by PGY level, our PGY-1 residents saw 0.75 patients per hour, PGY-2 residents saw 1.10 patients per hour, and PGY-3 residents saw 1.12 patients per hour. Prior studies have demonstrated similar patterns with PGY-1 to -3 residents seeing between 0.79–0.81 patients per hour, 1.05–1.2 patients per hour, and 1.22–1.27 patients per hour, respectively.[17–19] A study by Henning et al showed rapid progression from PGY-1 to PGY-2 year and then gradual progression in PGY-3 year but was based on patients per day.[20] Similarly, a study by Turner-Lawrence and Todd saw increasing productivity from 1.2 patients per hour to 1.5 patients per hour to 1.6 patients per hour by PGY-1 to -3 residents, respectively.[13] While these productivity numbers are higher than those in our study, the authors did not adjust for additional variables.

In a more comparable study, Kirby et al reported the efficiency of EM residents during ED crowding.[14] The authors used the National Emergency Department Overcrowding Study (NEDOCS) scoring system to categorize states in the ED as not crowded, crowded, and overcrowded. They found that resident productivity measured as new patients per hour increased initially in all year groups as the ED transitioned from not crowded to crowded, but then remained stable when transitioning from crowded to overcrowded. While the NEDOCS score uses a measure of ED boarding (the waiting time of the longest admitted patient), it does not include total patient boarding hours as in our study. Our study more directly examines the effect of boarding (one element of crowding) on resident productivity. The paradoxical increase in resident productivity in the Kirby study may have been due to an increased number of patients presenting to the ED, which could have increased the NEDOCS score. Our study demonstrated that resident productivity increased with higher patient volumes, and including this in our model allowed us to better isolate the effect of boarding.

According to a study by the Academy of Administrators in Academic Emergency Medicine and the Association of Academic Chairs of Emergency annual benchmark survey, boarding times have dramatically increased since the COVID-19 pandemic.[21] By the end of their study period, the median number of boarding hours per month was 11,480, which approximates to 382 hours of daily boarding. In our study, which includes a pre-pandemic period, the median daily boarding was 261 hours, suggesting that boarding is likely worsening over time and is a problem at many academic medical centers.

The educational impact of decreased patient volumes caused by boarding is uncertain. It is reasonable to expect that residents seeing fewer cases may lose valuable learning opportunities, but this has not been well studied and no firm numbers exist to suggest a threshold at which education suffers. Prior authors have surveyed residents regarding a perceived decrease in education during crowding.[22,23] These studies concluded that residents did not perceive a difference in education during these times, but they used differing measures of crowding, were survey-based, and underpowered. Educators may switch to different models of teaching during periods of high boarding, leading to residents perceiving a less deleterious effect.[24]

Others have postulated an educational Starling effect whereby some boarding allows supervising physicians more time to teach, but at some point there are diminished returns as fewer new patients become available to discuss.[25] A more recent study was conducted during the current boarding epidemic; the authors surveyed EM program directors regarding their perceptions of the impact of boarding on resident training.[26] In this study, 80% of the respondents felt that boarding negatively affected resident education, especially in the domains of managing department throughput and managing high volumes of patients per resident. While survey-based in nature, the study results broadly aligns with the prior studies in this area.

Theoretically, residents who see fewer cases may lose valuable learning opportunities. While the components of Bloom's domains of educational activities can be learned via different modalities of instructional techniques, clinical experience allows for the linking of knowledge to skills and then to attitudes/emotions.[27] By decreasing a learner's exposure to patients, one could argue that residents may lose valuable experiential learning opportunities. While some of these can be replicated in simulation or case-based discussion, other skills cannot and are best learned via hands-

on, experiential learning encounters. Experiential learning theory, as described by Kolb, highlights the importance of real-life experience and the influence this has on learning.[28] Unlike traditional learning and instructional methodology that focuses on rote memorization, experiential learning is an active process where residents are engaged in concept transformation through action as well as reflection on their experiences and patient encounters.

This learning theory also emphasizes principles of adult education in which prior learning experiences can be leveraged to create more meaningful and relevant educational experiences.[29] Additionally, decreasing patient interaction may also affect residents' application and translation of knowledge into practice. Behavioral learning theory emphasizes learning through interactions with the environment where reinforcement and feedback can encourage modification of behaviors. By incorporating behavioral learning strategies, medical education can foster not only technical competencies but also the development of professional habits such as effective communication between team members and patients.[30]

LIMITATIONS

This study has several limitations. This was a single-center study that took place in a high acuity, quaternary-care center that also experiences high levels of boarding, which may limit generalizability to other centers. The database that captured the resident patient assignment was based on tracking board data and may have occasionally miscredited a resident with a patient encounter; however, as the dataset was large and involved multiple years with complete datasets for three full classes of residents this is unlikely to have greatly influenced the data. Our resident class size did increase during the 2021 year and thus could theoretically have decreased the number of patients available per resident. While we did not study that directly, it is unlikely to have impacted the data greatly as the additional residents allowed for the creation of an outside rotation at a free-standing emergency center and, therefore, resident staffing hours stayed generally consistent at the study site.

Our model did not include a measure of patient acuity as a covariate. While the ESI category and disposition were recorded for each patient, we did not feel there was a reliable way to convert this data into a meaningful measure of hourly acuity that influenced the amount of time a resident might dedicate toward patient care. For example, an ESI-1 patient who is admitted for an ST-segment elevation myocardial infarction may stay in the department for 15 minutes leaving the bed open for a new patient, while an ESI-3 patient requiring a workup for abdominal pain including imaging who is discharged may occupy a room and a resident for multiple hours. Since our dataset was large, it was assumed that all residents would be exposed equally to the same mix of acuities on individual shifts, by the end of their residency and thus limit the effect on the data. Additionally, recent studies have called into question the accuracy of the ESI.[26,27] A prior study on resident productivity did not show a correlation between ESI and clinician disposition times.[14]

Our study also included data from the COVID-19 pandemic, which affected patient volumes and ED boarding. The dataset we used was initially meant for reporting individual residents' productivity measures, so data from the first few months of the pandemic was not available for our current study. This likely served to decrease the effect of the initial pandemic response on our data. Just prior to the pandemic our ED had seen a growth in patient volumes from 87,000 patients per year to a peak of 101,000 patients per year, which was followed by a rapid decline to 83,000 a year in the 2021–2022 year. The volumes did slowly rise after the study period. This may have influenced some of the data from our later resident-year groups and served to decrease productivity.

Our measure of boarding may also have limitations. Total boarding hours per day was the variable available from our hospital analytics department. The number of boarded patients per day may have provided different data. For example, in our model a single behavioral health patient boarding for 20 hours from one day would be indistinguishable from 20 patients boarding in 20 individual rooms for a single hour each. As the dataset is large, and all residents were exposed to the same conditions throughout their time, it is unlikely any one resident's data (or the trend) would be affected based on these types of outliers.

CONCLUSION

We found a significant reduction in resident productivity as measured by patients per hour during periods of increased boarding. Further studies are warranted to determine the educational impact of these findings.

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Preparation for Rural Practice with a Multimodal Rural Emergency Medicine Curriculum

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Rural regions face emergency physician shortages. Most training programs are located in cities and lack rural clinical experiences, didactics, and mentorship to excite and prepare residents for rural emergency medicine (EM) practice. There is limited data on optimal training methods for preparing residents for rural practice. To address this need for rural EM training and workforce, we developed a rural EM curriculum for a single EM residency program in the United States. We began with a two-year case review from critical access emergency departments. Rural EM skills were defined and taught using lectures, simulation cases, and clinical rotations. We obtained quantitative and qualitative feedback from the first 10 residents participating in the curriculum. Qualitatively, 10/10 residents gained new skills and found these experiences valuable to their training and career choice, with 100% expressing interest in rural practice and 70% choosing a rural practice. Quantitatively, residents managed a wide variety of patient acuity and volume and performed new procedures compared to their academic center rotations, all while gaining unique skills from the challenges of a rural environment. Focused rural EM clinical experiences and nonclinical teaching during residency are a promising approach to bridge the gap between urban, tertiary-care training programs and rural emergency care needs.

BACKGROUND

Rural regions face significant emergency physician (EP) shortages.[1,2] As rural patients age and face even greater disparities and barriers to care,[3–6] the need for skilled, rural EPs prepared to practice full spectrum emergency medicine (EM) with limited resources is paramount. Recent EM workforce studies demonstrate that the critical need for rural EPs is likely to worsen rather than improve for several reasons.[7–10] There is a significant mismatch in the distribution of EPs throughout the United States, with a surplus of EPs in urban areas and a deficit in rural areas.[9] Rural areas have lower rates of physician entry, an older workforce, and higher rates of attrition.[10] Most important for the future of the rural EM workforce, EM training programs continue to proliferate in urban areas, with very few programs in rural areas with rural-focused training.[7,8]

Several training programs have sought to encourage rural practice by incorporating rural clinical electives and published guidelines for developing rural clinical experiences.[11,12] Additional research demonstrates that rural rotations are educationally valuable and include greater or similar numbers of procedures to urban tertiary rotations.[13] Despite these efforts, a significant educational gap remains for most residents. There is no requirement for rural EM clinical or nonclinical education within the Accreditation Council for Graduate Medical Education core competencies for EM and no standardized rural EM curriculum for residencies to reference. There is also very limited data on optimal training methods for preparing residents for rural practice.

OBJECTIVES

Our team of rural EM clinician-educators is well versed in the staffing needs and clinical demands of rural EM practice. We aimed to leverage our unique, rural-academic health network and address this educational challenge. Our objectives were to 1) deliver a multimodal (didactic, simulation, and clinical) rural EM curriculum that prepares trainees to independently work in rural emergency departments (ED) at graduation; and 2) evaluate our program quantitatively and qualitatively to assess the opportunities and limitations of rural training.

CURRICULAR DESIGN

To develop our curriculum content, rural EM needed to be defined: What are the rural-specific skills that EPs need to deliver excellent care that are not part of a typical tertiary-care residency curriculum? To answer this question, we conducted a two-year case review of all admissions, transfers,

and greater than six-hour length-of-stay (LOS) cases from the EDs of two rural critical access hospitals (CAH) in our network. To be designated "critical access," a hospital must be located in a rural area more than 35 miles from another hospital, provide 24/7 emergency care, and have 25 or fewer inpatient beds.[14] The two CAH EDs in our study each see 6,000 patients annually with basic EM resources including lab, plain radiographs, computed tomography, and point-of-care ultrasound, with a solo coverage EP staffing model. There is no specialty back-up, no operating room, no obstetrical services, no blood bank, no respiratory therapy, and limited pharmacist coverage.

We focused on cases requiring critical care, transfer, specialty consultation, and greater than six-hour LOS, because these cases pushed our attending group to think harder, review a procedure or pathology, or use skills typical of not only an EP, but also a respiratory therapist, pharmacist, and/or specialist. This allowed us to identify a library of challenging rural EM cases. We also created a 15-member rural EM faculty working group of academic physicians who routinely practice in rural environments. Our rural CAH case review was combined with input from our rural EM working group to create a list of knowledge and skills essential to rural EM practice yet missing from our existing teaching (Figure). In parallel, we developed a selection of EM clinical rotations at our network's CAHs and at partner rural sites throughout the country.

Ten residents completed a pilot two-week or four-week rural EM rotation and 18 months of the rural nonclinical curriculum from July 2021–August 2023. These 10 home residents were the first 10 residents to choose this rural rotation in their second or third year as part of a new residency program. During the study period, eight other home residents chose alternative elective rotations. All 18 home residents completed the rural nonclinical curriculum. During the study period, we also opened our rural EM rotation to visiting residents. Four visiting residents from three urban residency programs completed the clinical rotation but did not participate in the nonclinical curriculum. Zero residents entered our rural curriculum with an explicit commitment to future rural practice. One home resident in each group and two visiting residents grew up in a rural area—defined as a United States census-designated place with a population less than 2,500.[15]

Qualitative and quantitative feedback on the rural rotation was solicited from home and visiting residents. Residents completed a voluntary survey that asked the following: 1) Was the rotation beneficial to your clinical training; 2) describe any new skills and unique experiences; 3) discuss any limitations of learning in a rural environment; 4) are you interested in rural practice; and 5) where will you practice upon graduating? We also collected data on patient volume, patient acuity (discharged, admitted, or transferred), and procedures performed from April 2022–August 2023. Prior to April 2022, our electronic health record did not consistently enable resident documentation, preventing accurate chart review. This quality improvement and education project using research methods was submitted to our institutional review board (IRB); it did not meet the definition for human subjects research and was exempt from IRB review and approval.

IMPACT/EFFECTIVENESS

The rural EM curriculum has proven successful over the first three years and continues to evolve. A total of 10 of 10 home residents and four of four visiting residents who completed the clinical rotation reported gaining new skills and confidence. In their free-text responses, residents stated that providing respiratory support without a respiratory therapist, managing multiple critical patients, providing solo-coverage trauma care, and delivering orthopedic care were highlighted skills of the rotation. Compared with academic, tertiary-care sites, residents see patient volumes that are more variable at rural sites with more extreme peaks (six patients per hour) and troughs (zero patients per hour) consistent with solo coverage EM practice. Acuity is

Lecture Topics	Simulation Exercises
Respiratory support without a respiratory therapist	Adult respiratory distress from HFNC to NIV to MV
How to size up your resources on your first rural shift	Infant bronchiolitis from HFNC to NIV to MV
Critical care pharmacy basics	Critical access neuro critical care
Rural EMS operations and medical direction	Rural pediatric crashing asthma
EMTALA and transfer logistics	Solo-coverage two-patient trauma
Rural obstetrics	Triple patient transfer logistics and telemedicine
Rural point of care ultrasound applications	You are the OB: delivery with PPH
Rapid rural procedures for solo coverage	You are the NICU: neonatal resuscitation
Rural pediatric critical care pearls	You are the intensivist: code on the floor
Rural orthopedics: Solo coverage tips and tricks	You are the ENT: fiberoptic airway assessment
Teaching cases from critical access EM	You are the RN: key nurse tasks for rural docs

Figure. Nonclinical rural curriculum components.
EMS, emergency medical services; *EMTALA*, Emergency Medicine Treatment and Labor Act; *HFNC*, high-flow nasal cannula; *NIV*, non-invasive ventilation; *MV*, mechanical ventilation; *IO*, intraosseous; *OB*, obstetrician; *PPH*, post-partum hemorrhage; *NICU*, neonatal intensive care unit; *ENT*, ear nose and throat; *RN*, registered nurse.

Table. Rural emergency medicine curriculum participation and resident job choice.

Resident group	Number of residents	Rural curriculum completed	Rural practice
Home resident, pilot	10	Clinical and nonclinical	70% (7/10)
Home resident, other elective	8	Nonclinical	75% (6/8)
Visiting resident	4	Clinical	25% (1/4)

similarly more variable than at academic sites on a given shift, but high-acuity cases were noted to be some of the highest yield learning experiences with residents performing full-spectrum emergency care. Residents performed a greater variety of procedures than at their tertiary site and more new procedures. These were procedures they often deferred to specialists on busy shifts including fracture-dislocation reductions, arthrocentesis, complex laceration repair, priapism reduction, and regional anesthesia. A total of 100% of home and visiting residents reported interest in future rural practice, and 70% of home residents who completed the clinical and nonclinical rural curriculum signed a contract with a rural CAH or sole community hospital[16] for a portion of their practice on graduation (Table). Additionally, 75% of home residents who completed the nonclinical curriculum only also chose a rural practice.

As of 2024, this curriculum continues to evolve based on resident and faculty feedback. Data collection on the impact of rural EM education in our program is ongoing.

LIMTATIONS

This single-center pilot study of a new curriculum within a rural health network comes with inherent limitations. For measuring impact, no comparison group was available. As a new residency program, there are no prior classes of residents to compare outcomes pre- and post- rural curriculum. All home residents completed the rural nonclinical curriculum and received mentorship from rural faculty. Additionally, five of the eight residents who did not choose the pre-designed rural EM rotations created their own rural/austere rotation. Thus, our study does not isolate clinical or nonclinical components to determine which might be more strongly associated with our residents' high rate of rural practice following graduation.

For generalizability, many programs may lack easy access to rural clinical sites, mentorship from rural faculty, or rural lecture/simulation resources. With innovation and collaboration, however, rural clinical and nonclinical education should be feasible for any program. All programs have didactic time, access to simulation training, and patients received in transfer from rural sites in their region. Clinical experiences could be created through partnerships with other programs if not available locally. To support other programs' rural-focused education, we are developing a free, open-access "Rural EM Resource" website (ruralemresource.us) to share our lectures, simulation cases, and template for building rural clinical rotations.

CONCLUSION

A multimodal, rural curriculum represents a feasible approach to preparing residents for independent practice in rural settings. Innovative rural curricula should be shared broadly, and urban residency programs should partner with rural clinical sites to provide expanded training opportunities. This type of focused rural clinical and nonclinical curriculum development represents a promising approach to bridging the gap between urban, tertiary-care training programs and rural emergency care needs.

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Emergency Medicine Clerkship Grading Scheme, Grade, and Rank-List Distribution as Reported on Standardized Letters of Evaluation

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Background: The Standardized Letter of Evaluation (SLOE) is a crucial component of the emergency medicine (EM) application process. Given the critical role of the SLOE, we attempted to better understand the grading scales used, as well as the distribution of grades and rank-list positions.

Objectives: Our primary objective in this study was to determine the distribution of grading formats, grades given, and rank-list positions across EM clerkships using the SLOE.

Methods: We performed a cross-sectional study of the grading formats, grades given, and ranking distributions as reported on the SLOE during the 2022–23 application cycle. We obtained data on SLOEs from EM residency programs accredited by the Accreditation Council for Graduate Medical Education by reviewing all applicants who applied to either of two EM residency programs in geographically different regions. Trained abstractors recorded the following data: number of students rotating in the prior year; grading format used; and grade and rank distribution among students.

Results: We included 264 programs in our final analysis, after 13 programs met exclusion criteria. The majority of programs (72.2%) use an Honors/High Pass/Pass/Fail grading scheme. We determined the mean percent of each grade: Honors/A 27.6%; High Pass/B 31.1%; Pass/C 40.8%; Low Pass/D 0.2%; and Fail/F 0.3%. Finally, we determined the mean percent for each rank-list position: top 10% was 17.6%; top third 36.5%; mid third 34.1%; and low third 11.8%.

Conclusion: We determined the grading schemes and grade and rank-list distributions for EM programs during the 2022–2023 academic year. Most programs used a Honors/High Pass/Pass/Fail grading scheme, with the majority of students receiving Honors or High Pass, while 0.3% failed their rotation. Both grades and rank list demonstrated evidence of a skewed distribution toward higher grades and rank-list position. [West J Emerg Med. 2025;26(1)66–69.]

INTRODUCTION

The Standardized Letter of Evaluation (SLOE) is a crucial part of the National Resident Matching Program (Match) process into emergency medicine (EM) residencies in the United States since it replaced the narrative letter of recommendation in the 1990s.[1] The SLOE uses evaluations from EM rotations to compare medical students in a standardized, objective manner for the Match. The SLOEs have become universally adopted after being deemed a reliable tool in stratifying EM residency candidates, making it a key

portion of the application process, especially considering recent changes to qualifying board exams moving to pass/fail.[2]

The top three facets of the application used by program directors overall are core clerkship grades, EM clerkship grades, and letters of recommendation.[2] The EM clerkship grading is irregular, with no standardization between programs regarding the assignment of grades.[3] Schools have a number of different grading systems as well as requirements to meet each grade level, making it more difficult to compare students from different medical schools. The clerkship grading is considered to be not as fruitful about the applicant's overall performance as the global assessment section of the SLOE.[4] In fact, the initial creation of the SLOE was spurred partially to combat speculated grade inflation among programs. Even so, the Council of Residency Directors in Emergency Medicine (CORD) Task Force found that grade inflation was still a limiting factor of the SLOE, with some improvement in rank-list inflation noted between 2012 and 2017.[2,4]

Many SLOE writers have indicated that they did not receive formal training in how to properly fill out the SLOE and often do not access the CORD guidelines for doing so.[5] The creation of the eSLOE in 2016 contributed to an overall improvement in the ranking distribution of students; however, the system is still inconsistent.[4] There is also variability in the interpretation of the SLOE, with a significant number of program directors agreeing that their interpretation of the data is impacted by who the letter writer is.[6] Speculation exists regarding the validity of these evaluation letters because of this inconsistency, even extending to other specialties.[7]

Considering the critical role of the SLOE as a tool for rank-list determination, there is a need to better understand distribution of grades and rank-list positions. Our primary objective in this study was to determine the distribution of grade scheme, grade, and rank-list positions across EM programs using the SLOE.

METHODS

Study Design

We performed a cross-sectional study of the grading and ranking distributions of EM medical student clerkships as reported on the SLOE during the 2022–23 application cycle. The SLOEs were evaluated for the reported clerkship grading and rank-list positions from the previous year, a required component of the SLOE. We did not review the grades and rank-list positions that were given to current applicants who applied to our programs. This study was deemed exempt by the institutional review boards at the University of Florida – Jacksonville, and Rush University Medical Center.

Study Protocol

We included all EM residency programs across the United States that were accredited by the Accreditation Council for Graduate Medical Education. To obtain SLOEs from each EM US residency-based clerkship, we reviewed SLOEs from all applicants during the 2022–23 cycle who applied to either of two EM residency programs that are located in different geographic regions. The University of Florida – Jacksonville is a three-year, county EM program located in Jacksonville, FL. Rush University Medical Center is a three-year, academic EM program in Chicago, IL. We included all clerkship SLOEs from programs that had an affiliated EM residency program and had reported either grade distribution or rank distribution from the prior year. We excluded programs without a rotation the preceding year, programs without reported data for the preceding year, or programs for which we did not have access to a SLOE.

Measures

Trained abstractors from each institution collected data using a pre-piloted standardized data-abstraction tool. The abstractors recorded the following data: number of students rotating in the prior year; grading format used (eg, Honors/High Pass/Pass/Fail [H/HP/P/F]; A/B/C/D/F; P/F; other); prior year grade distribution; and prior year rank distribution (top 10%/top third/middle third/bottom third). We performed dual extraction for all programs with at least two SLOEs available.

Data Analysis

Descriptive statistics are reported for the type of grading format and distribution. We report the mean with standard deviation and median with interquartile range (IQR) for each grade and rank distribution at the rotation level. We also report the overall reported number and reported percentage of total applicants receiving each category across all combined data. Reported number was defined as the total number of students receiving a specific grade or rank by a given program. We defined reported percentage as the percentage of the total students in a given program receiving a specific grade or rank. All analyses were performed using Microsoft Excel 2018 (Microsoft Corporation, Redmond, WA).

RESULTS

Of 277 programs identified, we included 264 (95.3%) EM residency-based clerkships in our analysis. Thirteen clerkships met exclusion criteria (two that had no rotation the prior year, one that did not report data due to new SLOE format, and 10 with no SLOE available in our set). We identified a median of 21 (IQR 15–30) SLOEs written per program.

The majority of programs, 72.2% (190/263), used an H/HP/P/F grading scheme, followed by P/F 17.5% (46/263), A/B/C/D/F 2.7% (7/263), and other 7.6% (20/263). The other grading schemes are included in Appendix 1. One program did not provide a grading scheme. When evaluating grade

Table 1. Number and percentage distribution of students for each grade for various grading formats at non-pass/fail and pass/fail programs.

	Non-pass/fail programs (N = 13,599) n (%)	Pass/fail programs (N = 1,964) n (%)	All programs (N = 15,563) n (%)
Honors/A	4,296 (31.6%)		4,296 (27.6%)
High pass/B	4,837 (35.6%)		4,837 (31.1%)
Pass/C	4,380 (32.2%)	1,963 (99.9%)	6,343 (40.8%)
Low pass/D	37 (0.3%)		37 (0.2%)
Fail/F	48 (0.4%)	1 (<0.1%)	48 (0.3%)

Table 2. The mean and median number of students and mean and median percentage of students' grades on Standardized Letters of Evaluation (SLOE) for each program. (Median of 21 [interquartile range 15–30] SLOEs per program.)

	Mean number* (SD)	Median number* (IQR)	Mean percentage** (SD)	Median percentage** (IQR)
Honors/A	16.4 (22.7)	9.0 (2.0–20.9)	26.9% (0.2%)	23.0% (8%–40%)
High pass/B	18.5 (23.0)	12.1 (1.9–24.8)	30.7% (0.2%)	33.0% (8%–40%)
Pass/C	24.2 (32.8)	12.0 (3.3–33.3)	41.7% (0.4%)	35.0% (10%–70%)
Low pass/D	0.1 (1.4)	0.0 (0–0)	0.2% (0.0%)	0% (0%–0%)
Fail/F	0.2 (0.7)	0.0 (0–0)	0.3% (0.0%)	0% (0%–0%)

*The total number of students receiving a given grade by each program.
**The percentage of students receiving a given grade by each program.
IQR, interquartile range.

Table 3. The mean and median number of students and mean and median percentage of students' rank-list positions on Standardized Letters of Evaluation (SLOE) for each program. (Median of 21 [IQR 15–30] SLOEs per program.)

	Mean number* (SD)	Median number* (IQR)	Mean percentage** (SD)	Median percentage** (IQR)
Top 10%	4.1 (2.9)	3.0 (2–5)	19.8% (0.1%)	16.4% (10.7%–25.2%)
Top third	8.6 (5.6)	7.0 (5–12)	37.1% (0.1%)	36.1% (27.8%–45.1%)
Mid third	8.0 (6.7)	7.0 (4–11)	32.3% (0.2%)	32.1% (25%–41.2%)
Low third	2.8 (3.3)	2.0 (0–4)	10.8% (0.1%)	8.8% (0%–17.3%)

*The total number of students receiving a given grade by each program.
**The percentage of students receiving a given grade by each program.
IQR, interquartile range.

distribution, we determined the mean percentage of each grade for all 14,562 students: Honors/A 27.6% (4,296); High Pass/B 31.1% (4,837); Pass/C 40.8% (5,343); Low Pass/D 0.2% (37); and Fail/F 0.3% (49). Grade distributions were then divided into non-P/F programs, and P/F programs, and presented in Table 1.

When evaluating rank-list distribution, we determined the mean percentage for each rank-list position for all students across all programs. The mean percentages of students (6,221) for each rank-list position were as follows: in the top 10% there were 1,094 students (17.6%); in the top third there were 2,271 students (36.5%); in the mid third 2,123 students (34.1%); and in the low third 733 students (11.8%).

Finally, to assess program-level differences, we determined the number and percentage of students receiving a given grade and rank by each program. We then calculated the mean and median number and mean and median percentage across programs. The mean percentage of students given Honors across programs was 26.9%, followed by 30.7% who were given High Pass, and 41.7% Pass (Table 2). The mean percentage of students ranked in the top 10% by programs was 19.8%, followed by 37.1% in the top third, 32.3% in the mid third, and 10.8% in the low third (Table 3).

DISCUSSION

This study provides an updated representation of national trends in EM SLOE grade and rank distribution. Historically, significant emphasis has been placed on the SLOE grade and rank list. Current issues with the SLOE

writing system include concerns ranging from inexperienced authors and non-standardized grading schemes to systematic grade inflation.

With the continued use of non-standardized grading schemes, it may appear this element of the SLOE provides little value. Our results show that while a majority of programs used the H/HP/P/F scheme, nearly 30% of programs favored other formats. Of those SLOEs using the P/F system, of which there were nearly 2,000 graded students, only one recorded a failing grade. With such an overwhelming predominance of passing grades, there may be more significance for a failing grade than a passing grade. Results from non-P/F programs show a nearly equal distribution of grades between Honors/A, High Pass/B, and Pass/C (31.6%, 35.6%, and 32.3%, respectively) with less than 1% receiving a grade of low pass or fail.

While SLOE 2.0 no longer contains a global assessment, the rank list remains a valued tool for differentiating applicants. Previous studies have demonstrated an improved spread of distribution over the past decade[2,4]; however, that trend may have become stagnant. Our data shows a nearly identical rank-list distribution to that of the 2016–2017 SLOE dataset, in which the top 10% contained 18%, the top third contained 37%, the mid third contained 35%, and the low third contained 10%, respectively (with our results showing 17.6%, 36.5%, 54.1%, and 11.8%, respectively).[4] Whether this is a coincidence or evidence that the distribution of the rank list has truly stagnated remains unclear. Evaluators continue to rank very few applicants in the low third, representing an overly favorable evaluation of their rotating students.

LIMITATIONS

There are several limitations that warrant consideration. First, this study was limited to a single year; future work should evaluate differences in grading trends over time. Additionally, the data was limited to self-report, and it is possible that some programs may not have accurately reported their grade and rank distribution for the prior year. While the majority of programs used the H/HP/P/F scale, some programs used alternate scales, which may not fully map to the more common H/HP/P/F scale. Moreover, we were limited to applicants who applied only to our two programs. Despite this limitation, we had a very high response rate and only missed 10 programs nationally. Finally, the rank-list reports perceived rank-list position but may not have reflected students' actual position on the rank list.

CONCLUSION

We determined the grading formats and grade, and rank-list distributions for EM programs during the 2022–2023 academic year. Most programs used the Honors/High Pass/Pass/Fail grading scheme, with the majority of students receiving Honors and High Pass, while 0.3% failed their rotation. Both grades and rank list demonstrated evidence of skewed distribution toward higher grades and rank-list position.

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Leadership Perceptions, Educational Struggles and Barriers, and Effective Modalities for Teaching Vertigo and the HINTS Exam: A National Survey of Emergency Medicine Residency Program Directors

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Introduction: The utility of the three-part bedside oculomotor exam HINTS (head impulse test, nystagmus, test of skew) in the hands of emergency physicians remains under debate despite being supported by the most recent literature. Educators historically lack consensus on how specifically to teach this skill to emergency medicine (EM) residents, and it is unknown whether and how EM residency programs have begun to implement HINTS training into their curricula. We aimed to characterize the state of HINTS education in EM residency and develop a needs assessment.

Methods: In this cross-sectional study, we administered a survey to EM residency directors, the themes of which centered around HINTS education perceptions, practices, resources, and needs. We analyzed Likert scales with means and 95% confidence intervals for normally distributed data, and with medians and interquartile ranges for non-normally distributed data. Frequency distributions, means, and standard deviations were used in all other analyses.

Results: Of 250 eligible participants, 201 (80.4%) responded and consented. Of the 192 respondents providing usable data, 149/191 (78.0%) believed the HINTS exam is valuable to teach; 124/192 (64.6%) reported HINTS educational offerings in conference; and 148/192 (77.1%) reported clinical bedside teaching by faculty. The most-effective educational modalities were clinical bedside teaching, online videos, and simulation. Subtopic teaching struggles with regard to HINTS were head impulse test and test-of-skew conduction and interpretation, selection of the correct patients, and overall HINTS interpretation. Teaching barriers centered around lack of faculty expertise, concern for poor HINTS reproducibility, and lack of resources. Leadership would dedicate a mean of 2.0 hours/year (SD 1.3 hours/year) to implementing a formal, standardized HINTS curriculum.

Conclusion: Despite controversy surrounding the utility of the HINTS exam in EM, most residency directors believe it is important to teach. This needs assessment can guide development of formal educational and simulation curricula focusing on residency directors' cited HINTS exam educational struggles, barriers, and reported most-effective teaching modalities. [West J Emerg Med. 2025;26(1)70–77.]

INTRODUCTION

Background

Posterior stroke presenting with dizziness is misdiagnosed by emergency physicians (EP) in 35% of cases,[1] which can lead to severe debilitation and sometimes death.[2] Paradoxically, of patients discharged from the emergency department (ED) with a diagnosis of dizziness or vertigo, only 1 in 500 is diagnosed with a stroke within the first month.[3] With advances in stroke treatment modalities, it makes sense that there is heightened emphasis on detection. In 2013, the annual cost of imaging for acute dizziness in United States EDs was nearly $4 billion.[4] Much of this cost is due to utilization of non-contrast computed tomography (CT) of the head[5] despite its low sensitivity for detecting posterior fossa stroke (mean 41.8%, 95% confidence interval 30.1–54.4%)[6] and the low lifetime cost-effectiveness compared to magnetic resonance imaging (MRI).[7] Specifically, it is estimated that over $1 billion per year is wasted on inappropriate CT imaging for patients with dizziness/vertigo.[8]

A worldwide survey of EPs published in 2008 found that the development of a better clinical decision rule for identification of central vertigo was the second highest clinical priority for participants.[9] Management of dizziness and vertigo is included in the Joint Task Force Emergency Medicine Model of Clinical Practice,[10] and EPs are expected to diagnose and manage patients with these chief complaints. It is, therefore, incumbent upon EM residency programs to provide adequate education and training on dizziness and vertigo. However, a 2005 study found that only 35% of EM residency programs required a clinical neurology or neurosurgery rotation, and an annual mean of 12 hours (of 280 total didactic education hours) was dedicated to neurologic emergencies.[11] It is unknown how much of this time is devoted specifically to dizziness and vertigo, or exactly what is being taught regarding appropriate history, physical, and diagnostic workup recommendations.

The clinical HINTS exam (head impulse test, nystagmus, test of skew)[12] is a three-part bedside oculomotor exam with diagnostic accuracy for central vertigo similar to that of MRI. A 2023 Cochrane Review of 12 studies and 1,890 participants found the clinical HINTS exam to be 94% sensitive and 87% specific.[13] This exam may be appealing to the EP because it is purported to be a rapid and low-cost bedside evaluation. However, literature suggests that its diagnostic accuracy has fallen short for EPs using the HINTS exam in clinical practice, with findings suggesting that the reasons are application to inappropriate patients (eg, those without acute vestibular syndrome and nystagmus) and difficulty in interpreting head impulse test (HIT) results.[14,15] In addition, the literature has shown poor inter-rater reliability among EPs using the HINTS exam.[16] With these concerns in mind, two other clinical decision tools have since built on HINTS principles. The first is the HINTS "plus" tool, which adds a hearing test (95.3% sensitive and 72.9% specific).[13] The second is the STANDING (spontaneous nystagmus, direction, head impulse test) algorithm, which uses two parts of the HINTS exam and additional physical exam maneuvers (93–100% sensitive and 72–94% specific).[17–19]

Population Health Research Capsule

What do we already know about this issue?
When properly used, the HINTS exam has high diagnostic accuracy for central causes in dizzy patients, but the state of HINTS education in (EM) is inadequately characterized.

What was the research question?
What are program leadership perceptions, educational practices, and barriers to teaching HINTS in EM residencies?

What was the major finding of the study?
78.0% of program leaders believe the 3-part oculomotor exam is valuable to teach, and 64.6% offer formal HINTS education sessions.

How does this improve population health?
Teaching HINTS to EM residents requires improved curricula, resources, and faculty expertise. Better education may help translate promising HINTS literature into clinical practice.

The 2023 American College of Emergency Physicians (ACEP) Clinical Practice Guideline offers specific HINTS exam recommendations and cautions: "Before employing a maneuver such as HINTS, physicians should have sufficient education to perform the technique; not using tools such as HINTS may lead to excessive testing and admission; and incorrect implementation may lead to an increased risk of misdiagnosis."[20] In addition to ACEP's recommendations, in 2023,the Society for Academic Emergency Medicine released Guidelines for Reasonable and Appropriate Care in the Emergency Department (GRACE-3): Acute Dizziness and Vertigo in the Emergency Department. They had similar recommendations that EP education should involve the following : "receive training in the HINTS exam; use the HINTS exam (once properly trained) in patients with nystagmus; and consider the HINTS exam as the first-line test over MRI (if a HINTS-trained clinician is available)."[21,22] The authors of GRACE-3 also acknowledged a discordance in that most EPs have not received special training in the use of the HINTS exam. This

lack of special training may have led to the HINTS testing inaccuracies reported in the recent literature.[14,15] This begs the question of which, if any, educational tactics have been effective.

From the recent GRACE-3 guidelines[21] and releases by EM societies,[10,20] there is a clear call for EM HINTS education and HINTS exam integration into the EM clinical arena. However, the current state of HINTS exam acceptance, education, and training is unclear. If HINTS curricular implementation has occurred, information about the needs, barriers, teaching struggles, and educator perspectives may add further weight to the argument for our specialty's overall acceptance of the HINTS exam.

Importance

The standard of care for the ED evaluation of dizzy patients may be evolving to embrace the HINTS exam, but translation of the literature to clinical practice remains unclear. It is also unclear what proportion of EPs have been adequately trained in the use of the HINTS exam. Furthermore, residency programs may lack the faculty expertise, time and funding to add new items such as HINTS education to their curricula. Programs that have adopted the societal guidelines addressing the HINTS exam may have already adjusted their didactic and simulation content. Supporters of the HINTS exam will recognize the importance of a needs assessment with regard to residency efforts and perceived challenges and barriers to dizziness evaluation and HINTS education. Skeptics will find the knowledge of current HINTS teaching paradigms useful to determine their own practice and the potentially evolving standard of care.

Goals of This Investigation

While recent research supports a need for change in our ED clinical practice, it has yet to be assessed whether these ideas are currently being taught within EM residency programs, and if so, how they are being taught. Our goal in this investigation was to assess the current United States EM residency program leadership perspectives, teaching paradigms, teaching barriers, and future needs for implementing educational curricula on assessment of the dizzy patient, with a particular focus on the HINTS exam. The results of this educational needs assessment can serve to guide and refine the construction of educational resources including didactic and simulation modalities.

METHODS

Study Design and Setting

This was a cross-sectional observational study in a virtual setting. Participants were offered no incentives, there was no funding, and the study was institutional review board-approved as exempt. An electronic survey was administered to EM residency directors between April 6–July 13, 2023. The study was conducted in compliance with STROBE (Strengthening the Reporting of Observational studies in Epidemiology) cross-sectional reporting guidelines.[23]

Selection of Participants

Included were current program directors for categorical EM residency programs in the US. Excluded were program directors from residency programs that received initial accreditation from the Accreditation Council for Graduate Medical Education on or after January 1, 2020. The rationale for this exclusion was that new programs were less likely to have administered an entire educational curriculum cycle. The target population included 250 program leaders (one from each eligible program). Program director contact information was obtained from medical society databases and residency program websites. While both work and personal emails were often publicly available, we prioritized making contact via work emails. See Appendix A for the participant recruitment message.

Survey Development

The survey instrument was developed, tested, and validated using a rigorous process with close guidance and leadership from seasoned national medical education experts via a formal Medical Education Research Certification program through the Council of Residency Directors in Emergency Medicine. We followed the systematic, seven-step protocol for developing medical education research questionnaires described by Artino et al.[24] Formal focus groups were used to propose, discuss, and rework survey items using an iterative process until consensus was reached regarding face validity and internal consistency. The survey was piloted by a group of 20 members of the nonprofit medical education alliance ALL NYC EM (consisting of EP medical educators, residency leadership members, and resident education fellows) for feedback on clarity and usability. The sole consensus recommendation was to shorten the survey, which was done prior to national distribution. Final survey items included program/institution demographics and questions about perceptions and practices regarding dizziness, vertigo, and HINTS exam education within each residency program. See Appendix B for a copy of the complete survey tool.

Study Protocol

We used the electronic platform SurveyMonkey (SurveyMonkey Enterprise, San Mateo, CA) to distribute the survey and collect data. The 250 program directors were initially contacted individually via email with the recruitment message and their personalized survey link. Subsequent contact attempts (required for 235 program directors) were made for non-responses or incomplete surveys. At the end of the data collection period, all complete and partial surveys were included in analysis if the participant provided data

beyond the informed consent question. Except for the informed consent question, no survey question was required. This allowed participants to opt out of answering specific questions if they wished while still enabling them to participate. Missing data from participants who opted out of a question was not included in the calculations for subsequent statistical analysis for that item.

Outcomes

Intended outcomes centered around residency directors' HINTS exam perceptions as well as current HINTS educational practices within residency programs, resources available, and curricular needs. The purpose of gathering information on these outcomes was to generate a needs assessment for dizziness and HINTS exam curricula in EM residencies.

Analysis

We analyzed data using R version 4.3.2 for MacOS (R Foundation for Statistical Computing, Vienna, Austria). Likert-scale data was analyzed using medians and interquartile ranges for non-normal data distributions or using means and 95% confidence intervals (CI) for normal data distributions. We tested normality of data distributions by examining estimates of skewness and kurtosis for each scale, as well as by plotting histograms and comparing distributions to the normal curve. Normality was concluded only if all estimates of skewness and kurtosis fell below the thresholds of 2 and 7, respectively, and all histograms aligned closely with the normal curve.[25] We used the Wilson score statistic for calculation of 95% CIs for binomial proportion items (yes/no items with an answer of "yes" defined as a positive result).[26,27] Frequency distributions were used to analyze questions about struggles and barriers to teaching the HINTS exam. We used descriptive statistics (means and standard deviations for all other quantitative data. As participants were permitted to skip any question, missing data was omitted from item-level analyses. See Appendix C for details on missing data and item-level response rates.

RESULTS

Characteristics of Study Subjects

Of 250 eligible programs, leadership from 204 opened the survey and 201 provided informed consent for an overall survey response rate of 80.4%. Among consenting respondents, 192 programs provided useful data beyond the initial informed consent question. See Appendix D for the enrollment flowsheet. Participating program demographic characteristics were well representative of the population of all eligible programs (see Appendix E).

Main Results

Overall, 149/191 (78.0%) believed the HINTS exam is valuable to teach, 16/191 (8.4%) believed it is not, and 25/191 (13.1%) were unsure. On subgroup analyses of these and other key survey items, program demographic factors (program length, setting, type, and region) were of no statistical significance after controlling for multiple comparisons. The most effective educational modalities for teaching the HINTS exam were reported to be clinical bedside teaching, videocasts/online videos, and simulation. Perceptions of modality effectiveness varied widely. See Figure 1.

Program leadership reported perceptions that their residency graduates were, on average, more confident and competent than their faculty members at performance and interpretation of the HINTS exam. They also reported perceptions that, for both residency graduates and faculty members, confidence was higher than competence. However, none of these patterns reached statistical significance. See Appendix F.

The most frequently cited HINTS subtopic teaching struggles centered around the HIT, test of skew, HINTS application to correct patients, and overall HINTS interpretation. See Figure 2. The most frequently cited HINTS teaching barriers centered around lack of faculty expertise, concern for poor HINTS exam reproducibility, and lack of resources. See Figure 3. Lastly, program leadership indicated that they would dedicate a mean of 2.0 hours/year (SD 1.3 hours/year) to implementing a formal, standardized HINTS exam curriculum if such a curriculum were widely available.

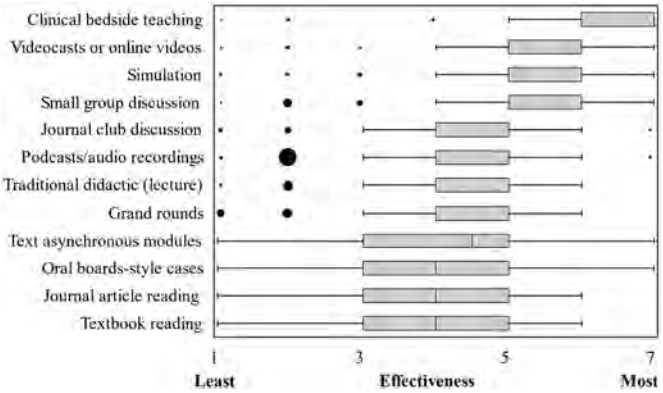

Figure 1. Box-and-whisker plot of leadership-perceived educational modality effectiveness for teaching the HINTS* examination: 188 participants provided usable data on this item (item-level response rate 75.2%). Likert-scale ratings from least (1) to most (7) effective were used. Data for one of the 12 modalities (clinical bedside teaching) was not normally distributed and thus medians and interquartile ranges (IQR) were used for all analyses. Medians are represented by thick vertical lines, IQRs are represented by gray boxes, whiskers represent 1.5* IQR, and outlier data is represented by black dots, with the area of each dot proportional to the answer frequency.
*HINTS**, head impulse test, nystagmus, test of skew.

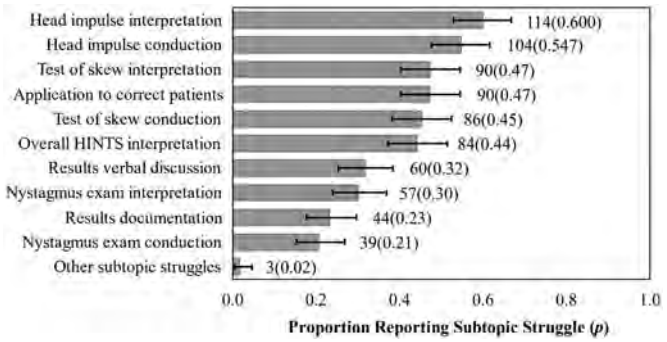

Figure 2. Frequency of residency program director-reported HINTS exam subtopic teaching struggles: 190 participants provided useable data on this item (item-level response rate 76.0%). Error bars represent the 95% confidence interval for these binomial proportion items using the Wilson statistic.

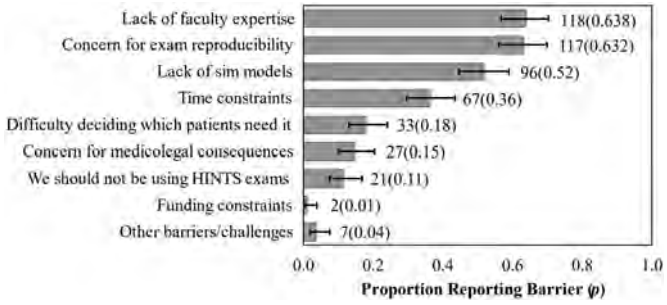

Figure 3. Frequency of residency program director-reported barriers to teaching the HINTS* examination. 185 participants provided useable data on this item (item-level response rate 74.0%). Error bars represent the 95% confidence interval for these binomial proportion items using the Wilson statistic.
**HINTS*, head impulse test, nystagmus, test of skew.

DISCUSSION

Our findings may reflect underlying causes for the difficulties EPs have teaching and using the HINTS exam. Faculty members may hesitate to teach it if they exhibit discomfort with their own HINTS exam skills. In our findings, program leadership expressed lack of faculty expertise as an educational barrier, and they also perceived their residency graduates to be more competent with this skill than their faculty members (although this finding did not reach statistical significance). Additionally, program directors' cited barrier of concern for poor HINTS exam reproducibility may point toward physicians' innate desire for diagnostic certainty and the perception that the HINTS exam is fallible. Our respondents reported that HINTS is valuable to teach, but they less often reported HINTS offerings in conferences. The cited reasons for this discordance centered around lack of time, resources, and faculty expertise.

It has been shown in the original HINTS literature and subsequent research released from neurology and EM collaboration efforts that it is possible to effectively learn this skill,[13,21] yet our results do not describe widespread skill acquisition among EPs. It is possible that educational collaboration between the specialties could positively impact EPs' proficiency in the exam itself and in optimal educational methods. Regardless, our survey results support a desire to address the lack of faculty expertise. Much collaboration is already occurring, as evidenced by recent dizziness and vertigo literature authored by teams including members of both specialties,[21,28–30] as well as research with mixed cohorts from both specialties.[1]

Our results show that simulation was perceived as one of the most effective modalities for HINTS education, but lack of simulation models was also cited as a top educational barrier. The HINTS education literature from neurology and neuro-subspecialties has proposed some innovative simulation adjuncts. For example, one study found that neurology trainees' utilization of video-oculography (VOG) technology in simulation correlated with significant improvements in HIT performance.[31] Two studies used virtual reality-enhanced manikin task trainers for HINTS simulation, demonstrating exam sensitivity and specificity improvements, including among EP cohorts.[32,33] While such "partial task trainers" may have utility, our survey suggests they are not widely used or commercially available. The VOG devices are commercially available and have quality assurance (QA) features to assist examiners' HIT performance via feedback on maneuver angles and velocities. A recent study used these QA features in EM resident HIT simulation and reported significant improvement in HIT maneuver performance.[34]

There are no published parameters from the neurology or subspecialty literature regarding the optimal HINTS curriculum training durations. However, a 2022 systematic review of HINTS and STANDING education reported on five institutions' EM educational practices. They found wide curricular variability in didactic time (1–5 hours), workshop time (1–8 hours), neurology exposure (clinical rotations), and proctored exams (up to 15) over each resident's duration in the program.[35] Our participants indicated they would dedicate a mean of 2.0 hours/year to HINTS education, and over the course of a three- or four-year residency, this would be adequate time for the parameters described.[35] Despite willingness to commit this time, other literature suggests that the exam application and maneuvers may be more complex than our specialty recognizes.[14] As reflected in our results, program leadership perceived higher confidence than competence among graduates and faculty alike (although this did not reach statistical significance). This phenomenon—the Dunning-Kruger effect—is present in medicine, and existing literature suggests that assessments by examiners from multiple disciplines are required to ensure proficiency in such high-level skills.[36,37] This would potentially add more time to a HINTS curriculum.

Our results contribute to a growing description of the HINTS educational modalities in use, but each modality has

pros and cons beyond the training hours required. Clinical bedside teaching (the highest-rated modality in our survey) provides the highest-fidelity and real-life experience but is dependent on case convenience (dizzy/vertiginous patients presenting) and educator availability on shift. The opportunity cost of bedside training must be considered as well. The survey does not explore the hypothetical on-shift faculty time spent and associated opportunity cost, which would be a useful topic for future research.

Simulation tied for second place as the highest-rated HINTS educational modality. It mitigates the case convenience issue by providing on-demand patient cases in a controlled setting, but it also presents a faculty opportunity/cost issue by increasing training time in the simulation center. Hands-on skill simulation requires small-group or individual instruction, which uses more faculty time and the use of simulation models, and possibly other simulation adjuncts. Our survey did not ask about specific HINTS simulation equipment or techniques being used at EM residency programs in the US, but even if aggressive cost-of-implementation estimates are made, the return on investment would make HINTS educational initiatives financially worthwhile. The nationwide capital expenditures (specifically, VOG devices for simulation) cost about $9.76 million, which amounts to 1% of the estimated $1 billion/year spent on inappropriate CT imaging for patients with dizziness/vertigo in the US.[8] The estimated national yearly cost after capital investment (specifically, the cost of faculty time) is about $331,883 in addition to costs for any equipment repair or new devices/adjuncts. See Appendix G for the cost-of-implementation analysis.[34,38–41]

Notably, HINTS manikin "partial task trainers" have been developed and tested, but none are widely available.[32,33] The 2023 ACEP Clinical Policy recommended incorporation of technology such as Frenzel goggles and ocular tracking software in training.[20] The VOG devices are commercially available for $12,000–40,000 per device and have shown promise in the simulation environment.[31,34,38,42]

To describe the effectiveness of many educational options (including those amenable to asynchronous and large-group sessions), we asked about several other modalities in addition to clinical bedside teaching and HINTS simulation. Online videos and videocasts were tied with simulation for the second highest-rated teaching modality among participants. Contrary to bedside and simulation teaching, this modality requires no faculty time or supervision and is free. Online HINTS educational videos can be used as an asynchronous supplement to clinical bedside teaching and simulation, but watching videos is a passive learning technique with no hands-on practice or opportunity for acquisition of muscle memory. However, recent studies suggest that achieving HINTS exam skills (particularly HIT skills) does require a hands-on component for motor skills acquisition.[34]

Overall, more time, effort, funding, and educational research could be targeted toward creating HINTS curricula and simulation modalities, and on making these resources widely available to improve EM residency HINTS educational options. The variability in our survey results shows that multiple education modalities are likely being employed across the residency training programs in the US but with some consensus about the most useful modalities. In such a situation where multiple modalities are being employed to the same end, further research toward development of a standardized training plan is needed.

LIMITATIONS

To achieve adequate response rates from our survey, the length of the survey was limited at the recommendations of the expert pilot test group. Additionally, variability of the question design was employed to hold participants' interest and increase response rates. As a result, some questions were asked in a binary "yes/no" format instead of Likert scales or rankings, potentially sacrificing some depth of response interpretation. Another concern with our survey design was response bias. While allowing questions on the survey to be left unanswered supports overall increased response rates, bias may have been introduced via respondent-allocated missing data. It is possible that program leaders who answered fewer questions had more passive opinions about the HINTS exam, exhibiting neutral response bias wherein, for example, they selected "neutral" or "no opinion" on classic Likert-scale questions. The opposite is also possible wherein the survey results are biased toward those in strongly in favor of or strongly against the HINTS exam (extreme response bias). Fortunately, our overall high response rates and wide variability of responses suggests these limitations are minimal.

Surveys were initially sent to EM residency program directors who had the option of either completing it themselves or assigning the responsibility to an associate program director, or to the faculty leader of the residency's curricular content. There is, thus, a possibility that answers varied depending on the role of the survey-taker for each program, which was not recorded.

CONCLUSION

Emergency medicine residency programs and medical educators should focus their HINTS educational priorities on development of a formalized curriculum with adequate resources. Programs will also need to address the barrier of lack of faculty expertise.

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Characteristics and Outcomes of Implementing Emergency Department-based Intensive Care Units: A Scoping Review

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Introduction: The prolonged stay of critically ill patients in the emergency department (ED) may lead to worse clinical outcomes. An emergency department (ED)-based intensive care unit (ICU) is one of the proposed solutions to deliver critical care in the ED. We thus aimed to characterize existent ED-ICU models and their reported association with clinical outcomes in critically ill adult patients.

Methods: We searched the Ovid MEDLINE database from inception to October 2, 2023. We included studies that report an ED-ICU structure, defined as a space capable of providing ICU-level care within or adjacent to the ED, and its characteristics. We excluded personnel-focused intervention (without the presence of a separated space) or a space without ICU-level care capability. We collected information on process measures, patient-related outcomes, and cost-related outcomes.

Results: We screened 2,824 studies, of which 125 full-text articles were assessed for eligibility and 31 studies were included in this scoping review. Studies reported on 14 ED-ICUs across seven countries, with capacities ranging from 3–17 beds. All ED-ICUs served early and ongoing critical care needs in the ED, including three distinct themes: short-stay; palliative care; and disaster-response ICUs. Implementing the ED-ICU was associated with decreased time to ICU-level care and reduced number of inpatient ICU admissions, but it was not consistently associated with improved survival.

Conclusion: Several ED-ICUs have been established around the world with different characteristics depending on local needs. Implementation of the ED-ICU may be associated with improved clinical outcomes and patient flow. [West J Emerg Med. 2025;26(1)78–85.]

INTRODUCTION

Emergency department (ED) crowding is a recognized global health problem.[1] Crowding can manifest as prolonged boarding of critically ill patients in the ED.[2] In turn, delayed admission to the intensive care unit (ICU) may lead to clinically worse outcomes, including increased hospital stay and all-cause mortality.[3,4] One strategy to mitigate this problem is to provide critical care in the ED. Several studies have identified different models of providing critical care in the ED, including geography-based and personnel-focused models.[5] The personnel-focused model highlights the need to have early critical care consultation, while the geography-based model involves the expansion of ICU beds, either in the existing inpatient ICU or in the ED (the latter is generally called the ED-based ICU or the ED-ICU model).[5] Theoretically, the ED-ICU model could provide timely critical care to patients in need; establishing it, therefore, represents a promising strategy to deal with ED crowding.[6–8] Despite its promising nature, the specific characteristics of different ED-ICUs across the world have not been described. It is also uncertain whether the application of this ED-ICU model to an existing, operating ED affects its processes and clinical outcomes, in addition to costs.

In this scoping review we aimed to explore the characteristics (eg, capacity, staffing, and utilization) of implemented ED-ICU models. We further sought to explore how ED-ICUs affect process measures, in addition to clinically relevant outcomes and healthcare-associated costs.

METHODS

Data Sources

We searched the Ovid MEDLINE database from inception until October 2, 2023 using a search strategy developed with an experienced medical librarian (see Supplementary Table S1). We specifically chose to limit the Ovid MEDLINE search since we expected that this database would result in the highest yield of articles for the topic of interest. Keywords for the search strategy included emergency department, intensive care unit, and ED ICU. There were no language or study design restrictions. We screened the references of the included studies and manually searched them to identify additional eligible papers.

Study Selection

We included all studies that reported an ED-ICU model structure, defined as a dedicated physical space with intensive care capacity within or adjacent to the ED, and its characteristics or outcomes. We captured information on reported characteristics such as number of ICU beds, staffing, reasons for ED-ICU initiation, and admission criteria. Information on reported outcomes including process measures, patient-related outcomes, and cost-related outcomes was also collected. We excluded studies that reported only on personnel-focused models of critical care delivery in the ED (ie, without a dedicated physical area), or a physical space that could not provide organ support measures that are core to an ICU-level care (eg, invasive mechanical ventilation or vasopressor support). Two authors independently screened abstracts and full texts (JS, LS, or PB). Conflicts were resolved by consensus through discussions held in a virtual meeting.

Data Extraction and Synthesis

Specific data extracted from the included full texts included the name of the ED-ICU model, country, institution, year of establishment (and reason), number of beds, type of staffing, admission criteria, yearly census of the corresponding ED, utilization of ED-ICU, ED-ICU length of stay (LOS), ED-ICU reported mortality, description of process measures, patient-related or cost-related outcomes, first author and year of publication, study design, funding, and potential conflict of interests. Data was extracted independently into a pre-piloted data abstraction form by two authors (JS, LS, or PB). Conflicts were resolved by consensus through discussions held in a virtual meeting. We summarized the characteristics of each ICU using descriptive statistics as feasible, and we identified themes of utilization of the ED-ICU. The reported outcomes were grouped into three categories: 1) process measures; 2) patient-related clinical outcomes; and 3) cost-related considerations.

The protocol of this scoping review was registered and can be accessed on Open Science Framework (OSF) website (registration DOI: https://doi.org/10.17605/OSF.IO/MEVQB). This report follows the PRISMA extension for scoping reviews.[9]

RESULTS

We screened 2,824 studies and assessed125 full-text articles for eligibility, of which 31 were included in the present scoping review (Figure 1). Of the 31 included studies, there was one prospective cohort study,[10] 23 retrospective cohort studies,[6–8,11–30] one systematic review,[31] four narrative reviews,[2,5,32,33] one report,[34] and one commentary.[5] These studies reported on 14 different ED-ICUs. Table 1 provides the characteristics of these 14 ED-ICUs. Supplementary Table S2 and S3 provide further details of ED-ICUs and each study.

Main Characteristics of ED-ICUs

The ED-ICUs are described using different names or abbreviations, such as emergency department intensive care unit (with the abbreviations EDICU, ED ICU, or ED-ICU), emergency ICU (EICU), emergency critical care center (EC3), resuscitation and critical care unit (ResCCU), resuscitation and acute critical care unit (RACC), or shock room. The identified ED-ICUs were deployed in seven countries: six in the United States; three in Taiwan; and one each in Korea, France, Belgium, Turkey, and Brazil. While

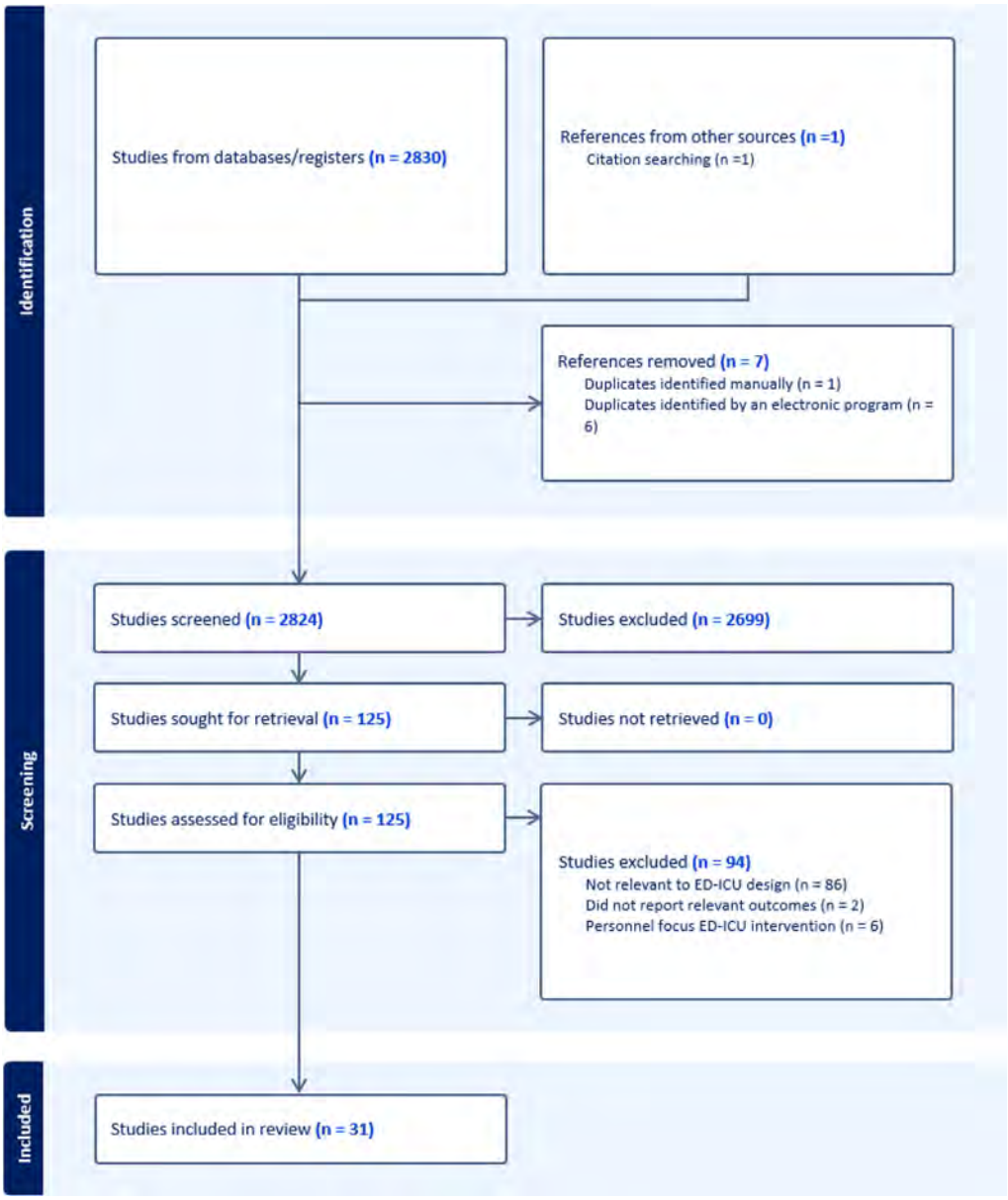

Figure. PRISMA chart for scoping review impact of intensive care units within emergency departments.
ED-ICU, emergency department-based intensive care unit.

most ED-ICUs had one or two studies that reported on their overall structures, the EC3 in the US had 18 related articles.[2,5,6,18–22,25–33,35] Bed capacity ranged from 3–17 beds with a median of 10 beds (interquartile range 7–13). Six ED-ICUs were reported to not be able to admit patients when inpatient ICUs were available, but three were reported to do so (see Table 1). Several common staffing patterns were observed in these ED-ICUs; for example, the presence of 1) emergency physicians, with or without training in critical care medicine, 2) registered nurses with a nurse-to-patient ratio of approximately 1:2, and 3) interdisciplinary team members, including respiratory therapists or pharmacists. One ED-ICU operated only on weekdays.[8,17,23]

Overarching Themes

Three themes emerged from reviewing the unique utilization of these ED-ICUs: namely the ED-ICU as a short-stay, palliative care, or disaster-response ICU. First, ED-ICUs could provide short-stay intensive care for critically ill patients who were expected to recover quickly after a period of intensive observation or treatment (eg, patients with acute poisoning, upper gastrointestinal [GI] bleeding, diabetic ketoacidosis [DKA], or minor intracranial hemorrhage).[17,18,22,23,26] Second, when inpatient ICU beds are full, patients who are unlikely to survive could be alternatively admitted to the ED-ICUs. Such ED-ICUs, thus serving as a palliative-care ICU, could

Table. Characteristics of emergency department-based intensive care units.

Name	Country	Institution	Reason for initiation	Admission criteria	Available beds
Emergency critical care center (EC3)[2,5,6,18–22,25–33,35]	United States	University of Michigan	ED boarding of ICU patients	Ongoing critical care need (even when other ICU bed is available)	9
Resuscitation and critical care unit (ResCCU)[2,5,8,17,23,32]	United States	Hospital of the University of Pennsylvania	ED boarding of ICU patients	Ongoing critical care need (even when other ICU bed is available)	6
Resuscitation and acute critical care unit (RACC)[2,5,32,33]	United States	Stony Brook University Medical Center	ED boarding of ICU patients	Ongoing critical care (when an ICU bed is not available)	3
ED intensive care unit (EDICU)[10,31]	Turkey	Hacettepe University	ED boarding of ICU patients	Ongoing critical care (when an ICU bed is not available)	8
ED ICU[5,14]	France	Amiens University Medical Center	To manage general critical care; eg, stroke patients	Not reported	6
ED intensive care unit (EDICU)[12,31]	Taiwan	Chang Gung Memorial Hospital	ED boarding of ICU patients	Ongoing critical care (when an ICU bed is not available)	14
Shock room[11]	Belgium	Erasme University Hospital	Facilitating rapid diagnosis and management of acutely ill patients	Unstable patients	4
ED-ICU[15]	Brazil	Instituto Central do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo	Not reported	Ongoing critical care (when an ICU bed is not available)	17
Emergency ICU (EICU)[7]	Republic of Korea	Seoul National University Hospital	ED boarding of ICU patients	Ongoing critical care need (even when other ICU bed is available)	12
Emergency ICU (EICU)[24]	Taiwan	Taipei Veterans General Hospital	ED boarding of ICU patients	Ongoing critical care (when an ICU bed is not available)	13
ED-ICU[16]	Taiwan	Taipei Medical University Hospital	Reservoir of critical care for hospital	Ongoing critical care	8
Emergency intensive care unit (EICU)[13]	United States	Bellevue Hospital Center	Disaster (hurricane)	Ongoing critical care before transfer	10
ED-ICU[34]	United States	Mount Sinai Hospital	Disaster (COVID-19)	Ongoing critical care need	13
Not reported[5]	United States	Henry Ford Hospital	ED boarding of ICU patients	Ongoing critical care (when an ICU bed is not available)	16

ED, emergency department; *EM*, emergency medicine; *EP*, emergency physician; *CCM*, critical care medicine; *COVID-19*, coronavirus disease 2019; *ICU*, intensive care unit.

be a place where physicians initiate end-of-life care discussions and palliative care consultations.[10,15,24] Third, ED-ICUs were used for disaster response. For example, in the event of a hurricane or the coronavirus disease 2019 pandemic, temporary ED-ICUs were set up to increase hospital-bed capacity.[13,34]

Process Measures

The ED-ICUs have been shown to potentially improve several process measures, including decreased time from ED presentation to deployment of ICU-level care.[6,7,17,18,26] A retrospective cohort of 349,310 ED visits revealed that critically ill patients receive ICU-level care with a median of

1.9 hours earlier after opening an ED-ICU compared to before opening.[6] Critically ill patients admitted to an ED-ICU had 27.5% shorter boarding time than patients admitted to other ICUs.[7] Implementing the ED-ICU model resulted in an increase in the number of patients who received evidence-based critical care in the ED.[14,27] For example, in patients presenting with acute ischemic stroke, the presence of an ED-ICU was associated with an increase in thrombolysis rate.[14] Furthermore, among intubated patients in the ED, establishing an ED-ICU increased the number of patients receiving a lung protective ventilation strategy at the time of ED departure (65.8% vs 43.1%).[27]

Moreover, an ED-ICU model could facilitate the reduction of inpatient ICU admission and preserve inpatient ICU capacity. Opening an ED-ICU was associated with a reduction in the odds of overall admission to an inpatient ICU (adjusted odds ratio [aOR] 0.80; 95% confidence interval [CI], 0.76–0.83).[6] Furthermore, reduced inpatient ICU admissions were found in cohorts of patients with DKA or upper GI bleeding after the ED-ICU implementation.[18,26] In another setting, a study showed that the opening of an ED-ICU was associated with a decrease in ICU admission in the first month after opening among adult patients with sepsis.[8]

Patient-Related Outcomes

Overall, the reported LOS of patients in the ED-ICUs varied widely. The ED-ICUs that admitted patients with acute poisoning, DKA, or minor intracranial hemorrhage reported their ED-ICU LOS as follows: 72% of patients with acute poisoning had an LOS of less than 24 hours[23]; the mean LOS for DKA was 18.1 hours[18]; and the median LOS for minor intracranial hemorrhage was 15.7 hours.[22] In contrast, the other two ED-ICUs that admitted patients with a worse overall prognosis reported a median ED-LOS of 120 hours (interquartile range [IQR] 4 hours-49 days),[10] and a median of 3.2 days (IQR 1.9–5.9 days).[15] Similarly, a wide range of mortality rates were also observed, from less than 1% to ≈75%. Dispositions of patients in ED-ICUs varied; they could be subsequently transferred to inpatient ICUs, transferred to general wards, or discharged home.

We found conflicting data on the association of an ED-ICU model implementation with patient-related outcomes. For example, some studies showed that an ED-ICU was associated with improved clinical outcomes.[6,14,25] In an adjusted analysis of consecutive ED visits, implementation of the ED-ICU was associated with reduced 30-day mortality (aOR 0.85, 95% CI 0.80–0.90).[6] Further, in a matched cohort from the same institution, the opening of an ED-ICU was associated with lower 60-day mortality (hazard ratio 0.84, 95% CI 0.70–0.99).[25] When focusing on patients with acute stroke, the number of patients with favorable clinical outcomes increased after the opening of an ED-ICU.[14]

Conversely, several other studies highlighted that creating an ED-ICU did not necessarily translate to improved survival.[8,12,26,30] When analyzed using different subgroups (ie, subgroups of patients with upper GI bleeding or decompensating patients), the data from the ED-ICU that previously exhibited survival benefit did not show differences in mortality between the pre- or post-implementation cohorts.[26,30] Among patients with acute respiratory failure or sepsis, the implementation of an ED-ICU was not associated with in-hospital survival.[8] Finally, a study showed increased mortality among patients admitted to the ED-ICU compared with patients admitted to other inpatient ICUs. This could be due to a higher proportion of patients with a higher burden of comorbid conditions or higher severity of disease admitted to the ED-ICU (compared to the inpatient ICU).[12]

Cost-Related Outcomes

One study explored the association of ED-ICU and cost-related outcomes. Establishing the ED-ICU was associated with increased inflation-adjusted net revenue per encounter: 7% (95% CI, 3.5–10.6%) and without increased inflation-adjusted cost.[29]

DISCUSSION

In this scoping review, we identified that several ED-ICUs have been established around the world with both unique and shared characteristics. Overall, these ED-ICUs are characterized by the provision of early and continued ICU-level care and are generally staffed by emergency physicians, nurses, and interdisciplinary team members. Implementing an ED-ICU model may be associated with timely ICU-level care, as well as reductions in inpatient ICU admission rates without compromising clinical patient outcomes.

Importantly, despite sharing several characteristics, both LOS and mortality risk varied greatly across reported ED-ICUs. This variability could be due to different utilization of ED-ICUs and different case mix (eg, higher LOS associated with the care of patients who have a higher degree of severity at baseline, while shorter LOS may be associated with lower overall severity or transitioning to palliative care). Notably, we identified ED-ICUs as being predominantly a 1) short-stay ICU; 2) a palliative-care ICU; or a 3) disaster-response ICU. The latter type was fueled by lack of appropriate resources in the time of a disaster, whereas the short-stay and palliative-care ICUs were mostly initiated due to a lack of inpatient ICU beds. As short-stay ICU admissions generally comprise a high proportion of all ICU admissions, diverting these patients to an ED-ICU model could preserve important inpatient ICU capacity.[36] The potential diagnoses that could be served under a short-stay ED-ICU admission model may include acute poisoning, intoxication, upper GI bleeding, DKA, minor strokes, and transient cerebral ischemia.[17,18,22,23,26,36,37] On the other end of the spectrum, patients who are unlikely to benefit from a prolonged trial of invasive, life-sustaining interventions could also be assessed

and cared for under an ED-ICU model that can then serve as a transition to a different pathway such as a palliative-care approach. Such implementations could potentially explain the high mortality rate observed in some of these ED-ICUs where terminally ill patients are admitted.[10,12]

In this review, we identified that establishing an ED-ICU was potentially associated with improvement in several process measures, including time to ICU-level care, reduction of inpatient ICU admission rates, and increased delivery of evidence-based treatments. However, whether this translates to clinically relevant patient-related outcomes remains unclear given that 1) studies report conflicting data on patient-related outcomes and 2) the high likelihood of confounding by indication.[38] For example, the higher mortality rate observed within some ED-ICUs might be due to confounding due to baseline severity; patients with higher burden of comorbid conditions and severity at baseline (who are at higher risk of in-hospital death) might be selectively admitted to the ED-ICUs.[10,12] Moreover, whether the implementation of an ED-ICU model can be expected to impact clinical outcomes beyond process measures (compared to timely ICU-level care delivery elsewhere) remains unclear.[39]

Although establishing an ED-ICU model may lead to improved timely ICU-level care and preservation of inpatient ICU capacity, adopting an ED-ICU model requires multiple considerations. First, institutional needs assessment should be performed by focusing on identifying key stakeholders, evaluating ED throughput, and determining bed capacity and availability of resources.[5] Second, the financing and staffing model should not be neglected. Finally, healthcare leaders should also consider alternative solutions to an ED-ICU model, including improved institutional policy, personnel-focused intervention, or increased number of inpatient ICU beds.

LIMITATIONS

Several limitations need to be considered when evaluating our findings. First, it is likely that many more ED-ICUs exist than those reported in the literature. For example, there were at least three more ED-ICUs in the US than was reported in the indexed literature.[40] It remains unknown whether the reported ED-ICU models represent the latter, unreported group. Additionally, we did not include a commonly cited ED-ICU implementation because it did not meet our definition of an ED-ICU model, as it was located farther away from the ED and specifically designed to accept critical care transfers from other hospitals.[41,42] Second, most of the reported outcomes associated with ED-ICU operation were from one site (with 18 related studies) of the identified 31 papers. This could potentially limit the generalizability of our findings. Third, the reported outcomes were largely obtained from retrospective cohorts, with several limitations in their design; most studies did not provide sample-size determination, and were subject to unmeasured and residual confounding as well as outcome misclassification. Fourth, ideally, the data from each study should be pooled and analyzed collectively. However, due to the significant heterogeneity in data reporting, patient inclusion, and severity of disease across studies, summary statistics were not calculated for all reported data.

CONCLUSION

Several ED-ICUs have been established around the world with different characteristics depending on local needs. Implementation of the ED-ICU may be associated with improved process measures; however, its impact on clinical outcomes remains not fully characterized. Importantly, future research should focus on how the establishment of an ED-ICU could be useful in different contexts and geographical areas, alongside its related success factors. Furthermore, cost-related outcomes should be further explored, as they are important considerations for stakeholders in adopting an ED-ICU model.

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Emergency Medical Services Provider-Perceived Alzheimer's Disease and Related Dementias in the Prehospital Setting

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Objective: Our goal was to assess emergency medical services (EMS) provider-perceived Alzheimer's disease and related dementias (ADRD) by patient sociodemographic characteristics and ZIP code tabulation areas (ZCTA) in the prehospital setting.

Methods: We conducted a retrospective descriptive analysis of EMS calls with patient contact for adults ≥ 65 years of age who were provided prehospital care between February 1, 2020 and January 31, 2022, using data from the San Francisco Department of Emergency Management and the 2021 American Community Survey. Logistic regression models assessed the associated between EMS provider-perceived ADRD and patient sociodemographic characteristics, including age, race/ethnicity, incident location, and ZCTA-level socioeconomic status.

Results: A total of 55,129 patient encounters were recorded, with EMS provider-perceived ADRD recorded in 4,112 (7.5%). Among cases with EMS provider-perceived ADRD, the most common primary impressions were mental disorders (17.1%), weakness (17.0%), injury (15.7%), and pain (13.1%). Increasing age was associated with higher odds of EMS provider-perceived ADRD among both sexes. Among females, EMS provider-perceived ADRD was higher among Hispanics (odds ratio [OR] 1.30, 95% confidence interval [CI] 1.11–1.52), Blacks (OR 1.20, 95% CI 1.03–1.40), Asians (OR 1.18, 95% CI 1.06–1.31), and Native Hawaiian and Pacific Islanders (OR 1.48, 95% CI 1.05–2.08]), while among males, only Asians (OR 87, 95% CI .76–.99) had lower odds, all compared to Whites. Females in low- and medium-income ZCTAs had lower odds of EMS provider-perceived ADRD relative to high-income ZCTAs, with no significant findings in males.

Conclusion: Our findings suggest a higher prevalence of EMS provider-perceived Alzheimer's disease and related dementias among minoritized and socioeconomically disadvantaged populations, including the oldest adults, and racial and ethnic minority communities. Future research and more precise data collection is needed to ensure equity for older adults who access emergency care in the prehospital setting. [West J Emerg Med. 2025;26(1)86–95.]

INTRODUCTION

Alzheimer's disease and related dementia (ADRD) cases among adults ≥65 years of age in the United States are projected to increase from 6.7 million to 13.8 million between 2023 and 2060.[1] The projected increase in ADRD cases is partially attributed to the increasing population of adults ≥65 years of age, which is expected to rise from 58 million to 88 million between 2021 and 2050.[1] Although older age does not directly cause ADRD, it is a significant risk factor for disease development.[2] The estimated ADRD prevalence is 5% for ages 65 to 74, 13.1% for ages 75 to 84, and 33.3% for ages ≥85, indicating a heightened disease burden with increasing age.[1]

Existing literature provides evidence of the presence of health disparities in ADRD incidence and prevalence based on sex, race, ethnicity, and socioeconomic status.[3] Alzheimer's disease and related dementias are more prevalent in older adult women than men.[1,3] While women, on average, have longer life expectancies at age 65 than men, this finding does not fully account for their increased ADRD risk.[1,3] Among older adults, Black and Hispanics are 2 and 1.5 times more likely, respectively, to have ADRD compared to Whites.[3] Dementia incidence, including ADRD, is highest among Blacks and American Indian or Alaska Natives (AIAN), intermediate for Hispanics, Native Hawaiian and other Pacific Islanders (NHOPI), and Whites, and lowest among Asian-Americans.[4] Lower education is associated with an increased risk of ADRD, which suggests socioeconomic disparities.[5]

Population Health Research Capsule

What do we already know about this issue?
Alzheimer's disease and related dementias (ADRD) in older adults is projected to increase from 6.7 to 13.8 million cases between 2023 and 2060.

What was the research question?
How does EMS provider-perceived ADRD among older adults vary by sociodemographic characteristics and geography?

What was the major finding of the study?
In females, perceived ADRD was higher in minorities, including Hispanics (OR 1.30, 95% CI 1.11–1.52], P = <.05), compared to Whites.

How does this improve population health?
Revealing sociodemographic and geographic variations among subpopulations of older adults advances our understanding of EMS provider-perceived ADRD in the prehospital setting,.

Importance

The existing literature suggests that there are health disparities in ADRD detection, treatment, and research.[3,6,7–9] Hispanic and Black older adults report worse cognitive function and more functional limitations at ADRD diagnosis compared to Whites, suggesting detection at a later stage of the disease.[6] Racial and ethnic disparities in ADRD-targeted treatment are mixed.[6,7] Non-adherence and discontinuation rates of ADRD medications are higher among Hispanic and Black older adults compared to Whites, partially due to challenges with access and cost of healthcare.[6,7] The generalizability of ADRD research is also limited due to the under-representation of certain racial and ethnic groups, including Hispanic older adults in clinical trials.[8,9] Given the robust literature suggesting racial and ethnic disparities in ADRD detection, treatment, and research, assessing healthcare services provided to persons with ADRD in the US emergency care system is critical.

Previous studies suggest that the US emergency care system serves as an entry point for older adults with ADRD.[10,11] Most research, however, focuses on in-hospital emergency care provided in the emergency department (ED).[11] Older adults with ADRD have higher rates of ED visits, 30-day ED revisits, and inpatient admissions compared to older adults without ADRD.[11] In the ED, 40% to 64% of visits by older adults with ADRD result in an inpatient hospital admission, averaging a stay of 6.5 days.[11] Among older adults with ADRD, the most common reasons for ED visits include accidents and behavioral disturbances.[12] Older adults with ADRD who are female, ≥85 years of age, and who have multiple medical comorbidities are more likely to use the ED.[12]

Goals of This Investigation

While studies suggest that older adults with ADRD are more likely to use in-hospital emergency services, including the ED, few studies have examined the provision of emergency medical services (EMS) to older adults with suspected or confirmed ADRD.[10–12] One study that assessed the provision of EMS to older adults with ADRD reported more ambulance transports to an ED for this population, compared to older adults without ADRD.[13] In this study, we aimed to 1) assess the most common primary and secondary EMS-provider impressions listed in the prehospital setting for persons with EMS provider-perceived ADRD; and 2) analyze EMS provider-perceived ADRD by patient sociodemographic characteristics and ZIP code tabulation areas (ZCTA).

METHODS

Study Setting

We used 9-1-1 EMS data from the consolidated city-county of San Francisco, CA. San Francisco is one of 58 counties in California with a population of 815,201 as of 2021.[14] San Francisco has 46.9 square miles of land, making it the smallest county in the state in terms of square mileage but the most densely populated with 18,629 people per square mile.[14] San Francisco is one of the most racially and ethnically diverse counties in the state, with a racial composition of 49.9% White, 39.8% Asian, 15.7% Hispanic, 6.7% Black, 1.7%, AIAN, 0.9% NHOPI, and 14.2% two or more races.[14] Adults ≥65 years of age and older comprise 17.5% of the county's population, an estimate that is projected to increase over the next three decades.[14,15]

Study Design

In this retrospective descriptive analysis we used data from the San Francisco Department of Emergency Management and the 2021 American Community Survey five-year estimates. The San Francisco Department of Emergency Management dataset contains patient sociodemographic characteristics (eg, age, race, ethnicity, sex), incident ZIP code, provider primary and secondary impressions, and EMS provider-perceived ADRD for all patient encounters. The 2021 American Community Survey five-year estimates include ZCTA-level estimates and median household income.[16] This study is exempt from institutional review board review.

The EMS data from the San Francisco Department of Emergency Management includes all patient encounters submitted by the San Francisco Fire Department, King American Ambulance Company, and American Medical Response, Inc. These 9-1-1 agencies include both municipal and private entities. The EMS dataset includes all patient encounters with adults ≥65 years of age who had an incident in San Francisco between February 1, 2020–January 31, 2022. The study timeframe began on February 1, 2020, because this is the date when the California data repository began to reliably populate electronic patient care report data after a change in their analytic service.

A patient encounter is defined as a 9-1-1 call where there is an encounter between a patient and an EMS provider. A single person may have multiple patient encounters during the study period. Although all patient encounters involve an EMS response, not all EMS responses result in a patient encounter. The EMS responses without a patient encounter are excluded from this study, as their associated electronic patient care reports lack details on key variables, including patient sociodemographic characteristics, provider impressions, and EMS provider-perceived ADRD. Examples of EMS responses without a patient encounter include canceled calls or instances where patients were not found at the scene. This study also excludes interfacility transports, concentrating instead on EMS provider-perceived ADRD among non-institutionalized older adults in the community.

The American Community Survey is an ongoing national survey conducted by the US Census Bureau on a random sample of the population.[16] The survey is administered annually, with over 3.5 million households contacted every year to participate.[16] Selected households complete the survey via mail, telephone, or in-person interviews, providing data on a range of social, economic, demographic, and housing topics across several geographics.[16] For smaller geographics, including ZCTAs, five-year estimates are published to increase statistical data reliability and confidentiality. In this study we used median household income across ZCTAs from the 2021 American Community Survey five-year estimates.

Measurements

The dependent variable is presence (coded 1) or absence (coded 0) of EMS provider-perceived ADRD. This outcome is a combination of ADRD diagnoses disclosures by patients and caregivers, and perceived ADRD by the EMS provider. It is impossible, however, to disentangle confirmed with perceived ADRD from the data in the electronic patient care reports, although this is currently the best source of data available in the prehospital setting. Five independent variables including age, sex, race/ethnicity, ZCTA-level median household income, and incident ZIP code, are included based on previous literature.[17–19] Patient sociodemographic characteristics and incident ZIP code are recorded by EMS providers in the electronic patient care reports. The method used to collect sociodemographic information for each patient encounter is not available in the dataset, although it is likely that this data is obtained through a combination of patient self-report and provider report.

Age is coded using the following categories: 65–69 (reference group), 70–74, 75–79, 80–84, 85–89, 90–94, and 95+. Gender is coded 1 for female and 0 for male. The race and ethnicity variable is coded 1 to 6 with the following categories: White (reference group); Black; Asian; NHOPI; AIAN; and Hispanic. Median household income is coded into three groups: $0–$104,299; $104,400–$146,999; and ≥$147,000 (reference). Among the 27 ZIP codes in San Francisco, seven (94104, 94105, 94108, 94111, 94129, 94130, and 94158) had less than 40 EMS provider-perceived ADRD cases. These were pooled for reliable coefficient estimates in the statistical models. ZIP codes with over 40 incidents were sequentially coded from 1 to 20: 94102, 94103, 94107, 94109, 94110, 94112, 94114 to 94118, 94121 to 94124, 94127, and 94131 to 94134. Primary and secondary provider impressions in the electronic patient care reports are based on the International Classification of Diseases, 10th Revision, codes and are available to EMS providers a priori.

Outcomes

The first objective assesses how EMS provider-perceived ADRD is recorded in the prehospital setting, with a focus on the most common primary and secondary provider impressions. The second objective analyzes EMS provider-perceived ADRD by patient sociodemographic characteristics and ZCTAs.

Data Analysis

We calculated descriptive statistics of the most common primary and secondary provider impressions for patient encounters with EMS provider-perceived ADRD. Bivariate analyses were performed to assess the associations between the independent variables and the outcome variable (presence or absence of EMS provider-perceived ADRD). We used chi-square tests for categorical variables, while continuous variables were analyzed using Student *t*-tests. Stepwise logistic regression was used to identify the independent associations between the five independent variables (age, sex, race/ethnicity, incident ZIP code, and median household income) and the outcome variable. (See Web Appendices Table 1.) These regression models show statistically significant differences by sex in the odds of EMS provider-perceived ADRD, and we thus proceeded to estimate stratified models by sex. (See Web Appendices Tables 2 and 3.) For this study, we calculated 95% confidence intervals (CI), and a *P*-value of <.05 was used to represent statistical significance. We used STATA v 17.0 (StataCorp, College Station, TX) for statistical analyses.[20]

In conducting this retrospective descriptive analysis, we adhered to several best practices for retrospective chart review as suggested by Worster and Bledsoe.[21] Specifically, we clearly defined the dependent and independent variables, with the dependent variable being the presence or absence of EMS provider-perceived ADRD and the independent variables including age, sex, race/ethnicity, ZCTA-level median household income, and incident ZIP code. Additionally, our study's design and data analysis were meticulously planned and detailed to ensure a rigorous and systematic analysis of the data.

RESULTS

A total of 55,129 EMS patient encounters were documented among persons ≥65 years of age in San Francisco, CA, between February 1, 2020–January 31, 2022. Of these patient encounters, 51,017 (92.5%) did not indicate EMS provider-perceived ADRD. The remaining 4,112 (7.5%) did indicate EMS provider-perceived ADRD (Table 1). Among patient encounters that indicated the presence of EMS provider-perceived ADRD, the sociodemographic composition was majority female (60.4% female and 39.6% male), increased with age, except for a decline starting at 90 years, and was mostly White (42.7%) and Asian (32.3%), with smaller fractions of Black (13.5%), Hispanic (9.3%), NHOPI (1.4%), and AIAN (0.8%). Females had a higher proportion of EMS provider-perceived ADRD across all ages, compared to males, with widening sex differences starting at age 85 (Figure). The distribution of patient encounters showed a higher percentage of EMS provider-perceived ADRD in the following ZIP codes: 94112, 94109, and 94115. Of these ZIP codes, two are located in the north (94109 and 94115) and one is located in the south (94112).

Main Results

The first objective examines the most common primary and secondary provider impressions among patient encounters where EMS provider-perceived ADRD was recorded. A provider primary impression is defined as "the EMS personnel's impression of the patient's primary problem or most significant condition which led to the management given to the patient (eg, treatments, medications, or procedures)."[22] Similarly, a secondary provider impression is defined as "the EMS personnel's impression of the patient's secondary problem or most significant condition which led to the management given to the patient."[22] Table 2 shows the top 10 most common provider primary and secondary impressions recorded for patient encounters with EMS provider- perceived ADRD. The most common primary impressions were mental disorders/altered mental status (17.1%), weakness (17.0%), and injury (15.7%), while the leading secondary impressions were general medical exam without abnormal findings (57.9%), followed by weakness (9.8%), and mental disorder/altered mental status (5.4%). However, less common outcomes (eg, gastrointestinal and cardiac) are listed in similar proportions and ranking in both the primary and secondary provider impressions.

Our second objective was to analyze EMS provider-perceived ADRD by patient sociodemographic characteristics and ZCTAs. The stepwise logistic regression models presented in Web Appendices Table 1, 2, and 3 provide detailed analyses of males and females together and separately. Table 3 shows an abridged version of the last two models from Web Appendices Table 2 and 3, stratified by sex and controlling for all covariates, including age, race/ethnicity, median household income, and incident ZIP code. Among males and females, the odds of EMS provider-perceived ADRD were higher with increasing age, except for a slight decline among males ≥95 years, a trend that was likely influenced by mortality selection. Among females, the odds of EMS provider-perceived were consistently higher for Hispanics, Blacks, Asians, and NHOPI relative to Whites. In contrast, for males, only Asians showed significantly lower odds of EMS provider-perceived ADRD relative to Whites, with no significant differences among other racial and ethnic groups.

Table 1. Patient encounters[1] for persons ≥65 years of age with and without EMS provider-perceived dementia in San Francisco, CA, between February 1, 2020–January 31, 2022.

	Absence of EMS-provider perceived ADRD (n = 51,017)		Presence of EMS-provider perceived ADRD (n = 4,112)		Total sample size (presence and absence of EMS provider-perceived ADRD) (N = 55,129)	
	Number (#)	Percentage (%)	Number (#)	Percentage (%)	Number (#)	Percentage (%)
Sex						
Female	23,599	46.3%	2,485	60.4%	26,084	47.3%
Male	27,418	53.7%	1,627	39.6%	29,045	52.7%
Age						
65–69	13,008	25.5%	171	4.2%	13,179	23.9%
70–74	10,403	20.4%	348	8.5%	10,751	19.5%
75–79	7,532	14.8%	487	11.8%	8,019	14.6%
80–84	6,894	13.5%	776	18.9%	7,670	13.9%
85–89	6,367	12.5%	951	23.1%	7,318	13.3%
90–94	4,549	8.9%	906	22.0%	5,455	9.9%
95+	2,264	4.4%	473	11.5%	2,737	5.0%
Race/Ethnicity						
White	23,694	46.4%	1,755	42.7%	25,449	46.2%
Black	9,444	18.5%	555	13.5%	9,999	18.1%
Hispanic	4,278	8.4%	383	9.3%	4,661	8.5%
Asian	12,536	24.6%	1,329	32.3%	13,865	25.2%
NHOPI[2]	621	1.2%	58	1.4%	679	1.2%
AIAN[3]	444	0.8%	32	0.8%	476	0.9%
Incident ZIP code						
94102	5,395	10.6%	208	5.1%	5,603	10.2%
94103	4,165	8.2%	103	2.5%	4,268	7.7%
94107	1,137	2.2%	67	1.6%	1,204	2.2%
94109	5,481	10.7%	368	9.0%	5,849	10.6%
94110	3,166	6.2%	209	5.1%	3,375	6.1%
94112	3,880	7.6%	525	12.8%	4,405	8.0%
94114	1,134	2.2%	58	1.4%	1,192	2.2%
94115	3,657	7.2%	350	8.5%	4,007	7.3%
94116	2,468	4.8%	302	7.3%	2,770	5.0%
94117	1,321	2.6%	154	3.8%	1,475	2.7%
94118	1,759	3.5%	201	4.9%	1,960	3.6%
94121	1,784	3.5%	203	4.9%	1,987	3.6%
94122	2,212	4.3%	236	5.7%	2,448	4.4%
94123	982	1.9%	60	1.5%	1,042	1.9%
94124	2,568	5.0%	212	5.2%	2,780	5.0%
94127	853	1.7%	67	1.6%	920	1.7%
94131	1,076	2.1%	80	2.0%	1,156	2.1%
94132	1,623	3.2%	246	6.0%	1,869	3.4%
94133	1,761	3.5%	125	3.0%	1,886	3.4%
94134	2,001	3.9%	230	5.6%	2,231	4.1%

(*Continued on next page*)

Table 1. Continued.

	Absence of EMS-provider perceived ADRD (n = 51,017)		Presence of EMS-provider perceived ADRD (n = 4,112)		Total sample size (presence and absence of EMS provider-perceived ADRD) (N = 55,129)	
	Number (#)	Percentage (%)	Number (#)	Percentage (%)	Number (#)	Percentage (%)
94104, 94105, 94108, 94111, 94129, 94130, 94158[4]	2,594	5.1%	108	2.6%	2,702	4.9%

[1]Patient encounters are defined as an interaction between a patient and an EMS provider. A single patient may have activated EMS multiple times during the study period. The findings represent the number of encounters, not distinct individuals.
[2]NHOPI refers to Native Hawaiian or other Pacific Islander.
[3]AIAN refers to American Indian or Alaska Native.
[4]These ZIP codes each had less than 40 suspected ADRD cases, so they were aggregated to address problems with small sample sizes.
ADRD, Alzheimer's diseases and related dementia; *EMS*, emergency medical services.

Table 2. Top 10 most common EMS provider impressions for patient encounters[1] with EMS provider-perceived Alzheimer's disease and related dementias (N = 4,112).

EMS provider primary impression			EMS provider secondary impression		
	Number (#)	Percentage (%)		Number (#)	Percentage (%)
Mental disorder/altered mental status	703	17.1%	General medical exam without abnormal findings	2,380	57.9%
Weakness	699	17.0%	Weakness	403	9.8%
Injury	646	15.7%	Mental disorder/altered mental status	223	5.4%
Pain	537	13.1%	Injury	159	3.9%
Neurological	336	8.2%	Pain	111	2.7%
Respiratory	294	7.2%	Respiratory	96	2.3%
General medical exam without abnormal findings	268	6.5%	Neurological	90	2.2%
Gastrointestinal	104	2.5%	Gastrointestinal	72	1.8%
Cardiac	100	2.4%	Cardiac	46	1.1%
Other provider primary impression	397	9.7%	Other provider primary impression	231	5.6%
Missing	22	0.5%	Missing	301	7.3%

[1]Patient encounters are defined as an interaction between a patient and an EMS provider. A single patient may have activated EMS multiple times during the study period. The findings represent the number of encounters, not distinct individuals.
EMS, emergency medical services.

Among females, ZCTAs with a low ($0–$104,399) and medium ($104,400–$146,999) median household income showed significantly lower odds of EMS provider-perceived ADRD, compared to ZCTAs with a high median household income (≥$147,000). In contrast, for males, no statistically significant differences were detected by median household income. Among females, the race by median household income interaction suggested that Hispanics in low- (predicted probability = .11, 95% CI 0.09–.144) and medium-income ZCTAs (predicted probability = .11, 95% CI 0.95–0.12) had a higher predicted probability of EMS provider-perceived ADRD relative to Whites in high-income ZCTAs (predicted probability = .07, 95% CI 0.06–0.08). Among males, non-statistically significant findings were found for Hispanics in low-income ZCTAs relative to Whites in high-income ZCTAs, although Hispanics in medium-income ZCTAs (predicted probability = .07, 95% CI 0.06–0.09) had a higher predicted probability of EMS provider-perceived ADRD compared to Whites in high income ZCTAs (predicted probability = .04, 95% CI 0.04–0.05). Our findings underscore the importance of patient sociodemographic characteristics (eg, sex, race, ethnicity, age, median household income), geospatial features (eg, ZCTAs), and the interplay of these factors in

Table 3. Logistic regression models[1] for presence of EMS provider perceived ADRD among males and females by predictor specifications.[1]

	Females		Males	
	Model 1a	**Model 2a**	**Model 1b**	**Model 2b**
Age (ref = 65–69)				
70–74	2.52***	2.55***	2.35***	2.33***
75–79	4.39***	4.47***	4.61***	4.59***
80–84	6.59***	6.69***	8.75***	8.76***
85–89	9.26***	9.38***	10.46***	10.52***
90–94	12.36***	12.56***	13.71***	13.77***
95+	13.70***	13.97***	11.27***	11.39***
Race/ethnicity (ref = White)				
Hispanic	1.30**	1.30	1.03	.92
Black	1.20*	2.35***	1.18	1.64*
Asian	1.18**	1.41*	.87*	.78
NHOPI	1.48*	1.43	.70	.79
AIAN	1.14	1.11	.99	1.25
Median household income (ref = $147000+)				
$0–$104,399	.35***	.45**	.89	1.09
$104,400–$146,999	.34**	.43*	1.88	1.88
Race X median interaction (ref = White X $147,000)				
Black X $0–104,399		.45***		.44**
Black X $104,400–146,999		.46***		.91
Asian X $0–104,399		.81		.90
Asian X $104,000–146,999		.82		1.21
NHOPI X $0–104,399		.84		.77
NHOPI X $104,400–146,999		1.17		.89
AIAN X $0–104,399		1.11		.59
AIAN X $104,400–146,999		.98		1.00
Hispanic X $0–104,399		1.31		.84
Hispanic X $104,400–146,999		.89		1.25
Race X Median Income Interaction (*P*-value)[2]		0.01		0.02
Constant	<0.001***	<0.001***	<.001***	<.001***
Observations	26,084	26,084	29,045	29,021
AIC	15,103.15	15,101.4	11,198.68	11,195.24
BIC	15,380.90	15460.84	11,480.09	11,551.10

***$P < 0.001$, **$P < 0.01$, *$P < .05$.

Note: Black corresponds to Black or African American.

[1]All models control for incident ZIP code.

[2]*P*-value for the overall joint significance of all race-by-gender interactions.

AIAN, *American Indian or Alaska Native; AIC*, Akaike information criterion; *BIC*, Bayesian information criterion; *EMS*, emergency medical services; *NHOPI,* Native Hawaiian and other Pacific Islanders.

EMS provider-perceived ADRD in older adults in the prehospital setting.

DISCUSSION

This study advances our understanding of the provision of prehospital care for older adults with EMS provider-perceived ADRD. Our study highlights the critical role that EMS providers' perception and record-keeping practices may have on patients' trajectories through other sectors of the US healthcare system. Our study suggests that the most common provider impressions recorded for older adults with EMS provider- perceived ADRD are mental disorders,

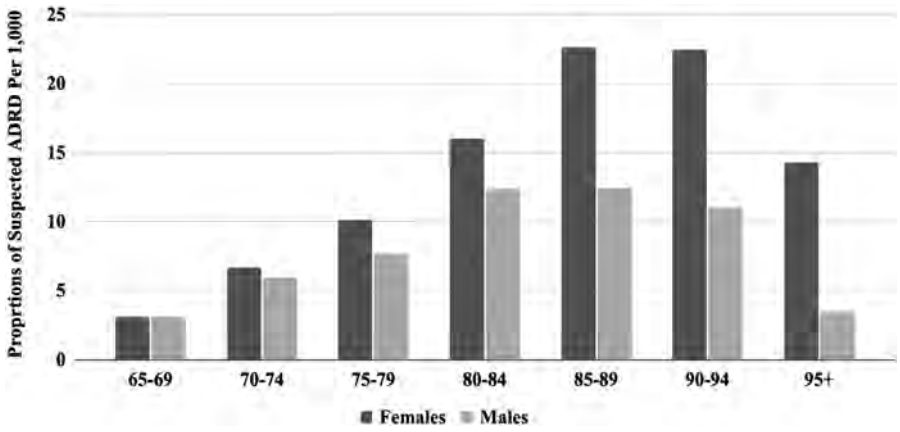

Figure. Emergency medical services provider-perceived Alzheimer's disease and related dementias by patient age and sex in San Francisco, CA, between February 1, 2020–January 31, 2022.
ADRD, Alzheimer's disease and related dementias.

weakness, and injury. These findings align with previous literature that suggests that accidents and behavioral disturbances are the most common reasons for ED visits among older adults with ADRD.[12]

Despite the insights from this study on EMS record-keeping practices, there are challenges in the identification of ADRD in the prehospital setting. It is impossible to differentiate between confirmed and perceived ADRD using documentation from the prehospital setting, and we did not have access to the electronic health records from the recipient hospitals. Furthermore, the findings from several studies suggest that the use of standardized cognitive assessments, which are commonly used in the in-hospital setting, may not be as effective in the out-of-hospital setting.[23–25] The challenges in identifying ADRD in the prehospital setting highlight the need for enhanced EMS provider training to improve detection, emphasize the importance of developing more precise assessment tools, and underscore the need for better record-keeping practices. The efforts by San Francisco to collect ADRD-related data in the prehospital setting can also inform future efforts by other EMS agencies to improve the care of persons with ADRD along the emergency continuum.

The findings from this study suggest a higher prevalence of EMS provider-perceived ADRD in marginalized and socioeconomically disadvantaged populations, including the oldest adults, and Black, Hispanic, and Asian communities. (See Web Appendices Tables 1, 2, and 3). These results suggest that there may be health disparities in EMS provider-perceived ADRD. Future research is needed at the intersection of EMS and ADRD to ensure equitable care for older adults who access emergency care in the prehospital setting. Although this study is based on EMS provider-perceived ADRD in the prehospital setting, the findings are consistent with previous studies in the ED. For example, one study reported that older age groups and females with ADRD were more likely to use the ED.[12] In the current study, EMS provider-perceived ADRD was also higher among older age groups and females (Table 3 and Web Appendix Table 1). Previous work suggests that Hispanic and Black older adults are 1.5 and 2 times more likely, respectively, to have ADRD than Whites.[3] Our study supports these findings, indicating Hispanics and Black older adults have a higher likelihood of having EMS provider-perceived ADRD in their electronic patient care report, suggessting a potential higher reliance on EMS for their healthcare needs.

Future research should continue to examine the possible impacts of intersectional identities on emergency care provided in both the prehospital and in-hospital emergency settings. Delving deeper into such interactions could provide more insights for EMS training and interventions, addressing potential biases at the intersection of multiple factors such as race, ethnicity, sex, socioeconomic status, age, language, and neighborhood. Future studies should consider incorporating varied methodologies to assess whether other factors, such as knowledge of ADRD, ageism, and patient-provider language barriers, affect EMS providers' perception of the presence of ADRD.

Leveraging EMS-ED linked data could also help compare EMS provider-perceived ADRD in the prehospital setting with clinically diagnosed ADRD in the ED. These EMS-ED data linkages are a novel approach used to study health outcomes in the emergency sector, including cardiac emergencies, opioid overdoses, and injuries.[26–28] The ADRD research can benefit from EMS-ED data linkages by studying the provision of emergency care to older adults across the emergency continuum. Furthermore, future studies should assess the role of EMS-provided interfacility transports to older adults with ADRD who reside in long-term care facilities. The EMS-provided interfacility transports for older adults with ADRD is also an understudied area within the US healthcare system.

LIMITATIONS

This study has several limitations. First, we examined EMS provider-perceived ADRD in the prehospital setting, which is a combination of ADRD-confirmed diagnosis disclosures by patients and caregivers, and perceived ADRD. It is impossible, however, to disentangle confirmed and perceived ADRD from the EMS documentation, and we were unable to assess the presence or absence of this health outcome in the electronic health records of the recipient hospitals. Recording the presence of ADRD, whether confirmed or perceived, is important because it may impact the course of treatment provided in the prehospital and in-hospital emergency settings and influence a patient's trajectory through the healthcare system. Future studies should review electronic patient care report narratives to better understand the provision of emergency care for suspected and diagnosed ADRD cases.

The second study limitation is that the EMS dataset consists of patient encounters, not individual patients. A person may be represented more than once in the dataset if there were multiple 9-1-1 calls (although this limitation is present in most EMS datasets). The third study limitation is the small sample size of EMS provider-perceived ADRD across several ZIP codes (94104, 94105, 94108, 94111, 94129, 94130, 94158). To address small sample sizes, obtain reliable statistical estimates, and maintain confidentiality we aggregated the seven ZIP codes with fewer than 40 EMS provider-perceived ADRD cases. A fourth study limitation is the reliance on incident ZIP codes and ZCTAs as the geographic units of analysis; while not exactly comparable, they are the most closely aligned geographic units available. A fifth limitation is the reliance on the electronic patient care reports from the San Francisco Department of Emergency Management, which limits the generalizability of the study results to other cities or counties.

CONCLUSION

This study advances our understanding of EMS provider-perceived Alzheimer's disease and related dimentias in the prehospital setting, revealing sociodemographic and geographic differences among subpopulations of older adults. The findings from this study also emphasize the importance of more precise data collection in the prehospital setting, especially with a focus on ADRD.

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Self-Reported COVID-19 Vaccine Status and Barriers for Pediatric Emergency Patients and Caregivers

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Objective: This study determined if the caregivers of children in the emergency department (ED) have the same COVID-19 vaccination status as the child, the reasons they chose to not vaccinate the child, and self-identified barriers to vaccination to determine if the ED is appropriate for vaccination intervention.

Methods: A survey was administered to caregivers of pediatric ED patients at four Children's Hospitals in: Augusta, GA, Buffalo, NY, Madison, WI, and Sacramento, CA. Participants were asked about their and the child's demographics, vaccination status, and barriers to vaccination. We used descriptive statistics, Cohen's kappa, and logistic regression to analyze responses.

Results: 941 caregivers were considered for enrollment, and 800 consented to participation. Participants were 75% women with a mean age of 40.9 ± 8.9 years. 51% (409) of the pediatric ED patients were COVID-19 vaccinated, as were 74% (591) of the caregivers. There was variation across sites, but overall, 15% of caregivers of unvaccinated children wanted the child tobe vaccinated with the most common barriers to vaccination identified as safety data (25%), time availability (20%), and ability to obtain an appointment (13%). The most common reason for not wanting the child COVID-19 vaccinated was concern the vaccine didn't work or had too many side effects.

Conclusion: A small but clinically important group of pediatric ED patients are not COVID-19 vaccinated but their caregivers want them to be vaccinated, indicating that consideration should be given to offering vaccination in the ED. Reasons for avoiding COVID-19 vaccination were primarily concerns with efficacy and side effects. [West J Emerg Med. 2025;26(1)96–102.]

INTRODUCTION

Vaccination has been a key intervention in reducing the burden of COVID-19 on society and the healthcare system. Vaccination provides protection against COVID-19 and its short- and long-term complications, including preventing multisystem inflammatory syndrome in children after a COVID-19 infection.[1] The COVID-19 vaccination also mitigates the risk of children acting as disease vectors for high-risk populations and reduces the burden placed on families when an infected child needs to be quarantined from childcare or school.[2] The COVID-19 vaccine was approved for emergency use in children ages 5–17 and as of August 2022, 38% of US children aged 5–11 and 70% of children aged 12–17 have received at least one dose of a COVID-19 vaccine.[3] In contrast, 57% of US children aged 5–12 and 48.1% of children 13–17 received the flu vaccine for the 2021–2022 season.[4]

The use of the emergency department (ED) to deliver vaccines like the COVID-19 vaccine may be a way to increase vaccination rates, especially during a pandemic when in-person primary care visits are limited. After recognizing the need for more targeted efforts to vaccinate those who had not yet sought the vaccine, or remained hesitant, and the potential role of the ED as a healthcare safety net during a pandemic, a survey was conducted of adults presenting to an ED in Buffalo, NY to identify vaccination rates among ED patients and barriers to vaccination. The authors of that study found that adult ED patients were vaccinated at a slightly lower rate than the general population and that a small but significant portion of those who were unvaccinated desired to be vaccinated, suggesting that the ED may be a suitable location to vaccinate adults against COVID-19.[5] The study did not consider children, a population in which vaccination hesitancy has historically been heightened stemming from false claims that autism spectrum disorder may be attributed to childhood vaccinations in the 1998 paper published in *The Lancet*,[6] which was subsequently discredited and the principal author Andrew Wakefield struck from the United Kingdom medical register. Studies have shown that providing the influenza vaccine in a pediatric ED (PED) can increase vaccination rates and overcome hesitancy.[7,8]

Vaccination rates for COVID-19 among children in the US vary greatly between states.[3] For this reason we chose to survey four different regions of the country. Little is known about the vaccination rate of the PED population. In this study we aimed to determine whether the adult companions of children in the ED had the same vaccination status as the child they were accompanying, the reasons they chose not to vaccinate the child they were with, and any self-identified barriers to vaccination of the child.

Population Health Research Capsule

What do we already know about this issue?
Vaccination is a useful intervention in epidemics by promoting herd immunity. The ED is often used as a safety net to provide primary care for underserved populations.

What was the research question?
Should the COVID-19 vaccine be offered in the pediatric ED?

What was the major finding of the study?
At four children's hospitals, the majority (73%) of adults accompanying children to the ED had the same vaccination status against COVID-19 as the pediatric patient. However, 15% of caregivers wanted to have their unvaccinated child vaccinated.

How does this improve population health?
The pediatric ED may be an adequate site for COVID-19 vaccination as a significant portion of the adult companions of unvaccinated pediatric patients desired vaccination for their child.

METHODS

We conducted a researcher-administered survey in four EDs providing pediatric emergency care in geographically diverse areas of the United States. The survey was conducted from June 15–October 28, 2022 with sites starting enrollment at different times based on when they received institutional review board (IRB) approval. The surveys were conducted when research assistants (RA) were available in the ED with the goal of collecting 200 surveys at each site. This study was approved by the IRBs at each site: Augusta University in Augusta, GA; State University of New York at Buffalo in Buffalo, NY; University of California Davis in Sacramento, CA; and University of Wisconsin Madison in Madison, WI. Each participant provided verbal consent to participate in the survey.

Setting

The survey was conducted at four pediatric specialty hospitals in the US. In Augusta, GA, the site was the region's only children's hospital, which sees approximately 30,000 ED visits per year. The hospital is in Richmond County with a population just over 200,000 people. In Buffalo, NY, the site was the region's only children's hospital, which sees 45,000 visits per year. The hospital is in Erie County with a population of just over 950,000 people. In Madison, WI, the site was the region's only children's hospital, which sees 18,000 visits per year. The hospital is in Dane County with a

population just under 270,000 people. In Sacramento, CA, the site is one of three children's hospitals, which sees 10,000 visits per year. The hospital is in Sacramento County with a population just over 1.5 million people.

Eligibility Criteria

All patients between 5–17 years of age who presented to a participating ED were considered for enrollment in the study. Triage category, chief complaint, and patient demographics were recorded from the patient's chart. The RA then approached the patient's clinician to determine whether the adult accompanying the patient could be approached for the survey. Reasons that the adult accompanying the patient was not able to be approached included infectious precautions for the patient, patient was too ill, patient was actively receiving medical care, the adult did not speak English, the patient was sleeping, or the clinician identified that it was not appropriate for them to be approached at that time. If the patient's adult companion could be approached for the survey, the RA entered the room and obtained verbal consent.

Data Collection

After consent was obtained, the survey was verbally administered to the adult companion of the patient and the answers were recorded using REDCap 10.3.3 (Research Electronic Data Capture, Vanderbilt University, Nashville, TN) (hosted at Jacobs School of Medicine and Biomedical Sciences) on an iPad (Apple Inc., Cupertino, CA). The survey questions are available in Appendix 1. Pediatric ED (PED) patient and adult companion demographic characteristics collected included age at presentation, race, ethnicity, and gender. We also collected education level, insurance type, and where the respondent reported obtaining their information on COVID-19.

Pediatric patients and adult companions were classified as COVID-19 vaccinated if they had received at least one dose of the vaccine. Those who were not vaccinated were divided into those who wanted to get the vaccine and those who did not want to get the vaccine. For queries regarding barriers to care, the question was read exactly to the participant, but answer choices were not provided. Instead, as the participant stated their response, the RA categorized the response or recorded it as "other," and wrote down what the participant had stated. For responses that did not fit one of the given categories, RAs documented them and one author (EBL) then classified them. If the response could not be classified, it was defined as "other" for analysis.

Data Analysis

Once data collection was completed, it was exported from REDCap and analyzed using SAS 9.4 (SAS Institute Inc, Cary, NC). We used descriptive statistics, Cohen's kappa, and logistic regression to analyze the survey responses. We excluded cases from further analysis if data was missing. We developed two logistic regression models to assess the effects of demographic factors on the adult companion's COVID-19 vaccination status and PED patient's COVID-19 vaccination status separately, where adult companion and child's COVID-19 vaccination status were both a binary response (vaccinated, not vaccinated), and different factors were used in two separate, logistic models. One logistic model was developed to assess the effects of adult clinical site on the adult companion's COVID-19 vaccination status. We built a second logistic regression model to investigate the effects of the study site on the PED patient's COVID-19 vaccination status. We excluded cases with missing data from these models. Finally, we used Cohen's kappa to measure the agreement between COVID-19 vaccination status of adult companion and PED patient.

Table 1. Individuals considered for enrollment and enrolled in the study compared by site.

	Total	Buffalo, NY	Davis, CA	Madison, WI	Augusta, GA
Considered for enrollment	941	261	230	241	209
Staff agreed to let research assistant approach	904	249	219	230	206
Reason not approached*		4 - patient sleeping 2 - adult did not speak English 2 - patient/adult not present in room 4 - staff not asked	1 - patient sleeping 1 - adult did not speak English 1 - patient/adult not present in room 1 - adult too upset 1 - unknown 6 - staff not asked	3 - adult did not speak English 1 - patient receiving medical care 2 - adult too upset 1 - infectious precautions 4 - staff not asked	2 - patient receiving medical care
Consented to participate	800	200	200	200	200

Note: In 13 cases staff were not asked first, but patient consented (3 Buffalo, 6 Davis, 3 Madison, 1 Augusta).

Table 2. Description of the included subjects compared by site.

		Total N = 800	Buffalo n = 200	Davis n = 200	Madison n = 200	Augusta n = 200
Gender of participant	Male	22% (174)	22% (44)	29% (57)	22% (43)	15% (30)
	Female	75% (600)	77% (154)	71% (141)	78% (155)	75% (150)
	Other or missing	3% (26)	1% (2)	1% (2)	1% (2)	10% (20)
Gender of patient	Male	49% (394)	49% (97)	42% (83)	55% (109)	53% (105)
	Female	50% (402)	52% (103)	59% (117)	44% (88)	47% (94)
	Other or missing	1% (4)	0% (0)	0% (0)	1% (3)	<1% (1)
Age of participant	Mean years (SD)	40.9 (8.9)	40.4 (8.9)	41.3 (8.8)	41.5 (6.6)	40.2 (10.6)
Age of patient	Mean years (SD)	11.2 (5.1)	11.7 (7.4)	10.6 (4.0)	11.6 (4.0)	10.8 (4.3)
COVID-19 vaccination status participant	Received any vaccine	74% (591)	80% (159)	74% (148)	82% (163)	61% (121)
COVID-19 vaccination status patient	Received any vaccine	51% (409)	56% (111)	47% (94)	70% (140)	32% (64)

Table 3. Self-reported barriers to vaccination in unvaccinated by desire to obtain vaccine.

	Reason don't want vaccine for themselves (N = 189)	Want vaccine for themselves; reason they haven't gotten it (n = 13)	Reason don't want vaccine for child patient (n = 318)	Want vaccine for child patient; reason they haven't gotten it (n = 56)
Afraid	1% (2)	-	1% (2)	2% (1)
Already had COVID-19	5% (10)	8% (1)	5% (15)	7% (4)
Can't get an appointment/no appointment at desired location	-	15% (2)	-	13% (7)
Child doesn't want vaccine	-	-	1% (4)	5% (3)
Don't think I/child is eligible to get vaccine/not sure when to get it	-	8% (1)	1% (4)	5% (3)
Do not have transportation to vaccine site	-	8% (1)	-	-
Don't think vaccine works	37% (70)	18% (1)	27% (87)	2% (1)
Underlying health condition	1% (1)	-	1% (3)	7% (4)
Let others get vaccine first	1% (1)	-	3% (9)	-
No reason/unsure	1% (1)	-	1% (2)	-
It is not necessary to be vaccinated	4% (8)	-	4% (13)	-
Other reason: not categorized or blank	2% (4)	-	3% (11)	4% (2)
Other family member doesn't want child to get vaccine	-	-	2% (5)	7% (4)
People like me/the child don't get severe COVID-19	3% (5)	-	2% (6)	-
Personal reasons	5% (10)	-	1% (4)	-
Pregnant, planning to get pregnant, or breastfeeding	1% (2)	-	-	-
Religious reasons	3% (5)	-	2% (7)	-
The side effects/risks associated with the vaccine	20% (38)	-	24% (77)	2% (1)
Waiting for more safety data on the vaccine	16% (30)	54% (7)	19% (62)	25% (14)
Waiting to receive physician approval for vaccine	-	-	1% (2)	2% (1)
Work or family commitments/lack of time	1% (2)	-	2% (5)	20% (11)

RESULTS

Between the four study sites, 941 adult companions were considered for enrollment, and 800 (85%) were able to be approached and consented to participate (Table 1). Of the participants, 75% were women and the mean age was 40.9 ± 8.9 years. In contrast, the PED patients were 50% female. When compared across study sites, there were differences in demographics that generally aligned with the participating hospitals' catchment areas (Table 2). Approximately half of the PED patients and three-quarters of their adult companions were vaccinated against COVID-19. There was variation across the sites, but for 15% (56) of the PED patients who were not COVID-19 vaccinated, the respondent stated that they wanted the child to be vaccinated. These 56 cases represented 7% of the total interviewed sample. Further, 92% (375) of the vaccinated PED patients and 97% (571) of the vaccinated adult companions reported receiving the recommended second COVID-19 vaccine dose or the single dose if they had received the Johnson & Johnson vaccine.

Of the adult companions who were not COVID-19 vaccinated and gave reasons for not getting themselves or the PED patient COVID-19 vaccinated, the most common reasons were feeling that the vaccine didn't work or had too many side effects (Table 3). When looking at the vaccination status of the PED patient and their adult companion, we found that for 49% both were COVID-19 vaccinated, and for 24% neither was vaccinated. It was more common for just the adult companion to be COVID-19 vaccinated (25%) than just the PED patient (3%). The kappa estimate was 0.44 (95% confidence interval 0.38–0.50), significantly different from zero, indicating moderate agreement between COVID-19 vaccination status of the adult companion and PED patient. We excluded five observations from comparison due to missing either the adult companion's or PED patient's COVID-19 vaccination status.

Figure 1 shows results of demographic factors associated with adult companion being COVID-19 vaccinated. The odds of being COVID-19 vaccinated for adult companions in

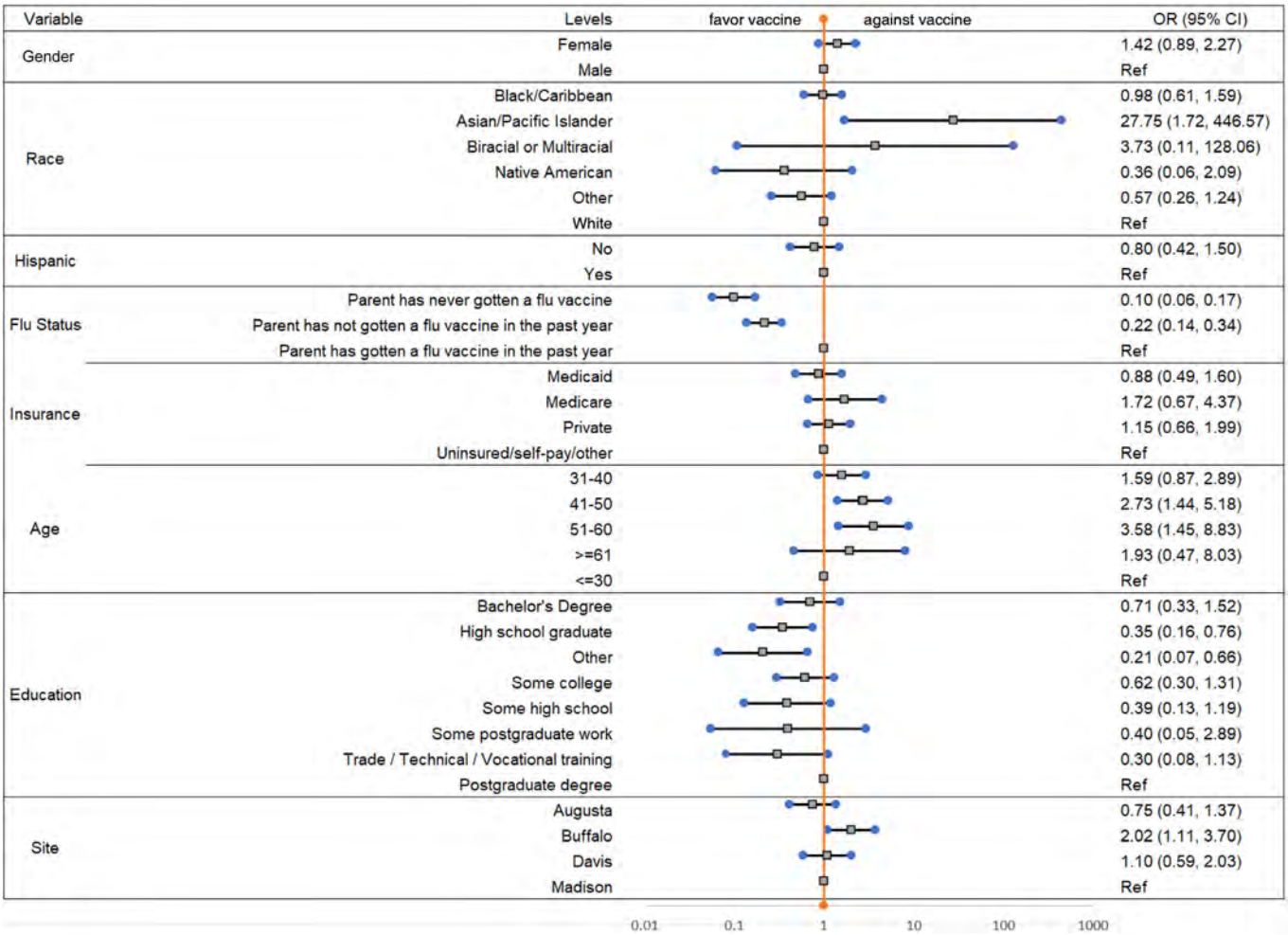

Figure 1. The odds ratios (OR) and 95% confidence intervals (CI) for parent companion vaccinated for different demographic characteristics. Note: Odds ratio for parent companion were estimated using Firth's penalized likelihood approach.

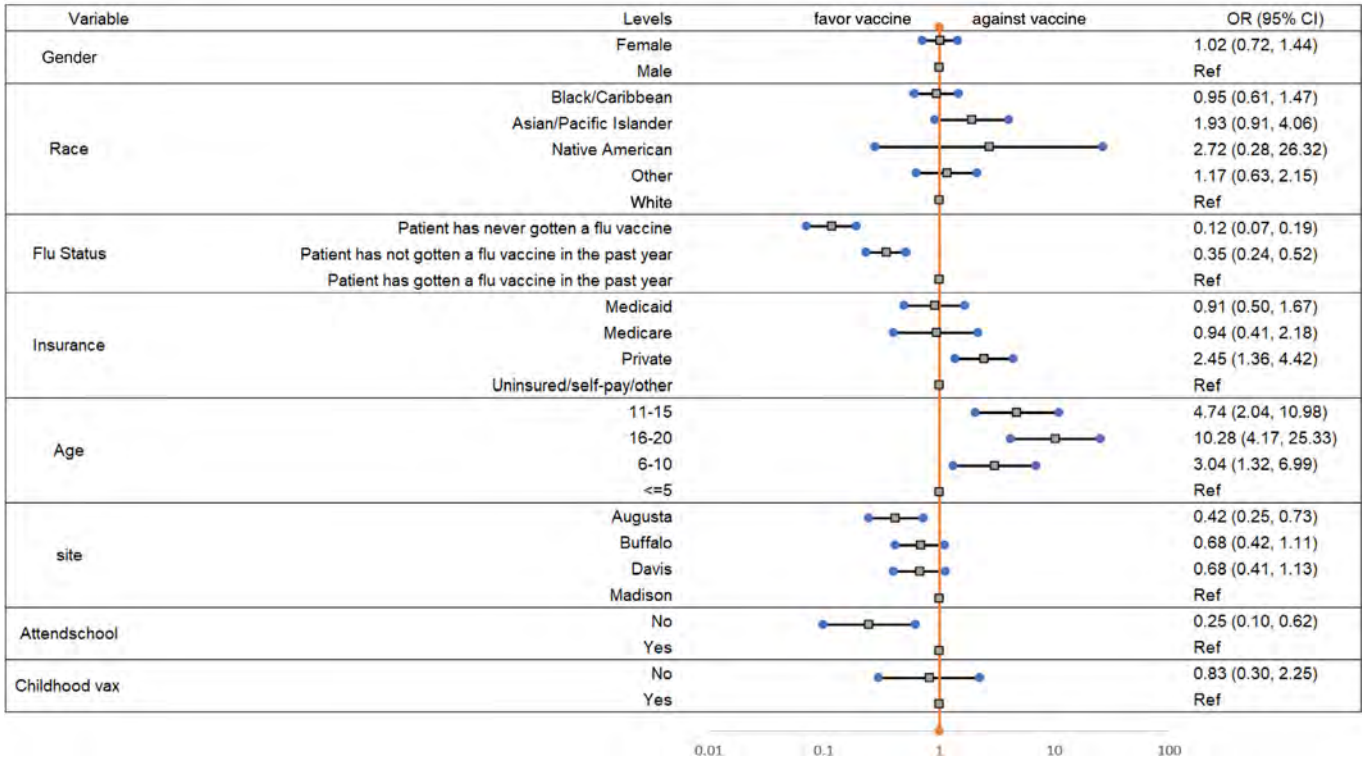

Figure 2. The odds ratios (OR) and 95% confidence intervals (CI) for child patient vaccinated for different demographic characteristics.

Buffalo was 2.02 times that of the Madison site. The results of demographic factors associated with the PED patient being COVID-19 vaccinated is shown in Figure 2. The odds of being COVID-19 vaccinated among PED patients at the Augusta site was 0.42 times that of PED patients at the Madison site. The logistic regression models for adult companions and PED patients were built on 738 and 775 of 800 participants, respectively. The remaining cases were missing data.

DISCUSSION

In this study we determined that the majority (71.9%) of adult companions of children in the PED had the same COVID-19 vaccination status as the child they were accompanying. Of those with different COVID-19 vaccination status, in most cases (90%) the adult companion had been vaccinated but not the child they were accompanying. This finding may reflect the hesitancy associated with child vaccines, particularly the COVID-19 vaccine.[9] It may also be the result of vaccine requirements that were placed on adults at this point in the pandemic: for example, the requirement that all federal employees, contractors, international travelers, Head Start education centers, and Centers for Medicare & Medicaid Services-certified facility employees be COVID-19 vaccinated, which was rescinded in 2023.[10] To our knowledge there were no federal or local requirements at our study sites to vaccinate children, which may have contributed to this finding.

Overall, 49% of the PED patients were not vaccinated. Similar to the results of the survey study of barriers to vaccination of adults presenting to the ED,[5] a small but significant number (15%) of adult companions of unvaccinated children from across all sites reported wanting the vaccine for the PED patient but had not yet received it. This population should be considered a primary target for increasing the COVID-19 vaccine rate in the pediatric population. Of these cases, one-third identified practical issues as the primary barrier to vaccination of the child. This finding was supported by the World Health Organization (WHO) Strategic Advisory Group of Experts Working on Group Vaccine Hesitancy. They identified practical issues as significant factors when considering vaccination, which included availability, affordability, ease of access, service quality, and respect from health workers.[11] The other reasons for not vaccinating these children were related to what the WHO report described as "thinking and feeling" issues related to risk and vaccine confidence and "social processes" related to social norms and health worker recommendations. Many of these issues might be able to be addressed through patient/adult companion education that can be provided in the ED. Even if vaccines are not offered in the ED, it may be advantageous to use the ED as a site for providing accurate information on the risks and benefits of COVID-19 vaccination.

LIMITATIONS

This study may have been limited by the patients who declined participation after being approached. As COVID-19 vaccination can be considered controversial, some individuals may have felt uncomfortable sharing their views and declined participation. It is possible that this group was more likely to not have been vaccinated. Additionally, the survey was read aloud to the patients and their verbal responses were recorded, which may have skewed results as people may have been ashamed to voice their views or fear judgment from medical professionals. Further, we did not study a representative sample of the ED patient population since we would not have approached those with serious or life-threatening illnesses. However, it is likely that any ED vaccination program would focus on this same subset of patients. We also were unable to interview adult companions who did not speak English. Finally, we assumed that the accompanying adult was a primary caregiver of the PED patient. The relationship between the PED patient and the adult companion was not determined or limited to just parents to ensure the study included non-traditional families.

CONCLUSION

A small but clinically important group of pediatric ED patients were not COVID-19 vaccinated, but their adult companions wanted them to be vaccinated, indicating that consideration should be given to offering vaccination in the ED setting. Most adults accompanying children had the same vaccination status as the pediatric ED patient but, interestingly, for the majority of those with differing vaccine status the adult was vaccinated but not the child. Reasons for avoiding COVID-19 vaccination seemed to center primarily on concerns with efficacy and side effects. Future studies could look at how patient demographics impact vaccination status and the intention to receive vaccination to target education and COVID-19 vaccination initiatives.

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Needs Assessment and Tailored Training Pilot for Emergency Care Clinicians in the Prehospital Setting in Rwanda

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Background: In low- and middle-income countries (LMIC), 45% of deaths could be addressed by implementation of an emergency medical services (EMS) system. Prehospital care is a critical component of EMS worldwide, and basic, affordable training has been shown to improve EMS systems. However, patient outcome impact is unclear. In this study we aimed to assess the current state of prehospital care in Kigali, Rwanda, through a needs assessment, focused training intervention, and analysis of current practices and patient outcomes.

Methods: We identified 30 clinicians through the prehospital medical command office and included them in the study. A prospective, nonrandomized, interrupted time-series approach was used. Data collected through closed- and open-ended questionnaires included age, sex, training, and knowledge assessment. We used the data to create a tailored, 18-hour training after which immediate and 11-month post-tests were administered. Linked prehospital and hospital care datasets allowed for evaluation of patient outcomes and prehospital process indicators that included training skill application, airway intervention, intravenous fluid administration, and glucose administration.

Results: Of 30 clinicians, 18 (60%) were female, 19 were nurses, and 11 were nurse anaesthetists. Median age was 36, and median years providing care was 10 (IQR 7–11). Twenty-four (80%) participants completed immediate and post-test assessments. Mean knowledge across 12 core skills significantly improved from a pre-test mean of 59.7% (95% confidence interval [CI] 42.2–77.20) to a post-test mean of 87.8% (95% CI 74.7–100). At 11 months post-training, the score improvement maintained, with a mean score of 77.6% (95% CI 59.2–96.8). For patient outcomes, the total sample size was 572 patients; 324 of these patients were transported to the ED during the pre-training period (56.4%), while 248 were transported post-training. Prehospital oxygen administration for patients with a saturation level of <95% significantly increased pre- to post-training (66.7% to 71.7%; $\Delta = 5.0\%$; Δ95% CI 1.9,–8.1%). No significant changes were noted in patient treatment outcomes or other process indicators due to small sample sizes.

Conclusion: This study provides insights on Rwandan EMS and demonstrates that a tailored intervention targeting education on prehospital process indicators has positive impacts on clinician knowledge and practice. [West J Emerg Med. 2025;26(1)103–110.]

Keywords: *trauma; training; emergency; prehospital; education.*

INTRODUCTION

Background

Emergency medical systems (EMS) provide populations with acute care for a diverse set of diseases spanning the spectrum of communicable infections, non-communicable diseases, obstetric and paediatric emergencies, as well as traumatic injuries.[1] The 2003 World Health Report drew attention to the increasing burden of non-communicable disease, chronic diseases, and trauma in low- and middle-income countries (LMIC)[2] and has called for "rapid and sustainable expansion of emergency treatments" globally.[3] Several studies, supplemented by reports from the World Health Organization (WHO), emphasize the importance of improving access to emergency health services to reduce morbidity and mortality specifically in LMICs.[1–11] An estimated 45% of deaths and 36% of disability-adjusted life years (DALY) in LMICs could be addressed by the implementation of emergency care systems.[4,5,6]

Prehospital care is a critical component of emergency care worldwide[1]. A systematic review of trauma systems by Mann et al showed consistent survival benefits following inexpensive interventions, such as organization and trauma system planning.[7] Survival benefits from addition of basic and affordable training to EMS have also been noted by health experts.[12,13] In resource-limited settings, prehospital training has shown success in improving clinician knowledge, although impact on clinician practice and patient outcomes is unclear.[14,15] Research on in-hospital emergency medicine training in LMICs is more robust, showing feasibility for such programs to improve patient and clinical outcomes as well as clinician knowledge.[16,17] Still, even for in-hospital programs, there remains a need for further research regarding their impact.[16] Further, existing literature on prehospital training in LMICs most often focuses on first responders who may not have formal trauma and emergent care training or who do not solely work in the prehospital setting.[18–21]

In Rwanda, the Ministry of Health (MOH) has made great strides in providing access to healthcare by rebuilding its health infrastructure in the aftermath of the 1994 genocide. To address prehospital care access, the MOH implemented an emergency medical ambulance system in 2007, named Service d'Aide Medicale Urgente (SAMU).[22] The SAMU prehospital professionals at the Centre Hospitalier Universitaire de Kigali (CHUK) are the sole providers of prehospital emergency care in Rwanda. Ambulances are equipped with oxygen tanks, intravenous fluids, supplies for peripheral line placement, medications, and defibrillators, and are staffed by nurses and nurse anaesthetists. A1 registered nurses with an advanced diploma have completed three years of post-secondary education while A0 nurses have a bachelor's degree with four years of post-secondary education and are capable of intubating patients.

Population Health Research Capsule

What do we already know about this issue?
In low- and middle-income countries, 45% of deaths could be addressed by emergency medical service (EMS) system implementation.

What was the research question?
How does am EMS training intervention impact current practices and patient outcomes?

What was the major finding of the study?
The use of oxygen for patients showed a significant increase post-training intervention (pre 66.7%, post 71.7%; Δ = 5.0%; Δ 95% CI 1.9–8.1%).

How does this improve population health?
Basic and affordable EMS training interventions can improve clinical medical knowledge and clinical processes.

Along with inexpensive training and trauma planning interventions, survival benefits associated with EMS are based largely on the identification of key performance indicators to improve the quality of patient care.[1,13,23] Thus, the Rwandan Human Resources for Health Strategic Plan recognized the need for nurse training programs that develop prehospital skills, while also strengthening ongoing mentoring and monitoring, especially as the standard nursing curriculum only offers in-hospital care training.[22] Despite the increased capacity of the Rwandan prehospital system, there is a paucity of information about the needs of prehospital professional training as well as limited information about current practices of prehospital management and its relationship to patient outcomes. To our knowledge this is the first study that aims to understand the needs of prehospital care professionals, and the impact of a novel prehospital professional training on clinical responsiveness and patient outcomes.

METHODS

Study Design

The study was conducted in multiple phases. In the first phase we analysed prehospital care needs and emergency care knowledge. The second phase was a training intervention designed from the results of phase 1. In the third phase we assessed data on prehospital process indicators and patient outcomes before and after the training intervention,

as well as prehospital professionals' pre- and post-test scores, to evaluate the impact of the training, using a prospective, quasi-experimental, non-randomized, interrupted time series design.

Study Setting

The training intervention was held at the Kigali Institute of Science and Technology (KIST) in May 2017. and we used data from the prehospital database at the University Teaching Hospital in Kigali (UTH-K) to analyse prehospital process indicators and patient outcomes. The study was approved by the Lifespan Institutional Review Board and the Institutional Review Board and Ethics Committee of UTH-K.

Participants

All 30 prehospital care professionals at the UTH-K were included in the needs assessment and training intervention. We identified the study population by a list of prehospital professionals as reported by the human resources department and confirmed with the director of the ambulance services. A non-randomized approach was taken to minimize interruption in participant workflow. We excluded ambulance drivers as well as EMS administrative staff at the call centres not directly involved in patient care.

We identified the patient study population sample through paper, prehospital ambulance records. A trained research assistant linked prehospital paper run sheets to emergency department (ED) health records. The linkage was performed through querying OpenClinic, an open-source, integrated hospital information management system (OpenClinic GA, San Diego, CA). Patient names, date of birth, and addresses found in OpenClinic were matched to the SAMU database to confirm identity. The eligible analytical sample included all patients transported to the UTH-K ED by SAMU between December 1, 2017–June 30, 2018. These dates are inclusive of four months of pre-training and three months post-training. We excluded paediatric patients with medical chief complaints and obstetric patients as they are transferred to their respective emergency centres.

Data Measurement

The needs assessment and pre-test data were collected using a closed- and open-ended questionnaire. The survey consisted of three parts: 1) demographic data, including age, sex, preferred language, and information about prehospital professional background; 2) needs assessment on prior 12 months training received on 12 core clinical skills; and 3) pre-test questions assessing clinical knowledge about and confidence in performing these 12 skills. We used the information collected from this instrument for the creation of an educational intervention deemed to be locally appropriate and based on the region's prehospital needs.

The EMS professionals attended a 17-hour educational intervention administered over two days. A two-day course was preferred by the local team to limit interruption of care to patients. The course structure included didactic lectures, team discussions, simulation exercises, and pre- and post-tests at the KIST simulation centre. The training intervention focused on pre-identified skills for improvement, based on the needs assessment. These skills are, therefore, inclusive of patient presentations that most often go unrecognized or untreated in a prehospital setting, as well as clinical interventions that are associated with decreased prehospital professional confidence. The efficacy of the training intervention was evaluated by an immediate post-test and 11-month post-test determining the knowledge gain and change in report of confidence in performing 12 core clinical skills (Table 1).

To collect data regarding implementation of these learned skills, we used a restrictive sampling frame. Key process indicators were selected based on elements of EMS care that are both responsive to system improvements and achievable in low-resource settings. An emphasis was placed on interventions with a high probability of decreasing medically preventable death or disability due to trauma. Outcomes for analysis thus included the following: use of IV fluid resuscitation for hypotensive patients (blood pressure less than 90/60 millimeters of mercury) or patients with burn injury; administration of oxygen to hypoxic patients (oxygen less than 95%); and administration of glucose to hypoglycaemic patients (glucose less than 60 milligrams per decilitermg/dl).

Patient outcome data extracted from hospital records included initial vital signs, diagnosis, hospital length of stay, and condition upon discharge. The extracted data was de-identified and entered into a secured RedCap database (Research Electronic Data Capture, Vanderbilt University, Nashville, TN) hosted at Lifespan in Providence, Rhode Island.

Statistical Methods

We analyzed pre- and post-tests for change in knowledge. Descriptive and inferential statistics were conducted, with median values and interquartile range (IQR) reported. Conducted statistical tests included the Fisher exact test for differences in proportions, the Wilcoxon rank sum test for tests of medians, and paired *t*-tests for differences in knowledge and confidence. Yes and no binary variables for prehospital clinical process indicators were coded as 1 or 0, respectively. The outcomes for fluid administration for patients with burns and those with hypotension were combined, due to the small numbers of patients (seven) with burns. Additionally, ED patient care outcomes pre- and post-training intervention were analysed. We conducted statistical analysis was conducted using SAS statistical software v 9.4 (SAS Institute Inc, Cary, NC).

Table 1. Prior 12-month core skill training experience of prehospital professionals in Rwanda.

Core skill	I do not know what this means n (%)	No training n (%)	1–5 hours n (%)	6–10 hours n (%)	More than 11 hours n (%)
a. Taking vital signs	0	19 (65.5)	3 (10.4)	1 (3.4)	6 (20.7)
b. Placing an Intravenous line	0	19 (65.5)	2 (6.9)	1 (3.4)	7 (24.1)
c. Placing an Intraosseous access	0	27 (93.1)	0	1 (3.4)	1 (3.4)
d. Checking glucose	0	15 (57.7)	3 (11.5)	1 (3.9)	7 (26.9)
e. Performing the trauma ABC evaluation	1 (3.5)	10 (34.5)	3 (10.3)	6 (20.7)	9 (31.0)
f. Intubation	0	11 (64.7)	1 (5.9)	1 (5.8)	4 (23.5)
g. Immobilizing a trauma patient	0	12 (44.4)	2 (7.4)	5 (18.5)	8 (29.6)
h. Performing needle decompression	0	18 (64.3)	4 (14.3)	4 (14.3)	2 (7.2)
i. Performing CPR	0	3 (15.8)	0	6 (31.6)	10 (52.6)
j. Performing defibrillation	0	18 (64.3)	2 (7.1)	3 (10.7)	5 (17.9)
k. Splinting a fracture	0	16 (59.3)	3 (11.1)	0	8 (29.6)
l. Injecting aubcutaneous epinephrine	0	21 (72.4)	4 (13.8)	1 (3.5)	3 (10.3)

CPR, cardiopulmonary resuscitation.

RESULTS

Participants and Descriptive Data

Of the 30 prehospital clinicians, 18 (60%) were female, 19 were nurses, and 11 were nurse anaesthetists. The median age was 36 years and median time providing care was 10 years (interquartile ratio 7–11). Twenty-four participants (80%) completed the training intervention and an immediate post-test. Sixteen participants (53.3%) completed both the immediate and 11-month post-tests.

Needs-Assessment Results

A needs assessment was conducted prior to training. Table 1 shows the frequency of prior past-year training reported by participants. Across the 12 core skills, 'no training' was most frequently reported for placing an intraosseous access (IO) (93.1%), injecting subcutaneous epinephrine (72.4%), taking vital signs (65.5%), and placing an IV line (65.5%). More than 11 hours of training was most often reported for performing cardiopulmonary resuscitation (52.6%), performing trauma ABC evaluation (31%), immobilizing a trauma patient (29.6%), and splinting a fracture (29.6%). Pre-intervention, 15 participants (50%) reported wanting more training on trauma skills (bleeding control, IV and IO line placement, use of oxygen masks, understanding vital signs).

Correspondingly, median confidence in performing these 12 core skills varied at the pre-training needs assessment (Table 2). Using the Wilcoxon rank-sum test with paired comparisons between the three assessments of confidence, we found there were significant increases in median confidence in placing an IO (pre to immediate post $P = .02$; pre to 3-month post $P < .01$); and performing needle decompression (pre to immediate post $P = 0.0002$, pre to 11-month post $P = 0.003$).

Knowledge Results

The mean pre-test correct knowledge score was 59.7% (95% confidence interval [CI] 42.2–77.20). The immediate post-test mean score was 87.8% (95% CI 74.7–100), and 11 months after training the mean test score was 77.6% (95% CI 59.2–96.8). There was a 56% (95% CI 36.2–75.8) relative increase in mean knowledge score that was maintained between the immediate and 11-month post-test. There was a significant gain in knowledge between pre-intervention and immediate post-test ($P < .001$), and this difference was significant between pre and 11-month post-test ($P < 0.001$) using paired t-tests comparing the survey administrations. The gain was significantly higher in the immediate post-test compared to the 11-month post-test ($P = .02$). Scores in the categories of patient assessment, respiratory intervention, and fluid therapy improved by 8%, 21% and 8%, respectively. All respondents reported that the training had both increased their medical knowledge and improved patient care, and all respondents requested further training.

Patient Care Results

In total, 572 patients were transported to the ED for care during the study; 324 (56.4%) were transported during the pre-training period. The average patient age was 37 years (SD 15.8, range 15–96), and 148 (25.7%) were female, with no significant difference in average age ($P = .08$) or sex ($P = .14$) proportion pre- and post-training. Table 3 shows the frequency of clinical conditions of interest pre- and post-training and clinical

Table 2. Prehospital professionals' confidence on Likert scale of 1–5 performing core skills.

Confidence in performing core skill	Median (IQR) pre training (1)	Median (IQR) post training immediate (2)	Median (IQR) post training 11 months (3)	Statistical comparison
a. Taking vital signs	5 (5,5)	5 (5,5)	5 (5,5)	1 vs. 2 = ns 1 vs. 3 = ns 2 vs. 3 = ns
b. Placing an intravenous line	5 (5,5)	5 (5,5)	5 (5,5)	1 vs. 2 = ns 1 vs. 3 = ns 2 vs. 3 = ns
c. Placing an intraosseous access	2 (2,3)	3 (2,4)	4 (3,4)	1 vs. 2 = 0.02 1 vs. 3 = 0.002 2 vs. 3 = ns
d. Checking glucose	5 (5,5)	5 (5,5)	5 (5,5)	1 vs. 2 = ns 1 vs. 3 = ns 2 vs. 3 = ns
e. Performing the trauma ABC evaluation	5 (4,5)	5 (5,5)	5 (5,5)	1 vs. 2 = ns 1 vs. 3 = 0.05 2 vs. 3 = ns
f. Intubation	3 (3,5)	4 (3,5)	5(4,5)	1 vs. 2 = ns 1 vs. 3 = ns 2 vs. 3 = ns
g. Immobilizing a trauma patient	5 (5,5)	5 (5,5)	5 (5,5)	1 vs. 2 = ns 1 vs. 3 = ns 2 vs. 3 = ns
h. Performing needle decompression	3 (3,4)	4 (4,5)	4 (4,5)	1 vs. 2 = 0.0002 1 vs. 3 = 0.003 2 vs. 3 = ns
i. Performing CPR	5 (4,5)	5 (4,5)	5 (5,5)	1 vs. 2 = ns 1 vs. 3= 0.04 2 vs. 3 = ns
j. Performing defibrillation	4 (3,4)	4 (3,4)	5 (4,5)	1 vs. 2 = ns 1 vs. 3 = 0.03 2 vs. 3 = 0.05
k. Splinting a fracture	5 (5,5)	5 (5,5)	5 (5,5)	1 vs. 2 = ns 1 vs. 3 = ns 2 vs. 3 = ns
l. Injecting subcutaneous epinephrine	4 (4,5)	5 (3,5)	5 (4,5)	1 vs. 2 = ns 1 vs. 3 = ns 2 vs. 3 = ns

ge; 1 = pre training, 2 = immediate post training, 3 = 11 months after training.
CPR, cardiopulmonary resuscitation; *IQR*, interquartile range.

outcomes. Using chi-square tests, we found no significant differences pre- to post-training across the three types of clinical presentation of interest ($P = .68$), ED disposition ($P = .24$), median hours spent in the ED ($P = .64$), or median length-of-hospital stay for those admitted ($P = .85$).

Process Indicator Results

Table 4 details the frequency of prehospital clinical interventions before and after the training intervention. A review of data showed that IV fluid resuscitation was given to all indicated patients pre- and post-intervention, and that the use of oxygen for patients with a saturation level of < 95% showed a significant increase in proportion pre- to post-intervention (pre = 66.7%, post = 71.7%; Δ = 5.0%; Δ 95% CI 1.9–8.1%), as the 95% CI around the Δ does not include 0. Table 4 also shows this significant change in administration of oxygen for hypoxic patients over the pre- and post-intervention period.

DISCUSSION

This study not only demonstrates statistically significant test improvements for a needs assessment-based, context-appropriate education intervention, but also explores

Table 3. Emergency department patient putcomes.

Clinical presentation n (%)	Pre training n = 324	Post training n = 248
Burn	5 (1.5)	2 (0.80)
Hypotension	15 (4.7)	13 (5.4)
Hypoxia	75 (23.2)	52 (20.7)
Hypoglycaemia	1 (0.30)	0
Clinical outcomes		
ED disposition	Admit = 154 (73.3) Transfer = 9 (4.3) Discharged = 39 (18.6) Died in ED = 8 (3.8) Died after admission = 18 (12.1)	Admit =142 (79.3) Transfer = 2 (1.1) Discharged = 33 (16.7) Died in ED = 5 (2.8) Died after admission = 15 (10.6)
Length of stay in ED (hours) Median (IQR)	24 (24,48)	24 (24,48)
Length of stay if admitted (days) Median (IQR)	3 (1,10)	3 (2,10)

ED, emergency department; *IQR*, interquartile ratio.

Table 4. Prehospital clinical process indicators (prehospital professionals' responsiveness).

Clinical presentation	Expected clinical intervention	Frequency administered pre training (%)	Frequency administered post training (%)
Burn and/or hypotension	Use of intravenous fluid resuscitation	20 (100)	15 (100)
Hypoxia ($SpO_2 < 95\%$)	Oxygen given	50 (66.7)	38 (71.7)
Hypoglycaemia	Glucose administered	0	0

prehospital process indicators and patient outcomes. The pre- to post-test improvements, especially regarding patient assessment, respiratory intervention, and fluid therapy, remained significant at the 11-month post-test, demonstrating long-term knowledge retention. Importantly, significant pre- to post-test increase in hypoxia responsiveness demonstrates actual implementation of learned skills. These concrete positive results are bolstered by statistically significant increases in prehospital clinical confidence, which occurred across multiple skills. These improvements are important, as self-confidence has been shown to enhance clinical competency and effective clinical decision-making.[24] Additionally, participants noted positive responses to the training modules and even requested additional training, speaking to desirability and feasibility of such prehospital training modules in similar contexts.

It is important to note that most prehospital professionals in this region are women, as sex may impact learning styles, clinical confidence, and other relevant variables.[25,26] Future studies are needed to assess the impact of gender on learning styles. It is also important to note that the data did not support any significant change in measured patient outcomes. This may be because measured outcomes were more impacted by issues in ED operations, such as staff boarding difficulties as well as limited capacity and resources. Also, there was a small decrease in ED and in-hospital mortality post-training, although the sample size was too small to detect any significant difference, and other interventions may have confounded the result.

Direct observation, prospective analysis, and improvement in methods are needed after such a training intervention to assess future patient outcomes. Overall, the promising association between a tailored training curriculum and improved post-test indicators in various trauma topics, as well as the acceptability of modules amongst participants, establishes the usefulness for such trainings amongst prehospital professionals. Further training should be considered for other groups including graduating medical students and general practitioners practicing emergency medicine.

Most importantly, this study is setting the stage for a longer term, comprehensive, and locally run emergency care training to sustainably establish knowledge retention and improve clinical process indicators.[16]

LIMITATIONS

CHUK is a tertiary-care hospital, with multiple subspecialty training programs that were in their infancy at

the time of this study. Other training programs could have introduced bias into the knowledge retention assessment and patient outcome analysis. Thus, these results may not be generalizable to other contexts. Training-specific limitations include interruptions in post-test administration due to leaves of absence of training staff, as well as loss of participants due to the need for staffing ambulances in critical need. As a result, their patient outcome data were not included in the study. The 11-month post-intervention analysis results did not have a control group, as equitable training was a necessary need at the time. More longitudinal studies evaluating the impact of tailored trainings on clinician retention and clinical effectiveness are needed.

Finally, process indicators to assess prehospital responsiveness did not encompass all skills from the training. Namely, the training improved prehospital professionals' patient assessment skills, but clinical case scenarios encompassed much more than what could be measured from the predefined prehospital process indicator run sheet. Quantity of fluid administration could not be analysed as this was not documented, and the impact of the training on prehospital responsiveness to patients with burn injury, as well as hypoglycaemia, could not be accurately measured due to limited data available for this patient population.

CONCLUSION

The study demonstrated that a basic course tailored to a group of prehospital EMS professionals in Rwanda could lead to improvement in emergency care knowledge, confidence, and an appropriate response to hypoxia. It is important to note that most prehospital professionals in this region are women. Context-driven education on prehospital emergency care is needed to appropriately address specific needs in LMICs and offers EMS professionals greater confidence in their knowledge and skills. The research contributes to the generalizable knowledge on prehospital care in resource-limited settings and serves as a foundation for the development of protocols that will improve patient care and strengthen the Rwandan healthcare system. Further studies are needed to evaluate such trainings in similar contexts, to investigate the impact on clinical outcomes.

Dissemination of Results

The results from this study were disseminated to stakeholders including prehospital EMS professionals, the Ministry of Health, and hospital staff.

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Emergency Physicians' and Nurses' Perspectives on Transgender, Intersexual, and Non-Binary Patients in Germany

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Introduction: Providing appropriate healthcare for transgender, intersexual and non-binary (TIN) individuals remains a significant challenge, as this group experiences higher rates of health inequalities, discrimination, and barriers to accessing care. Emergency physicians (EP) often lack formal training and knowledge about caring for TIN patients, while comparatively less evidence is available for other healthcare professionals, including emergency nurses (EN). Therefore, our goal in this study was to explore the experiences, knowledge, and attitudes as well as education/training needs of both ENs and EPs in Germany regarding the care of TIN patients.

Methods: In February 2023, we electronically surveyed EPs and ENs from emergency departments (ED) across Germany. The survey, developed through literature review and collaboration with experts and members of the TIN community, consisted of 15 closed-ended items divided into three sections: experiences and knowledge; attitudes; and education/training needs. We used standard descriptive statistics and tested for group differences using the chi-square test.

Results: Of the approximately 1,665 EPs and ENs contacted, 502 completed the survey and were eligible for further analysis (30% response rate). Of the respondents, 233 (46%) were EPs and 269 (54%) were ENs, with ENs being significantly younger and with fewer years in practice. More than half reported experience caring for TIN patients (71% of ENs vs 61% of EPs; $P = 0.002$), but there were significant gaps in medical and non-medical knowledge. Attitudes toward TIN patients were generally positive, but differences in communication approaches were noted, with ENs significantly more likely than EPs to limit their communication with TIN patients to what was necessary (25% of ENs vs 17% of EPs; $P = 0.006$). Most respondents (55% of ENs and 58% of EPs) had no training in the management of TIN patients, with only 8% of EPs and 17% of ENs having received such training during their medical/nursing school education ($P = 0.01$). Both groups agreed that there is an urgent need to increase awareness of emergency medical care for TIN patients among ED staff.

Conclusion: Both emergency physicians and nurses in Germany demonstrated deficits in knowledge of and clinical preparedness to care for patients in the ED who identify as transgender, intersexual and non-binary, indicating a clear need for enhanced education, training, and institutional support to improve emergency care for this vulnerable patient population. [West J Emerg Med. 2025;26(1)111–119.]

INTRODUCTION

Providing appropriate healthcare to people with transgender, intersexual, and non-binary (TIN) identities remains a significant challenge in many healthcare systems, including in Germany.[1] In the United States and Europe, approximately 0.6% of the adult population identifies as TIN, whereas the prevalence among adolescents is estimated to be approximately 1.4–4.1%.[2,3,4] While much of the relevant literature focuses on LGBTQ+ (lesbian, gay, bisexual, transgender, questioning/queer) patients in general and does not distinguish between sexual minorities (eg, LGB) and gender minorities (eg, trans), studies have consistently shown that TIN individuals in particular experience health inequalities, including higher rates of substance use disorder, disability, and mental illness.[5,6]

Their lifetime risk of attempting suicide is more than 10 times higher than that of the general population (54% vs 5%).[7] Individuals identifying as TIN are also disproportionately affected by homelessness, underemployment, and extreme poverty.[8,9] These challenges are compounded by barriers to accessing healthcare in both the US and Europe, as demonstrated for Germany in the InTraHealth study. Due to fear of discrimination or past negative experiences, many TIN individuals avoid interactions with healthcare professionals, which can lead to delayed presentation, diagnosis, and therapy.[6,10]

A recent study by Samuels et al found that nearly half of trans and non-binary individuals surveyed avoided care in the emergency department (ED) due to anticipated discrimination, fear of mistreatment, and long wait times.[11] Deficits in knowledge and clinical preparedness have been demonstrated for emergency physicians (EP) and residents in the US and Canada. While most EPs (88%) provide care to members of this population, few (27.5%) have had formal training and, therefore, lack clinical knowledge about important aspects of caring for TIN patients.[12] Similar deficiencies have been demonstrated among emergency medicine (EM) and pediatric residents.[13,14] The specific situation in Europe and especially in Germany remains largely unexamined.

Little evidence is available for other healthcare professionals, including registered nurses.[15] Emergency nurses (EN) are often the first to encounter these patients and to obtain relevant data, including gender. Receiving reassuring care at the beginning of emergency care is crucial to the patient's sense of trust and safety and may mitigate negative feelings due to possible past mistreatment. While nurses appear to have a wide range of attitudes, knowledge, and beliefs that affect the care they provide to sexual- and gender-minority patients in general, they often lack LGBTQ+ education specific to the needs of this population.[16] As of March 2024, to the best of our knowledge, there has been no published data on ENs and their attitudes toward TIN patients specifically. Despite increasing awareness and advocacy for sexual and gender minorities, until recently many health professional curricula (eg, medical school, nursing school) provided little formal instruction, presumably leading to the observed gaps in clinical and cultural competency.[17,18]

Population Health Research Capsule

What do we already know about this issue?
Transgender, intersexual and non-binary (TIN) individuals face significant health disparities and barriers to care in multiple settings, including EDs.

What was the research question?
To explore the knowledge and attitudes of emergency nurses (EN) and physicians (EP) in Germany regarding the care of TIN patients.

What was the major finding of the study?
ENs and EPs in Germany lacked key knowledge about TIN emergency care and had different approaches to communication with these patients.

How does this improve population health?
Recognizing the need to improve education and training for EPs and ENs regarding the care of TIN patients could lead to more equitable and respectful emergency care.

Most of the current literature on TIN emergency care comes from the US and Canada, with comparatively less research in Europe and no data available from Germany. Nevertheless, the perception that emergency care professionals know little about TIN individuals and their specific healthcare needs is also widespread among the TIN community in Europe; this is a concern for both healthcare professionals and patients.[4,19] Therefore, our aim in this study was to assess the knowledge and attitudes as well as education and training needs of both EPs and ENs in Germany regarding the care of TIN patients.

METHODS

Study Design

We conducted a cross-sectional study of staff members of EDs in Germany using a web-based survey. The survey was distributed to 70 randomly selected EDs of all sizes across Germany. Both EPs and ENs were considered eligible to participate. The Ethics Committee of the Hannover

Medical School approved the study (01/17/2023; No. 10706_B0_K_2023).

Survey Development and Administration

We conducted a literature review of healthcare professionals' experiences with TIN patients and the healthcare needs of this population. Based on existing studies and applied questionnaires, we developed a survey consisting of both new and previously used items to assess EPs' and ENs' experiences, attitudes, education and training needs related to caring for TIN patients.[12,20,21] For this purpose, previously used items from the literature were prioritized and adapted for content, structure, and language in collaboration with an interdisciplinary group of experts in questionnaire development. In addition, we worked with members of the TIN community to develop new items to better address the specific needs and concerns of this population with regard to emergency care.

We pre-tested all selected items in our survey for clarity with six EPs and five ENs, similar to the intended study population and piloted the same electronic delivery method as planned for wider survey distribution using an anonymous online survey (SoSci Survey GmbH, Munich, Germany).[22] The final survey consisted of 15 closed-ended items equally divided into three thematic categories: 1) five questions about the healthcare professionals' experiences and knowledge; 2) five regarding their attitudes; and 3) five questions related to education/training needs, with response options presented as either single choice or 4-point Likert scales (strongly agree – somewhat agree – somewhat disagree – strongly disagree). Study participants' demographic parameters were collected before the survey began, following consent for data use.

The anonymous, self-administered online survey was available for completion during a four-week period in February 2023. Invitations were sent via e-mail to ED medical directors with the request to distribute the link to the survey to their staff members, as no publicly available mailing list existed that allowed a direct invitation of EPs and ENs in these EDs. We estimated the number of EPs working in the 70 EDs to be approximately 742 and the number of ENs to be ≈923, according to public health data for EDs in Germany and recommendations of German EM societies.[23,24] No reminders were sent. All participants who met the inclusion criteria and completed at least the demographic parameters and the content category on experience were included in the final analysis.

Table 1. Demographics and descriptive characteristics of emergency department staff who participated in the survey.

Demographics	Physician		Nurse		$P < 0.05$
	n	%	n	%	*P*
Total	233	46.4	269	53.6	
Sex					
Male	128	54.9	83	30.9	
Female	103	44.2	186	69.1	
Diverse	2	0.9	0	0	<0.001
Age group (years)					
≤20	0	0	6	2.2	
21–30	54	23.2	99	36.8	
31–40	81	34.8	80	29.7	
41–50	59	25.3	43	16.0	
>50	39	16.7	41	15.2	0.001
Size of city of workplace					
<20,000	15	6.4	25	9.3	
20,000–100,000	59	25.3	73	27.1	
>100,000–< 1,000,000	125	53.6	144	53.5	
≥1,000,000	34	14.6	27	10.0	0.31
Working experience (years)					
In training	0	0	16	5.9	
<5	78	33.5	51	19.0	
5–10	38	16.3	60	22.3	
>10	117	50.2	142	52.8	0.001

Primary Data Analysis

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

RESULTS

During the study period, 536 surveys were returned, of which 502 were eligible for further analysis. Of those, 34 had to be excluded because the respondents did not complete at least the demographic parameters and the content category on experience. Ninety-five percent of respondents completed all 15 items. The overall response rate was 30%, with approximately 923 ENs (response rate 29%) and 742 EPs (response rate 31%) contacted by their respective ED medical directors to participate in the study. Of the respondents, 233 (46%) were EPs and 269 (54%) were ENs. There were significant intergroup differences in all demographic variables analyzed (sex, age, years of work experience), except for the size of the city where their ED was located. In particular, ENs were significantly younger (39% of ENs ≤ 30 years vs 23% of EPs ≤ 30 years, $P = 0.001$; V = 0.196) and had fewer years of work experience than EPs. Table 1 summarizes the characteristics of the respondents.

Experience and Knowledge

More than half of the respondents reported experience in caring for TIN patients in the ED in the prior two years. Compared with EPs, a higher proportion of ENs reported this experience (71% vs 61%; $P = 0.002$; V = 0.155) (Figure 1).

Both EPs and ENs lacked medical knowledge and knowledge of non-medical support services for transgender, intersexual and non-binary (TIN) individuals. While 24% of ENs and 19% of EPs were aware of non-medical support services or contact points for TIN individuals to which they could refer these patients, only 9% of ENs and 11% of EPs could name specific medication regimens used as part of gender reassignment treatment. In their work environment, almost all ENs (92%) and EPs (95%) reported a lack of official recommendations or their own limited awareness, of such recommendations for dealing with TIN patients in the emergency department.

Attitudes

Most respondents in both groups agreed that both gender identity and biological sex at birth should be documented when collecting personal information of patients presenting to the ED (73% of ENs and 74% of EPs) (Figure 2). Correspondingly, 77% of ENs and 80% of EPs felt comfortable asking TIN patients for their correct form of address. There were significant differences between ENs and

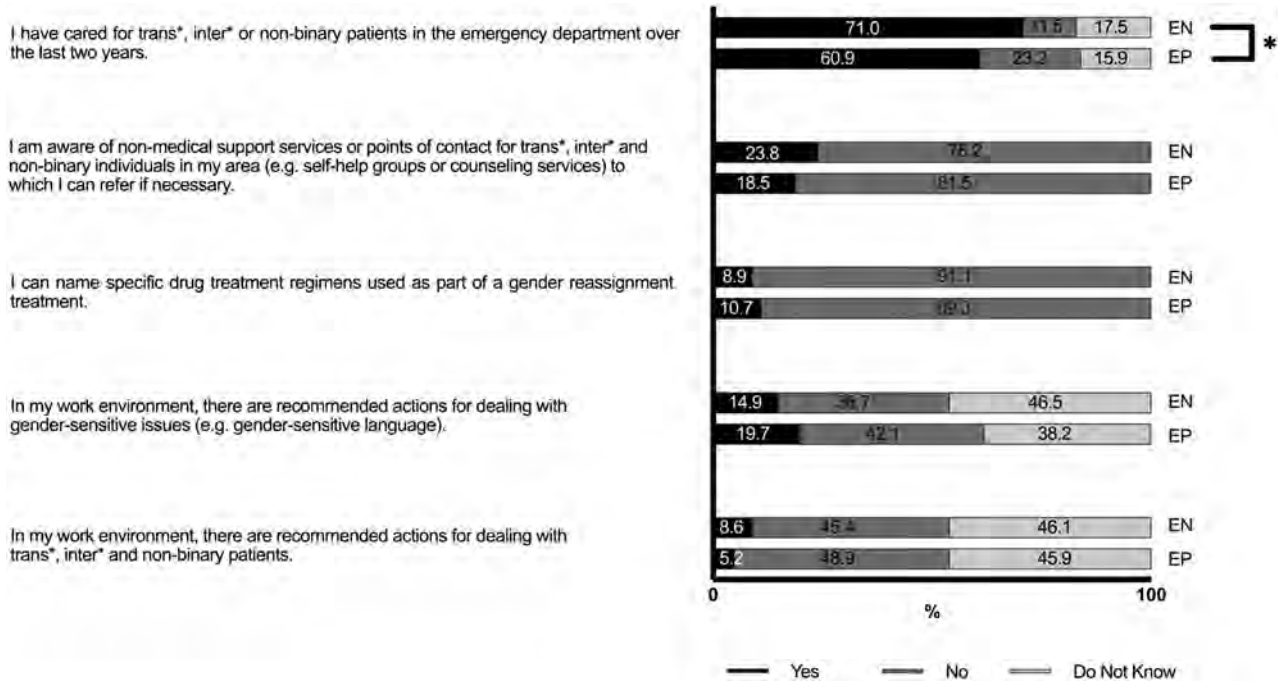

Figure 1. Experience and knowledge of emergency physicians and nurses in Germany in caring for transgender, intersexual and non-binary patients.
* = $P < 0.05$.
EP, emergency physician; *EN*, emergency nurse.

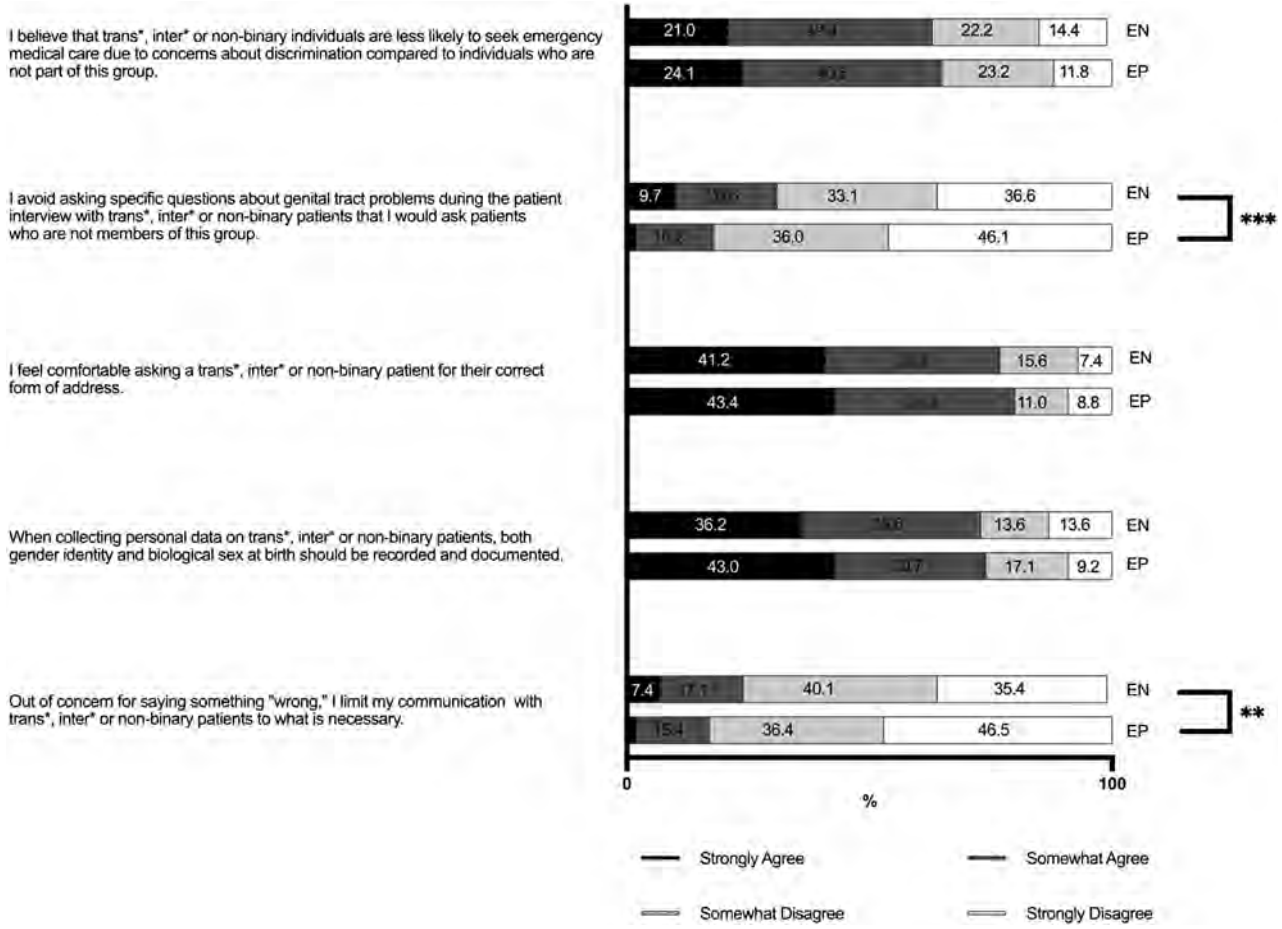

Figure 2. Attitudes of emergency physicians and nurses in Germany regarding transgender, intersexual and non-binary patients. ** = $P < 0.01$, *** = $P < 0.001$.
EP, emergency physician; *EN*, emergency nurse.

EPs as to whether they limited their communication with TIN patients to what was necessary out of concern for saying something wrong (25% of ENs vs 17% of EPs; $P = 0.006$; V = 0.160). The EPs were also less likely to agree that, when interviewing TIN patients, they avoided asking questions about genital tract problems that they would ask non-TIN patients (30% of ENs vs. 18% of EPs; $P = 0.001$ V = 0.187). In terms of oppression awareness, the majority of both groups agreed that they believed TIN individuals were less likely to seek emergency medical care than non-TIN individuals because of concerns about discrimination (62% of ENs and 65% of EPs).

Education and Training Needs

The majority of respondents reported that they had not received any training in the appropriate management of TIN patients (55% of ENs and 58% of EPs). Specifically, only 8% of EPs received such training during their undergraduate education (medical school) or postgraduate (residency/fellowship) training, while 17% of ENs received formal training ($P = 0.01$; V = 0.151). We found that 28% of ENs and 34% of EPs reported learning about this topic on their own (Figure 3).

Both EPs (68%) and ENs (74%) agreed that there was a need to increase ED staff awareness of emergency medical care for TIN patients, and that this should be part of medical education/professional training (78% of ENs and 76% of EPs). Correspondingly, the majority of both groups believe that continuing medical education (CME) regarding the appropriate management of TIN patients was useful (77% of ENs and 74% of EPs) and that they would participate in such CME when offered (96% of ENs and 92% of EPs) (Figure 4).

DISCUSSION

In this cross-sectional study, we found that both EPs and ENs in Germany lacked knowledge about important aspects of emergency care of TIN patients and showed differences in attitudes toward communication practices. There was consensus on the need for increased education and training in the management of such patients, with a majority agreeing on the importance of integrating this training into medical education and CME.

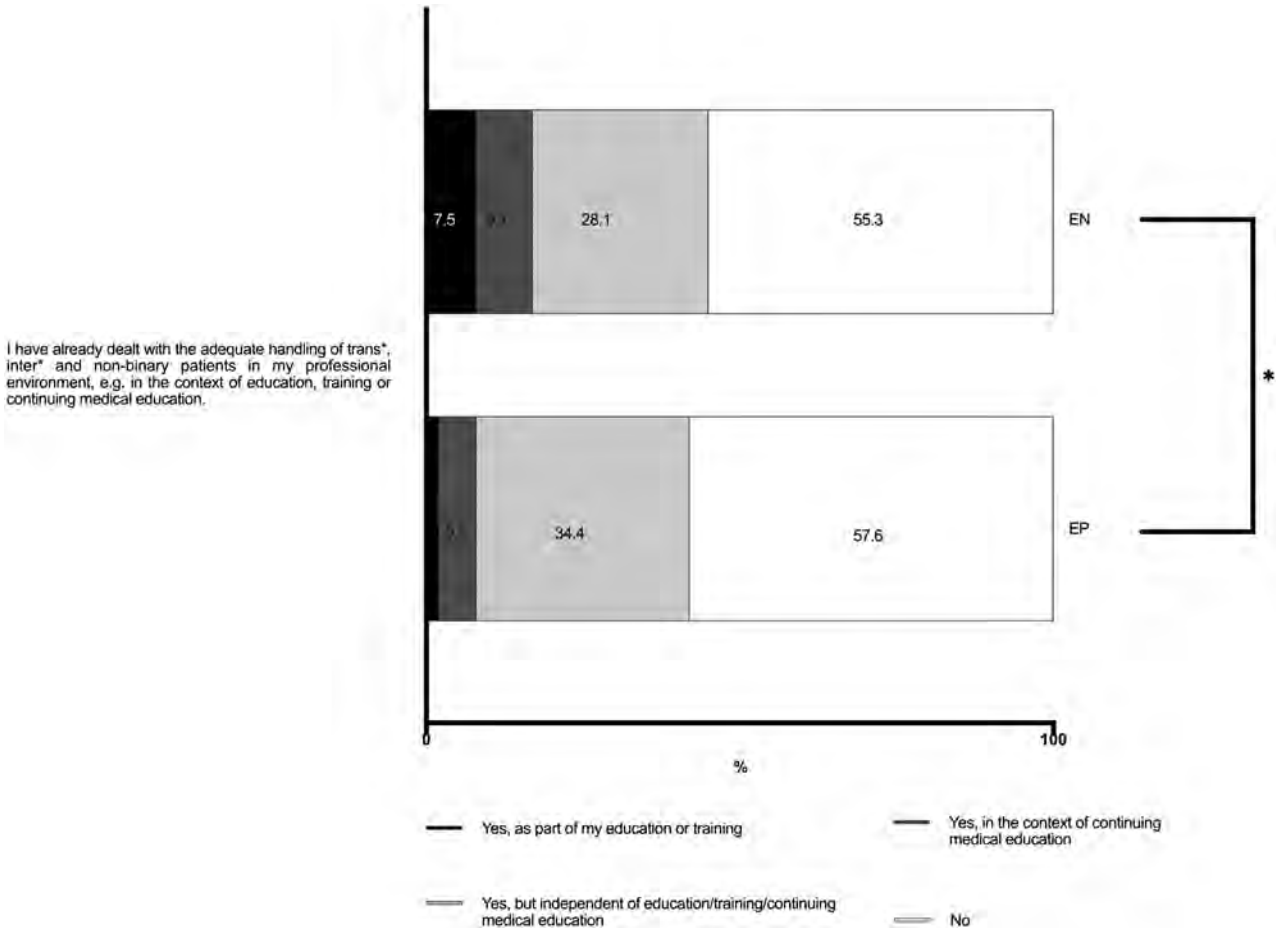

Figure 3. Education and training of emergency physicians and nurses in Germany regarding the care of transgender, intersexual and non-binary patients.
* = $P < 0.05$.
EP, emergency physician; *EN*, emergency nurse.

Although more than half of the respondents reported encounters with TIN patients in the ED, there was a clear knowledge gap, demonstrated by a lack of awareness of non-medical support services and specific medical regimens related to gender transition. Chisolm-Straker et al reported similar findings in their survey of EPs in the US, showing that the majority of the EPs had seen transgender and gender nonconforming patients, but few had received training in caring for this population and most had inaccurate knowledge of important aspects of transgender and gender nonconforming care.[12] Steward and O'Reilly pointed out that both nurses and midwives have a wide range of attitudes, knowledge, and beliefs that affect the care they provide to LGBTQ+ patients in general, and many issues of inadequate care appear to be due to a lack of education about LGBTQ health.[16] In a survey in pediatric EDs in Ireland, Kelleher et al showed that EPs, ENs, and other healthcare workers held positive attitudes towards LGBTQ+ young people; however, they were less confident in their knowledge of specific health issues and self-reported low levels of clinical preparedness.[14] This lack of knowledge, as demonstrated in studies that included both EPs and ENs, may lead to suboptimal care and increased discomfort for the growing global community of TIN patients as well as healthcare professionals in the ED. Furthermore, the lack of official recommendations for addressing gender-sensitive issues in EDs may contribute to disparities in emergency care experienced by TIN patients.

Several studies have examined the experiences of transgender and gender nonconforming patients in emergency care and demonstrated that more than half of these patients avoid EDs, mostly due to lack of clinician or nurse sensitivity, anticipated discrimination, and fear of mistreatment.[11,25] Focusing specifically on transgender patients, a Swedish study by Carlström et al highlighted the importance of recognizing TIN patients' vulnerability to violations of dignity, accepting their identity, and focusing on their healthcare needs to restore and maintain their trust in healthcare.[26] Contrary to these patient reports, and similar to the findings of Chisolm-Straker et al and others, the

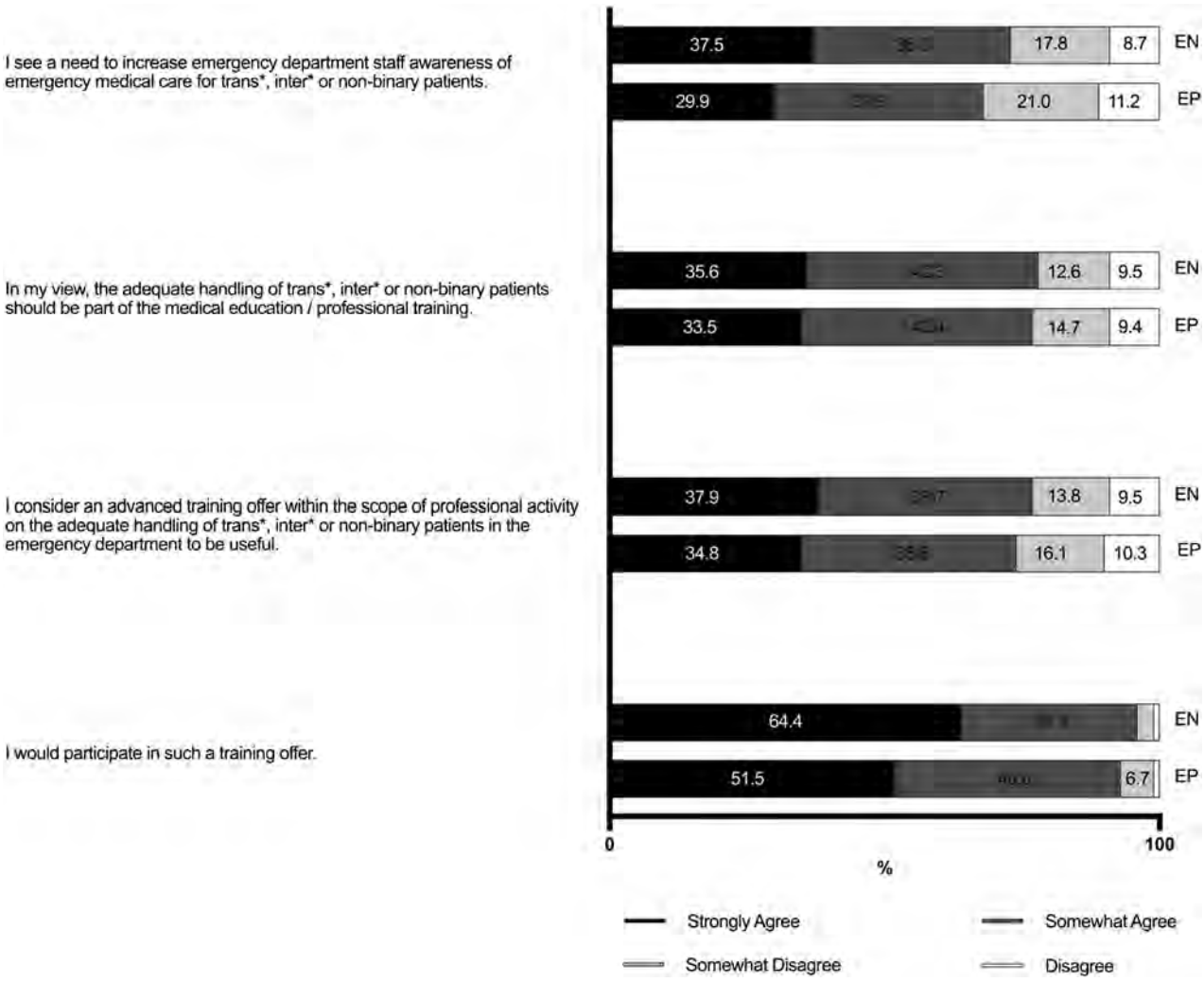

Figure 4. Education and training needs of emergency physicians and nurses in Germany regarding the care of transgender, intersexual, and non-binary patients.
EP, emergency physician; *EN*, emergency nurse.

majority of respondents in this study (both EPs and ENs) expressed comfort in asking TIN patients for their correct form of address and agreed with the importance of documenting both gender identity and biological sex at birth.[11,12,13] The reasons for these discrepancies between patients' experiences and EPs/ENs' perspectives are not entirely clear and require further investigation.

There may be a discrepancy between the comfort level of asking TIN patients for the correct form of address and the use of the correct pronoun in the actual patient encounter. In addition, most of the participants in this study were younger professionals working and living in large cities in Germany, who may be more open to diverse identities and, therefore, more accustomed to addressing such issues in their professional practice (see Table 1). The art of communication also requires further attention, especially regarding the correct use of gender-sensitive language and respectful communication practices, which should be trained regularly.

The majority of EPs and ENs in this study were aware that TIN individuals are less likely to seek emergency medical care than non-TIN individuals due to concerns about discrimination, indicating an awareness of oppression among EPs and ENs. This empathic awareness of the existence and impact of oppression against TIN people is crucial to removing barriers to healthcare access for these individuals.[27]

Comparing the two groups of EPs and ENs, we found notable differences in existing attitudes toward communication with TIN patients. The ENs were more likely than EPs to limit their communication with TIN patients to what was necessary, out of concern about saying something wrong, and to avoid asking TIN patients questions about genital tract problems. These differences may reflect different roles in patient care but may also reflect different levels of confidence in communicating with TIN patients, highlighting the importance of

targeted education and training programs for both EPs and ENs.

In accordance with this finding, most respondents in both groups reported a lack of formal training in the appropriate management of TIN patients, with only a small percentage having received such training during their undergraduate or postgraduate education. These findings are in line with previously published studies from both the US and Europe, highlighting the importance of integrating TIN-specific content into medical and nursing school curricula and providing ongoing CME opportunities for practicing healthcare professionals.[28,29,30] In Germany, the InTraHealth self-learning platform for health professionals has been available online since April 2023, offering guidance on addressing and preventing discrimination against TIN individuals in healthcare settings.[31] However, it is not specifically tailored to EPs and ENs. Similar initiatives and programs exist in the US and Canada but are also often limited to single-session interventions that focus primarily on attitudes and awareness rather than the development of clinical competencies.[32] Encouragingly, this study reveals a strong desire among EPs and ENs for more education and training to increase ED staff awareness of emergency medical care for TIN patients.

LIMITATIONS

We used a novel, non-validated survey instrument that relied on self-reported data from EPs and ENs, which may have been subject to response bias, including social desirability bias. In addition, no information was available on non-responders, which introduced the potential for positive selection bias. Emergency department directors, EPs, and ENs with greater interest or comfort with the topic may have been more likely to forward the invitation to their team members or participate in the study, whereas discomfort or lack of familiarity with caring for TIN patients may have acted as potential barriers to participation. In addition, the lack of a reminder for the study invitation may have contributed to a lower response rate, which could affect the generalizability of the findings. Finally, the sample was limited to EPs and ENs in Germany, which could limit the generalizability of the findings to other countries or healthcare systems.

CONCLUSION

This study adds to the growing body of evidence that emergency physicians have deficits in knowledge and clinical preparedness to care for TIN patients. For emergency nurses, similar deficits seem to exist, exacerbated by greater uncertainty about communicating with patients who identify as transgender, intersexual, and non-binary. This study indicates the need for enhanced education, training, and institutional support to improve the emergency care of TIN patients in Germany. This includes both knowledge of specific treatments and training in sensitive, respectful communication, as well as an understanding of the wider social challenges faced by TIN individuals. By addressing these challenges both in medical/nursing schools and beyond, we can strive to ensure that TIN individuals receive equitable and respectful medical care.

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Pediatric Emergency Department-based Food Insecurity Screening During the COVID-19 Pandemic

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Introduction: The emergency department (ED) is a safety net, caring for families who lack adequate access to food and other basic needs. The COVID-19 pandemic caused a dramatic rise in food insecurity (FI) nationally; however, little is known about the prevalence of FI among families seen in pediatric EDs (PED). In this study we aimed to determine the prevalence of FI, as well as awareness and utilization of supplemental food services, among families seen in an urban PED during the COVID-19 pandemic using an electronic screening survey.

Methods: This was a cross-sectional survey of families screened for FI in an urban PED. An electronic survey was advertised to all families via posters placed in patient rooms and other locations in the PED between February–October 2022. Surveys in English and Spanish were accessed on personal electronic devices via QR codes. Six validated US Department of Agriculture household food security questions and sociodemographic questions were included. We calculated respondents' food security and performed descriptive and bivariate analyses of patient sociodemographics and responses to FI questions.

Results: Of 42,697 PED visits, 612 surveys were completed and analyzed (1.4%). Nearly 50% of respondents identified as White and non-Hispanic, with approximately 80% female. Thirty percent had a household income of <$25,000 and 32% between $25,000–<50,000. Among survey respondents, 56.7% demonstrated FI: 25% with low food security, and 31.7% with very low food security. We identified statistically significant differences in awareness and use of supplemental food services by FI status, household income, and primary language spoken.

Conclusions: Nearly 60% of survey participants in an urban pediatric ED during the COVID-19 pandemic experienced food insecurity, substantially higher than previous reports. These results support the ED's contributory role in FI screening, particularly during times of a public health crisis, and highlights the need for targeted outreach in this setting. [West J Emerg Med. 2025;26(1)120–128.]

INTRODUCTION

Food insecurity (FI) is a significant public health issue, dramatically worsened by the COVID-19 pandemic.[1,2] Pre-COVID-19, an estimated 1 in 7 children in the US lived in households with FI. This strikingly increased to nearly *1 in 4* households with children during the early COVID-19 pandemic,[1,2] with approximately 6.4 million children living in FI households in 2022.[2] A survey performed one month into the COVID-19 lockdowns demonstrated FI among more than 40% of households of mothers with children ≤12 years of age.[3] Although children may be shielded from directly experiencing FI by their caregivers,[2,4] a nationwide survey of mothers with young children identified that in almost 20% of households with children <12 years of age, the children directly experienced FI.[3]

Given the myriad of physical and mental health implications of FI among children,[5] the American Academy of Pediatrics (AAP) Promoting Food Security for All Children policy statement advises that pediatricians "play a central role" in both screening and advocacy for FI among their patients.[5] The ED serves as a safety net for families experiencing poverty and barriers to resource access and utilization and who are at highest risk of FI and inadequately meeting basic needs. It has previously been reported that children with FI have higher odds of visiting an ED than those who do not.[6,7] Thus, pediatricians and other clinicians seeing these at-risk patients in the ED have a critical opportunity to provide the recommended screening. Previous pre-COVID-19 studies have demonstrated the feasibility of pediatric emergency department (PED)-based FI screening,[7–10] with a caregiver preference for electronic-based screening tools.[7,11]

Although studies in the general population have demonstrated marked increases in FI during the COVID-19 pandemic, the prevalence of FI among families in PEDs is not well understood. Thus, we aimed to describe the prevalence of FI among families in an urban PED during the COVID-19 pandemic with an electronic FI screening program using validated US Department of Agriculture (USDA) FI screening questions, and to describe the associated sociodemographics and caregiver awareness and use of supplemental food resources.

Population Health Research Capsule

What do we already know about this issue?
The COVID-19 pandemic caused dramatic increases in food insecurity (FI), affecting 1 in 4 families nationally.

What was the research question?
What was the prevalence of FI and use of supplemental food programs among families seen in a pediatric ED during the pandemic?

What was the major finding of the study?
56.7% of respondents had FI; 25% had low food security (95% CI 21.6–28.4) and 31.7% had very low food security (95% CI 28.0–35.6).

How does this improve population health?
Given the high prevalence of FI in this population, EDs have become important locations for FI screening.

METHODS

Study Population and Design

This survey was performed in the Hasbro Children's Hospital PED, the only children's hospital, PED, and Level 1 trauma center in the state of Rhode Island. The institutional PED cares for over 55,000 children annually from Rhode Island as well as neighboring areas of Massachusetts and Connecticut, serving as a safety net for a region comprising a broad spectrum of rural, suburban, and urban communities. Approximately 48% of patients seen in the institutional PED annually are female, 47% identify as White, 14% Black, and nearly 40% Hispanic. Over 55% of patients have government insurance. Additionally, approximately 83% of patients report English as the preferred language with 15% reporting Spanish.

Recruitment posters with survey QR codes, displayed in both patient rooms and public waiting areas within the PED, invited parents and caregivers >18 years of age to answer questions about their family demographics and access to food via an electronic survey (Qualtrics LLC, Provo, UT). Recruitment posters were not available in rooms dedicated to psychiatric evaluations and critical care, or in rooms used for after-hours urgent care overflow patients seen by PED clinicians in non-PED locations. To accommodate potential language challenges, posters were written in English and Spanish with basic instructions to scan the QR code with a smartphone. Surveys were displayed between February–October 2022 based on the grant funding period and availability of trained study staff. No direct assistance was provided during the enrollment process. Responses were collected anonymously. All respondents were given the option of providing contact information to be eligible for a small incentive, a grocery gift card. All respondents, regardless of food security status, were also given the option of providing their contact information to be contacted by a hospital resource advocate after the ED visit for assistance with enrollment in food resource programs.

The survey included sociodemographic questions pertaining to the respondent and the child currently being seen in the PED (age, sex, race, ethnicity, primary language, household size and income, employment status, education, housing, respondent's relationship to the child in the ED, insurance status, and the child's access to pediatric primary care), and six questions from a validated USDA Household Food Security Survey Module (Figure).[12] Respondents were also asked if they had ever "heard of" and/or were currently using supplemental food services (Women, Infants, & Children Program [WIC], Supplemental Nutrition Assistance Program [SNAP], local food banks, and free school-lunch programs), hereafter referred to as "awareness" and "utilization."

We assigned each of the six USDA screening questions an individual score based on the responses, and we then calculated a FI "raw score" by the sum of the individual

Prompt: Some people have made the following statement about their food situation. Please answer whether the statements were often, sometimes, or never true for you and your household in the last 12 months. *Additional options for "I don't know" and "Prefer not to answer" were provided.*
Q1: The food we bought just didn't last and we didn't have money to get more
Q2: We couldn't afford to eat balanced meals
Q3: Did you or anyone in your household ever cut the size of your meals or skip meals because there wasn't enough money for food? *Yes, no, I do not know, prefer not to answer*
Q3b: If yes, then how often did this happen? *Almost every month, some months but not every month, one or two months*
Q4: In the last 12 months, did you or anyone in your household ever eat less than you felt you should because there wasn't enough money for food? *Yes, no, I do not know, prefer not to answer*
Q5: In the last 12 months, were you or anyone in your household hungry but didn't eat because there wasn't enough money for food? *Yes, no, I do not know, prefer not to answer*

Figure. United States Department of Agriculture food insecurity screening questions.[a]
[a]Food insecurity raw score is calculated as follows: Answers of "often" or "sometimes" for questions 1 and 2, "yes" on questions 3, 4, and 5, and "almost every month" or "some months but not every month" on Q3b are all coded as affirmative (yes). The sum of the affirmative answers to these 6 questions are used to calculate a raw score. Score of 0–1 denotes high or marginal food security, 2–4 denotes low food security, and 5–6 denotes very low food security.

question scores for each of the FI screening questions, according to the USDA scoring guide.[12] We calculated the FI raw score as follows: answers of "often" or "sometimes" for questions 1 and 2, "yes" on questions 3, 4, and 5, and "almost every month" or "some months but not every month" on Q3b are all coded as affirmative (yes). The sum of the affirmative answers to these six questions was then used to calculate the raw score. Score of 0–1 denotes high or marginal food security, 2–4 denotes low food security, and 5–6 denotes very low food security. Low food security indicates that the household "obtained enough food to avoid substantially disrupting their eating patterns or reducing food intake by using a variety of coping strategies, such as eating less varied diets, participating in federal food assistance programs, or getting food from community food pantries."[2] Very low food security indicates that household members reduced their food intake because of inadequate money or resources for food.[2,4]

We translated respondents' food security raw scores into one of the three food security categories. Respondents were provided the option to answer "I do not know" or "I prefer not to answer" for each of the six screening questions. If respondents chose one of these options for ≥1 screening question and a minimum score of 2 could be calculated, the FI raw score was categorized as "low food security" (raw score 2–4). If a raw score of <2 or no score was calculated based on these incomplete responses, the respondent's FI status was categorized as "unable to calculate."

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Statistical Analysis

We collected all data through Qualtrics, supported by Brown University. Data was exported into Excel (Microsoft Corporation, Redmond, WA) for coding, and analysis was performed using SAS version 9.4 (SAS Institute, Inc, Cary, NC). All questions left unanswered in Qualtrics were coded as missing. We performed descriptive statistical analyses and reported the results as frequencies and proportions, with median and interquartile ranges (IQR) calculated. Bivariate analysis was performed to establish associations between respondents' food security status and various sociodemographic factors, with report of 95% confidence intervals (CI). We performed chi-square tests and Wilcoxon rank-sum tests for comparative analyses, when appropriate.

RESULTS

Sociodemographics and Health Statistics

Between February–October 2022, there were 42,697 visits to the PED; the number of patients cared for in rooms/areas where recruitment posters were not available is unknown. A total of 846 visits were associated with initiated surveys (2% of total visits). We excluded 234 responses (27.7% of initiated surveys) from the analysis due to lack of consent or missing responses to all six USDA screening questions, leaving 612 surveys (72.3% of initiated surveys and 1.4% of total visits) for analysis.

Most of the surveys (75.5%) were completed in English by respondents who identified English as their preferred language, 7.8% were completed in English by respondents who identified Spanish as their preferred language, and 15.7% were completed in Spanish by respondents who identified Spanish as their preferred language. Nearly 50% of respondents identified as White and non-Hispanic, respectively, with approximately 80% identifying as female (Table 1). Nearly 90% of respondents were the biological parent of the PED patient.

The mean number of household family members for respondents was 4.1 (IQR 3–5, SD 1.4), with 62% living in rented houses or apartments and 31.3% in owned houses

Table 1. Survey respondents' sociodemographics and food security status, N = 612.

	N (%)[a]
Survey language	
English	516 (84.3)
Spanish	96 (15.7)
Primary language	
English	437 (71.4)
Spanish	136 (22.2)
Other/missing	39 (6.4)
Sex	
Male	94 (15.4)
Female	482 (78.8)
Non-binary	4 (0.7)
Missing/prefer not to answer	32 (5.2)
Race	
Black	51 (8.3)
White	304 (49.7)
Other[b]	189 (30.9)
Missing	68 (11.1)
Ethnicity	
Hispanic	271 (44.3)
Non-Hispanic	294 (48.0)
Prefer not to answer	18 (2.9)
Missing	29 (4.7)
Household annual income	
Under $15,000	120 (19.6)
$15,000–$24,999	63 (10.3)
$25,000–$34,999	132 (21.6)
$35,000–$49,999	65 (10.6)
$50,000–$74,999	69 (11.3)
More than $75,000	100 (16.3)
Unsure/prefer not to answer	51 (8.4)
Missing	12 (2.0)
Housing[c]	
House/apartment owned	188 (30.7)
House/apartment rented	372 (60.8)
Other	24 (3.9)
Temporary/no housing	8 (1.3)
Prefer not to answer	8 (1.3)
Missing	12 (2.0)
Employment status	
Unemployed	185 (30.2)
Full-time	271 (44.3)
Part-time	102 (16.7)
Other/prefer not to answer/missing	54 (8.8)
Insurance type[d]	
Private insurance	312 (51.0)
Government insurance	217 (35.5)
Other	10 (1.6)
None	17 (2.8)
Missing/prefer not to answer/not sure	56 (9.2)

[a]Percent may not equal 100 due to rounding.
[b]Other category includes American Indian, Alaska Native, Asian, Native Hawaiian, and "other."
[c]Other category includes rented room/boarding house, mobile home/trailer, and "other."
[d]Private insurance includes Aetna (N = 8, 1.3%); Blue Cross Blue Shield (N = 98, 16.0%); Blue Chip (N = 67, 10.9%); Tufts (N = 67, 10.7%); United Healthcare (N = 72, 11.8%). Government insurance includes Neighborhood Health Plan, state Medicaid (N = 174, 28.4%); Medicaid plan not otherwise specified (N = 29, 4.7%); Medicare (N = 8, 1.3%); Rite Care (N = 3, 0.5%); TriCare – Military (N = 3, 0.5%). "Other" insurance category is a non-specified insurance (N = 10, 1.6%).

(Table 1). Among respondents, 29.9% had annual household incomes <$25,000, with a 2022 federal poverty level (FPL) for a family of 4 of $27,750.[13] An additional 32.2% had annual household incomes between $25,000–<$50,000, 15.7% between $50,000–<$100,000, 11.9% >$100,000, and 10.3% not reported. Full- or part-time employment was reported by 61% of respondents and over 88% had health insurance (Table 1). Additionally, 271 respondents (44.3%) had ≤ a high school degree or general equivalency diploma, 114 (18.6%) had a business or trade certificate or two-year college degree, and 126 (20.6%) had a four-year college or graduate degree. More than one-third of respondents (226, 36.9%) denied having a partner or spouse in the home. Respondents reported that 83% of the children that they accompanied to the ED had access to pediatric primary care.

Food Security Status

Food insecurity was demonstrated by 56.7% of the respondents (Table 2), high or marginal food security was demonstrated in 35.3%, and 8% were unable to be categorized based on "I do not know" and "prefer not to answer" responses to the survey questions. Additionally, 13.9%, 65.4%, and 89.2% of respondents in the high, low, and very low food security groups, respectively, reported that their family had to choose between food and other needs, such as paying for housing, utilities, and/or clothing, within the prior 12 months.

Bivariate analyses revealed statistically significant differences in awareness and utilization of supplemental food services based on respondents' household food security

Table 2. Survey respondents' food security status.

	N (%)[a]	95% CI of Percentage
USDA food insecurity category (N = 612)		
High or marginal food security	216 (35.3)	31.5, 39.2
Low food security	153 (25.0)	21.6, 28.4
Very low food security	194 (31.7)	28.0, 35.6
Unable to be calculated based on responses	49 (8.0)	6.0, 10.5
Choosing between food and other needs, by food security status[b] (N = 563)		
High or marginal food security (n = 216)	30 (13.9)	9.6, 19.2
Low food security (n = 153)	100 (65.4)	57.3, 72.9
Very low food security (n = 194)	173 (89.2)	83.9, 93.2

[a]Percent may not equal 100 due to rounding.
[b]Respondents were specifically asked if they had to choose between spending money on food or other needs, including rent, utilities, medical care, etc., within the last 12 months. Affirmative responses are reported here.
CI, confidence interval; *USDA*, United States Department of Agriculture.

status, household income, and primary language (Table 3). Overall, respondents reported highest awareness of SNAP compared to WIC, food banks, and free lunch programs. The most used service overall was SNAP. The lowest proportion of awareness and utilization among respondents was for local food banks. Except for SNAP, households with high food security and with household incomes >$50,000 annually had statistically significantly higher proportions of awareness of all supplemental food services, despite the lowest utilization of these services (Table 3). Notably, there was no statistically significant difference in the proportion of respondents with high, low, or very low food security who used free school lunches ($P = 0.90$), nor was there a statistically significant difference in utilization of free school based on primary language ($P = 0.19$). Despite no significant difference in the proportion of respondents with English vs Spanish as their primary language who used most supplemental food services, there were statistically significant differences in awareness of all these services based on primary language (Table 3).

Finally, 148 respondents (24.2%) requested follow-up with a resource advocate for assistance with food resources, including 74 respondents with very low food security (51.4%), 46 with low food security (31.9%), 21 with high food security (14.6%), and seven (4.9%) for whom the security status was unable to be calculated.

DISCUSSION

The COVID-19 pandemic had tremendous effects on families, with previously reported increases in FI among surveys performed in general populations.[1–4] The anonymous, electronic FI survey containing sociodemographic questions and six validated USDA FI screening questions revealed that 56.7% of respondents surveyed in an urban, tertiary, PED had some degree of household FI. Although baseline FI data among patients seen in the PED is unknown, this prevalence is markedly higher than the proportion of households in the study state with children <18 years of age reporting FI in 2021 (25%) and 2022 (41%).[14] The prevalence of FI in this population is also notably higher than pre-COVID-19 reports in PEDs,[7,8] as well as higher than reports of general populations collected during the pandemic nationally.[1–4] This study took place two years into the COVID-19 pandemic, after many federal and state legislative changes had occurred that may have impacted food security. It has been suggested that the observed increases in FI during this time was in part due to inflation and discontinuation of some COVID-19 relief programs that mitigated FI.[15]

Despite a state-wide increase in FI among households with children <18 years of age,[14] an even higher prevalence was seen in the PED setting and is likely multifactorial. First, the ED serves a high-risk population, with increased rates of ED visits among FI families compared to those who are not FI.[6,7] Thus, the patient population is likely to experience an overall higher prevalence of FI. Second, the anonymity of the electronic screening tool may have supported respondents' willingness to provide accurate information about their family's food security. While our study's higher prevalence of FI aligns with reports of increased FI during the COVID-19 pandemic, selection bias may have played a role due to the voluntary nature of our enrollment via posters and electronic surveys. This method could have led to an over-representation of families facing greater food-related hardships and/or those with access to and comfort with using smartphone technology. However, Gayle et al and Gonzalez et al have demonstrated that most caregivers preferred an electronic screening modality over verbal/face-to-face screening for social determinants of health,[7,11] and among those who respond electronically, a higher prevalence of FI was found.[7]

Table 3. Awareness[a] vs utilization of supplemental food services by food security status, annual household income, and primary language.

	3a. Food security status			
	High food security (n = 216)	**Low food security (n = 153)**	**Very low food security (n = 194)**	***P*-value**
Awareness				
WIC	167 (77.3)	87 (57.2)	110 (56.7)	<.001
SNAP	177 (81.9)	123 (80.9)	163 (84.0)	0.67
Food banks	144 (66.7)	65 (42.8)	83 (42.8)	<.001
Free lunch	154 (71.3)	71 (46.7)	83 (42.8)	<.001
Utilization				
WIC	33 (15.3)	43 (28.1)	52 (26.9)	<.001
SNAP	47 (21.8)	57 (37.3)	75 (38.9)	<.001
Food banks	13 (6.0)	20 (13.1)	33 (17.1)	<.001
Free lunch	44 (20.4)	32 (20.9)	43 (22.3)	0.90

	3b. Annual household income				
	<$25,000 (n = 183)	**$25,000 – <$50,000 (n = 197)**	**$50,000 – <$100,000 (n = 96)**	**≥$100,000 (n = 73)**	***P*-value**
Awareness					
WIC	101 (55.2)	128 (65.3)	69 (71.9)	57 (78.1)	<.01
SNAP	155 (84.7)	161 (82.1)	76 (79.2)	58 (79.5)	0.63
Food banks	70 (38.3)	93 (47.5)	71 (74.0)	54 (74.0)	<.001
Free lunch	78 (42.6)	95 (48.5)	68 (70.8)	58 (79.5)	<.001
Utilization					
WIC	53 (29.1)	58 (29.6)	5 (5.2)	2 (2.7)	<.001
SNAP	109 (59.9)	56 (28.6)	7 (7.3)	2 (2.7)	<.001
Food banks	26 (14.3)	28 (14.3)	10 (10.4)	0 (0)	<.01
Free lunch	40 (22.0)	52 (26.5)	17 (17.7)	7 (9.6)	0.02

	3c. Primary language spoken		
	English (n = 437)	**Spanish (n = 136)**	***P*-value**
Awareness			
WIC	307 (70.3)	65 (47.8)	<.001
SNAP	379 (86.7)	94 (69.1)	<.001
Food banks	257 (58.8)	39 (26.7)	<.001
Free lunch	274 (62.7)	42 (30.9)	<.001
Utilization			
WIC	84 (19.2)	48 (35.3)	<.001
SNAP	136 (31.1)	49 (36.0)	0.14
Food banks	47 (10.8)	20 (14.7)	0.43
Free lunch	97 (22.2)	23 (16.9)	0.19

[a]Respondents were asked if they had "ever heard of" the food services.
WIC, Women, Infants & Children Program; *SNAP*, Supplemental Nutrition Assistance Program.

Food insecurity is multifactorial, and household income does not necessarily reflect the financial needs and hardships of families. Although families may have household incomes exceeding the FPL, the high cost of living, utilities, and other expenses may limit the availability of funds for adequate food, resulting in higher rates of FI than rates of poverty. One report notes that one-third of households with FI reported a household income between 100–200% of the FPL, with an additional third reporting over 200% the FPL.[16] Similarly in this cohort, 169 respondents (27.6) had an annual household

income >$50,000, approaching or exceeding 200% of the FPL for a family of four ($55,000 in 2022),[13] and yet 41 (24.2%) in these income categories still were categorized as FI based on their responses. Additionally highlighting the complexities of food security in the setting of other household necessities, nearly 90% of respondents in this survey with very low food security, 65% with low food security, and 14% with high food security reported having had to choose between food and other necessities in the preceding 12 months. Furthermore, nearly 15% of the respondents who requested follow-up from a resource advocate were categorized as having high food security based on survey responses. This could be due to ongoing needs despite currently not meeting the screening threshold for FI, not answering all FI questions truthfully (thus not capturing their accurate food security status), or other reasons.

There were also notable differences in respondents' awareness and utilization of federal and local supplemental food services when analyzed by FI status, primary language, and household income, demonstrating key gaps within this high-risk population. Despite 83% of respondents reporting that their children had access to pediatric primary care, where the majority of FI screening and intervention generally takes place, less than half of households with low and very low food security reported awareness of local food banks and free school lunches. Approximately 60% had heard of WIC, and 84% had heard of SNAP, with even lower utilization of these services. Similarly, Coleman-Jenson et al previously reported that only 55% of eligible FI households participated in WIC, SNAP, and/or free school-lunch programs.[4] Some families who do identify primary care physicians may have limited availability to access routine care during regular business hours, thus missing opportunities for screening and intervention, and alternatively seeking care in urgent care or EDs where screening is not the standard of care. Additionally, depending on in-office screening methods (eg, paper, verbal, electronic) and limitations in time allotted for office visits and resource availability, primary care offices may not identify all FI families and/or be able to meet the needs of all its patients. Furthermore, primary care office staff may not be aware of all available local, statewide, and federal resources and eligibility criteria for patients who may qualify. A cycle of poor access, poor screening, inadequate guidance, and negative health outcomes subsequently develops.

The proportion of respondents in the high food security category as well as those with household incomes >$50,000 who reported awareness of all the supplemental food services was significantly higher than the proportion of respondents with low and very low food security and household incomes <$50,000. High resource awareness among food secure families and greater annual household incomes could be due to overall higher education and knowledge of social services even when they are not needed, awareness because of past or current utilization, or other reasons. In this cohort, respondents with the overall highest awareness of supplemental food services had the overall lowest utilization of services when stratified by household income and food security status. Based on these findings, those with the highest knowledge are not necessarily those who are in need. This data suggests that families who are food secure may not necessarily be food secure because of utilization of services; however, additional studies need to be done to further elucidate reasons for these findings.

Another notable finding is that the proportion of respondents who used free school lunches was not statistically significant regardless of food security status. This is likely due to legislation including the Families First Coronavirus Response Act that was put in place during the COVID-19 pandemic to allow access to free school lunches for all children regardless of income.[17] Unfortunately, despite universal accessibility to free school lunches, approximately 25% or fewer children in households with incomes <$50,000 annually and in the low and very low food security categories, regardless of primary language, participated in this service. Significant stigma around using free school meals can lead to children not participating in the program despite qualifying,[18] which may play a role in these findings. Considering legislative changes made during the pandemic to provide access to free school meals universally, additional studies are required to understand the impact of these programmatic changes over time.

While it is possible that respondents misunderstood or incorrectly answered questions related to awareness and utilization or did not know of these programs by name, these findings warrant further exploration. Barriers to awareness and utilization are well known, including English-language proficiency, difficulty navigating the complex application processes via phone, online, or in person, and lack of transportation and access to government offices and/or local food resources particularly during regular business hours, among other factors. Families are often not aware of eligibility criteria, particularly if they are not provided this information at healthcare visits, in schools, and through community outreach programs. Although undocumented families may qualify for state and federal assistance services, they may be reluctant to identify themselves to government programs. Although details of immigration status, exact household income, prior utilization of services, the status of pending immigration applications, and barriers to access are unknown among this study cohort, the differences in awareness and utilization are striking, and reiterate the need for further outreach and intervention among the most vulnerable populations.

LIMITATIONS

There are important limitations to this study to consider. The first is missing data. While over 800 respondents initiated

the study, many did not complete the USDA screening questions, thus excluding them from analysis. Among those who did complete the screening questions, not all completed the sociodemographic, awareness, and utilization questions, potentially impacting the results of our analyses. Second is selection bias, which may have been influenced by factors such as respondent interest in the survey, lack of direct recruitment, general and medical literacy, and access to smartphones to complete the survey. Because there was no direct recruitment, respondents with limited literacy and/or those who spoke a language other than English and Spanish also were missed, potentially introducing additional selection bias and limiting generalizability.

The recruitment poster specifically excluded the words "food insecurity" with the intent of trying to recruit respondents from all socioeconomic backgrounds. Because there was a small gift-card incentive offered for participation in the survey, some degree of selection bias likely remained, with those with higher needs primarily responding. However, it is notable that over 16% of respondents reported a household income above $75,000 per year, >250% of the FPL.[13] Further, approximately 1.4% of the annual PED volume completed surveys, which may not be representative of the general PED population at the study site or in other ED settings, limiting broader generalizability. However, the proportion surveyed is comparable to that of other studies with similar methodology (1.8%[8] and 0.5%[10]) and demonstrated similar increases in FI reported during the pandemic.[1,2]

Other potential biases are important to acknowledge, including the possibility of miscalculation bias, as respondents' answers may not have been accurate if they did not remember circumstances correctly or if they were not familiar with the names of supplemental food services, among other reasons. There may have been a contribution of social desirability bias, with respondents not accurately reporting their income, awareness, and utilization of services. The ability to take the survey anonymously may have mitigated this bias, however.

Among respondents who provided contact information to receive an incentive gift card, there were no duplicate names or addresses provided. However, a potential limitation includes repeat enrollment at subsequent visits among individuals who did not provide contact information. An additional limitation is that the six questions used are aimed at assessing *household* FI and responses may not directly reflect the food security status of the children living in the homes. Although children may not directly experience household FI, understanding the household dynamics and needs is still critical to identifying disparities and populations in need and identifying opportunities for interventions before children are impacted.

CONCLUSION

The COVID-19 pandemic had significant impacts on families, with an increase in food insecurity nationally. This study, aligned with prior published research, demonstrates that the ED is an important location for FI screening. Given the high needs of the patient population seen in the ED and this study's striking finding that more than one in two households screened had some degree of FI, additional studies must be done to optimize FI screening, including determining the best screening modality and interventions for this high-risk population.

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Effectiveness of a Collaborative, Virtual Outreach Curriculum for 4th-Year EM-bound Students at a Medical School Affiliated with a Historically Black College and University

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Background: Diversity within the physician workforce is associated with improved clinical outcomes and patient satisfaction. Despite this, the US physician workforce, particularly in emergency medicine (EM), remains relatively homogeneous. Of all Black medical school students in the US, 14% attend the four Historically Black Colleges and Universities (HBCU) that have a medical school. Unfortunately, none of these schools are affiliated with an academic EM program. Because of this, there is less professional mentorship focused on obtaining a career in EM and potentially less formal curricula for senior medical students doing their home sub-internship in EM.

Objectives: Our objective was to fill the gap left by the absence of an academic EM department at Howard University College of Medicine (HUCOM) by creating a collaborative educational experience for fourth-year medical students during their home EM sub-internship. The curricular objectives were to teach core principles of EM, build relationships with students, and prepare them for pursuing EM residency training.

Curricular Design: Four EM academic departments collaborated to create and implement a virtual curriculum using the six-step approach to curricular development.

Impact/Effectiveness: After completion of the course, five students (100%) reported strongly agreeing with the following statements. These sessions 1) helped me learn the approach to core EM topics more than I would have been able to do on my own; 2) helped me learn key skills for excelling in an EM rotation more than I would have been able to do on my own; and 3) allowed me to connect with faculty and resident mentors to learn more about the field of EM. Of these five students, 80% and 20% reported strongly agreeing and agreeing, respectively, that these sessions helped them learn about the process of applying to and selecting an EM residency program. [West J Emerg Med. 2025;26(1)129–134.]

INTRODUCTION

Need for Innovation

Medical students interested in emergency medicine (EM) who attend a historically Black college or university (HBCU) do not have the teaching and mentorship that occurs when a medical school is affiliated with an academic EM program. We formed a collaborative program among four academic EM departments to help fill this need for EM-bound students at Howard University College of Medicine (HUCOM). To our knowledge, this is the first such program to be reported in the literature.

Background

A diverse physician workforce is associated with increased access to and utilization of the healthcare system, improved health outcomes and patient experience, and improved fiscal margins for hospitals.[1–4,4–6] Despite this, the medical field as a whole has made minimal advances in increasing physician diversity. In 2008 the percentage of Black or Hispanic US physicians from all specialties was 6.3% and 5.5%, respectively. By 2018, however, those percentages were only 5.0% and 5.8%, respectively. Even more concerning given the diverse patient population that the emergency department (ED) serves, EM remains among the medical specialties with the lowest number of physicians from backgrounds under-represented in medicine (URiM). Between 2008–2018, the percentage of emergency physicians who identified as Black decreased from 5.0% to 4.5%, and stayed constant at 5.3% for Hispanic/Latinos.[7]

When surveyed, 35% of EM program directors reported that the small number of URiM residency applicants was the greatest barrier to obtaining a diverse residency class.[8] Of all Black medical school students in the US, 14% attend four HBCUs with a medical school. Because none of these schools are affiliated with an academic EM program, their medical students have decreased exposure to EM in the pre-clinical years, less professional mentorship focused on obtaining a career in EM, and fewer formal curricula for senior medical students doing their home sub-internship (sub-I) in EM. This lack of mentorship has been identified as a critical barrier for URiM students across various specialties, contributing to lower application rates and residency placement. Studies suggest that mentorship increases both career satisfaction and inclusivity and the likelihood of these students entering and succeeding in competitive fields like EM.[9,10] In addition, a national survey of clerkship directors found that having a structured, standardized sub-I curriculum significantly improved the preparedness of students for residency, especially when these rotations were affiliated with residency programs.[11]

The Emory University Department of Emergency Medicine created a program with Morehouse School of Medicine to provide guidance to medical students interested in EM. A total of 115 Morehouse students completed an EM clerkship at Emory, and 62.6% successfully matched into EM.[12] While this program was successful, students typically rely on their home sub-I to prepare for mandatory away rotations. This absence of support from an academic department prior to away rotations may cause the students to find themselves less prepared and at a competitive disadvantage when they begin their away rotations. Furthermore, many EM residencies are not in proximity to a HBCU, requiring students to bear the financial burden of traveling to other cities and states for their away rotations.

At HUCOM, the EM sub-I relied heavily on an older, recorded online lecture series from an external institution, supplemented by bedside teaching from community attendings at one site, Howard Hospital. Students noted that the absence of formal educational components, such as weekly didactics, journal clubs, and simulation, resulted in limited exposure to "cutting-edge" EM practices. Moreover, the lack of interaction with academic attendings who are dedicated to medical student education, along with the absence of residents—who represent the next step in career progression—left students without access to critical mentorship and guidance. This gap hindered students' ability to visualize their own progression and receive practical advice from individuals at a similar stage in training, further limiting their connection to the broader EM community.

To help overcome that barrier, we created a collaboration between four academic EDs and HUCOM in an attempt to augment curricular offerings for EM-interested students on their HUCOM fourth-year EM home rotation. The collaboration between four academic EDs broadens the exposure students receive to different teaching styles, institutional cultures, and clinical perspectives. This variety provides a more comprehensive educational experience than what can be offered by a single institution alone.

Objective of Innovation

We aimed to address the absence of an academic ED at HUCOM by developing a collaborative educational experience. This program focuses on core principles of EM and residency preparation and was designed specifically for fourth-year medical students during their home EM sub-I at HUCOM. We obtained institutional board review approval from Wake Forest University School of Medicine.

Development Process

We used the six-step approach to curricular development. All final curricular design and content was agreed upon by the faculty representatives at each of the four participating residency sites.[13,14] 1) *Problem identification and general needs assessment.* Unlike traditional curriculum development where the need assessment is based on a specific health problem, our needs assessment was based on the need to increase the diversity of emergency clinicians by helping prepare under-represented students to succeed in away

rotations and the match. 2) *Determining and prioritizing content.* While individuals at each participating institution were involved with teaching at their own institution, the needs of the HUCOM students were unique. Therefore, educational objectives were developed in conjunction with the faculty advisor to the fourth-year EM rotation at HUCOM who conducted stakeholder interviews with five current medical students and five alumni who had recently graduated and were currently in EM residencies across the country. It was decided that curricular content would include a mix of core EM topics (as determined from stakeholder interviews) and advising sessions.

After all sessions, students were provided with the contact information for the faculty lecturers and were encouraged to reach out. 3) *Goals and objectives*. Broad curricular goals were developed. These were to a) teach the approach to core complaints in EM; b) teach key skills in EM; c) demystify the process of applying to an EM residency program; and d) connect students with residents and faculty in the field of EM. After this, specific measurable lecture goals were developed based on cognitive, affective, and psychomotor objectives for the learner. 4) *Educational strategies*. We created an entirely virtual, four-week didactic program, with content organized into weekly four-hour blocks, each led by a different academic ED, on an interactive platform that allowed for case-based discussions, small-group discussions, and standard lecture format. Since implementation in 2022, the program has been mandatory for all students completing their fourth-year EM sub-I at HUCOM.

Each week, the sessions required the participation of four to five faculty members who volunteered their time, with the majority of lectures delivered by a single faculty member. However, select sessions, such as the "Application and Interviewing Process," were co-led by a dynamic team consisting of the assistant program director, program director, and chief residents, providing a well-rounded perspective and valuable insights for the participants. Content was mapped and coordinated, and pre-reading was assigned from the Academy for Diversity and Inclusion in Emergency Medicine webinar series "How to Be a Successful EM Applicant" and the Clerkship Directors in Emergency Medicine/Society of Academic Emergecy Medicine M4 curriculum. Each day included a mix of clinical topics and "advising" sessions (Table 1). 5) *Implementation.* Approval from the EM director was obtained, and the curricula was implemented. 6) *Evaluation and feedback*. After each block of content, evaluations for each individual session (including the presenter) were sent to participating students via REDCap (Research Electronic Data Capture, hosted at Howard University School of Medicine.

These evaluations consisted of one question for each session: "Please rate the effectiveness of the following session in accomplishing its learning objectives: *Session, Presenter*." At the end of the month-long program, an overall evaluation of the program was sent to participating students, also via RedCap. The program evaluation survey tool, including four multiple-choice questions regarding the overall learning objectives, is reflected in Figure 1. The tool also included two free-response questions: 1) "Which parts of the curriculum were of most value to you?"; and 2) "Which parts of the curriculum could be improved?" We refined the curricula each year during an end-of-year debrief.

Implementation Phase

Prior to the first session, students were provided a spreadsheet with pre-session work, curriculum topics, presenting faculty and residents, dates and times, and links to access the weekly virtual sessions. Each EM program provided four hours of interactive didactics to the students according to the scheduled dates and times.

Outcomes

A post-curricular survey found universal agreement from students that the curriculum was effective in meeting the above goals. Of the five students, 100% reported strongly agreeing with the following statements. These sessions 1) helped me learn the approach to core EM topics more than I would have been able to do on my own; 2) helped me learn key skills for excelling in an EM rotation more than I would have been able to do on my own; and 3) allowed me to

Table 1. Curricula from sample block.

	Didactic session one Institution one	Didactic session two Institution two	Didactic session three Institution three	Didactic session four Institution four
Lecture topics	Personal statement	Presentation skills	How to choose the right program for you	Application and interviewing process
	Chest pain	Altered mental status	Toxicology overview	Headache
	Shortness of breath	Abdominal pain	Shock and sepsis	Gynecologic and urologic emergencies
	Radiographs	Electrocardiogram introduction	Vaginal bleeding	Endocrine and electrolytes
	Social emergency medicine	Ultrasound basics	Advanced trauma life support	Advanced cardiac life support, basic life support

Session:
Presenter:

Please rate the effectiveness of the following session in accomplishing its learning objectives on a scale from 1 (not effective) to 5 (very effective)

Questions	These sessions helped me learn the approach to core emergency medicine topics (abdominal pain, chest pain, headache, etc.) more so than I would have been able to do on my own.	These sessions helped me learn key skills for excelling in an emergency medicine rotation including oral presentations, EKG interpretation, x-ray interpretation and ultrasound, more so than I would have been able to do on my own.	These sessions helped me learn about the process of applying to and selecting an EM residency program.	These sessions allowed me to connect with faculty and resident mentors to learn more about the field of emergency medicine.
Response Options	Strongly agree, agree, neutral, disagree, strongly disagree	Strongly agree, agree, neutral, disagree, strongly disagree	Strongly agree, agree, neutral, disagree, strongly disagree	Strongly agree, agree, neutral, disagree, strongly disagree
Response				

Which parts of the curriculum were of most value to you?

Which parts of the curriculum could be improved?

Figure 1. Evaluation form sent to students after each session.

connect with faculty and resident mentors to learn more about the field of EM. Of the five students, 80% and 20% reported strongly agreeing and agreeing, respectively, that these sessions helped them learn about the process of applying to and selecting an EM residency program.

Narrative feedback, such as the quotes below, from students highlighted the value of meeting with faculty and residents from different programs. from going through cases in real time.

> Meeting the faculty and program directors at various EM programs really was the highlight of the curriculum. It was great to get an inside look at each program and learn more about their culture, approach, and the people there.

> I really enjoyed hearing the residents' perspective on how to navigate the application process.

Narrative feedback, such as the quotes below, also emphasized the value of the curriculum's interactive nature and how traditionally in-person topics were effectively adapted for virtual learning.

> My favorite part was participating in real-time cases. Being involved as the case unfolded felt like hands-on practice.

> It was incredible to have the mechanisms of ultrasound explained in such detail. Breaking it down to the basics really helped me understand ultrasound for the first time.

REFLECTIONS AND LESSONS LEARNED

Engagement of the Home Institution

Successful implementation required active engagement from HUCOM, specifically the clerkship director and administrative staff, who served as lead contacts. Control over rotation scheduling was essential to ensure all students were fully engaged in the sessions. In addition, as participating institutions used various online platforms to communicate and disseminate curricula materials, such as *Tintinalli's Emergency Medicine*, with their students, it was necessary to have HUCOM manage a central communications- and video-conferencing platform that was accessible to all lecturing institutions and participating students.

Engagement of Collaborating Institutions

Recruiting faculty and residents for each institution's week was challenging, but having representatives with strong connections in medical education made a significant difference. These relationships allowed them to quickly and effectively recruit lecturers, leveraging their networks to secure individuals who were both willing and enthusiastic to participate. This highlights the value of having institutional leads with established ties to their educational infrastructure, streamlining the recruitment process.

Collaborative Power

The success of this project involved a high degree of trust as many of the institutional representatives had not worked together. To develop this trust, we followed the framework of engaging, listening, framing, envisioning, and committing.[15] The power of this program is truly in the collective rather than the individual. While students could learn about atrial fibrillation from one institution, the real learning occurs when they see the collaboration, get a sense of the scope of EM as a professional field, and are able to interact with varied institutions that have different approaches to teaching and the practice of medicine.

Challenges with Small Student Cohorts

Unlike traditional EM rotations that attract students from across the country, our program had a small cohort comprised solely of HUCOM students, as there was no affiliated residency. This small group size meant that if one student missed a session due to interviews, illness, or other reasons, it noticeably impacted the learning environment, limiting group dynamics and peer-to-peer learning.

Program Limitations and Adaptations

Virtual learning posed challenges for teaching interactive skills such as ultrasound. We addressed this by incorporating case-based learning with curated image libraries and real-time feedback. To further enhance the learning experience, future iterations should explore the integration of ultrasound simulation software to better mimic hands-on scenarios.

Scalability and Expansion

Although initially designed for HUCOM students, this model could be expanded to other medical schools without academic EDs, especially those with a high proportion of URiM students. With the opening of additional HBCU medical schools, there is an even greater need for programs that increase access to EM education.

Limitations

Study limitations include the small sample size as well as lack of a comparison group. Future analyses will address these limitations and include evaluation of match outcomes as well as other learner-centered targets such as performance in Standardized Letters of Evaluation or subsequent rotations and intern year performance.

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Associations of the Need for Surgery in Emergency Department Patients with Small Bowel Obstructions

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Objectives: Management strategies for small bowel obstruction (SBO) vary from conservative approaches to surgical intervention. A known complication of surgery is the subsequent adhesions that can cause recurrent SBOs, longer hospital stays, and higher treatment costs. Our primary outcome was to identify independent risk factors that are associated with the decision for surgical intervention, and our secondary outcome was to describe characteristics of visits associated with complications.

Methods: This study was a single-center, retrospective chart review from a large, urban university hospital. We included adult patients admitted to the emergency department (ED) with the International Classification of Diseases, 10th Rev, codes for small bowel obstruction from June 1, 2017– May 30, 2019. Eligible covariates were demographics, radiological findings, clinical presentation, past medical history, and results of radiologic testing. We identified univariate associations of outcome and then performed a multivariate logistic regression to identify independent associations of each outcome. Finally, a backwards selection was used to determine the final model. We calculated odds ratios (OR) and 95% confidence intervals (CI) along with the area under the curve (AUC), as appropriate.

Results: A total of 530 patients met the study criteria; 148 (27.9%) underwent surgery of whom 35 (6.6%) had complications. We identified seven independent associations for the decision of surgery: abdominal distension (OR 0.27, 95% CI 0.10–0.62); gastrografin (OR 0.41, 95% CI 0.20–0.81); previous SBO (OR 0.42, 95% CI 0.26–0.66); higher Charlson Comorbidity Index score (OR 0.87, 95% CI 0.80–0.95); nasogastric decompression (OR 2.04, 95% CI 1.25–3.39), initial systolic blood pressure <100 mm Hg (OR 2.65, 95% CI 1.05–6.53); free fluid or volvulus/closed-loop obstruction on computed tomography (OR 7.95, 95% CI 4.25–15.39), with the AUC for the predictive model equaling 0.73.

Conclusion: We identified seven independent associations present in the ED associated with the decision for surgery. These associations are a step toward building better prediction models and improving decision-making in the ED, allowing for a more adequate treatment plan. [West J Emerg Med. 2025;26(1)135–141.]

INTRODUCTION

There is currently a shift from the traditional dogma, "*Never let the sun rise or set on small bowel obstruction,*" which implies urgent surgical intervention, toward non-operative management when clinically indicated.[1] This is an important shift because non-operative management may

have less associated risk and help decrease resource utilization when appropriate.[2–4] The decision regarding small bowel obstruction (SBO) treatment and intervention is not always clear. While some studies have tried to elucidate ways to help manage our clinical decisions, there are no uniformly accepted clinical decision rules, and the approach is largely left to individual clinical judgment.

When evaluating a patient with a suspected SBO, it is important to understand the degree of obstruction and associated complications such as bowel ischemia, perforation, peritonitis, hernia strangulation, and anticipated course.[5,6] These considerations are important as surgery itself carries risks such as infection, bleeding, and complications from general anesthesia. Also concerning is the risk of additional adhesions leading to recurrent SBOs, as post-surgical adhesions are responsible for roughly 70% of all SBOs in the United States.[2,3,7,8] Conversely, it is imperative to discuss the risk of delayed intervention in SBO patients who require surgery. Examples include complications such as bowel resection, prolonged postoperative length of stay, and death.[9] The management for each SBO patient should be tailored to the degree of obstruction, associated characteristics, and anticipated course while evaluating the risks and benefits of conservative management versus surgical intervention.

Our goal in this study was to identify clinical associations that identify patients likely to progress to a surgical intervention. We collected data on patient demographics, physical exam findings, vital sign abnormalities, laboratory test results, and radiographic findings associated with SBOs diagnosed in the ED. Our primary outcome was to identify independent risk factors associated with the decision for surgical intervention, and our secondary outcome was to identify independent factors associated with complications.

Population Health Research Capsule

What do we already know about this issue?
There are varying management strategies for small bowel obstructions (SBO), but it is not clear which patients would most benefit from surgical intervention.

What was the research question?
Are there independent risk factors associated with surgical intervention for patients with SBO? And which patients developed complications during their inpatient admission?

What was the major finding of the study?
Seven factors were associated with decision for surgery: abdominal distension (OR 0.27, 95% CI 0.10–0.62); gastrografin use (OR 0.41, 0.20–0.81); previous SBO (0.42, 0.26–0.66); higher Charlson Comorbidity Index (0.87, 0.80–0.95); nasogastric tube (2.04, 1.25–3.39); systolic blood pressure <100 mm Hg (2.65, 1.05–6.53); free fluid or volvulus/closed-loop obstruction on CT (7.95, 4.25–15.39).

How does this improve population health?
These findings can help clinicians identify patients who might be a better candidate for surgical intervention vs conservative therapy to safely manage SBOs.

METHODS

Study Design

We performed a retrospective chart review of patients presenting to the ED (annual ED volume is 55,000 adult patients) of an urban, tertiary-care, academic medical center from June 1, 2017–May 30, 2019. Our study was reviewed and approved by the institutional review board. We followed all the best practices for chart review as described in Worst and Bledsoe with the exception of one, as our abstractors were not blind to the hypothesis.[10]

Inclusion and Exclusion

The study population consisted of ED patients ≥18 years with an International Classification of Diseases, 10th Rev. (ICD-10) code consistent with SBO (ICD-10 K56x, K91.3x, Q41.9, Q42.9, Q42.8, and Q43.1). We excluded patients who had advanced directives to avoid surgical intervention (ie, if the patient was a surgical candidate but elected not to have surgery) and patients with a large bowel obstruction identified by attending radiologist interpretation on computed tomography (CT).

Data Collection and Handling

We abstracted data via chart review by trained reviewers compiling data from the initial presentation without knowledge of the subsequent hospital course. The parameters investigated included demographics, elements of the clinical presentation, past medical history, vital signs, physical exam findings, and radiographic imaging. Specific demographics and patient data included age, gender, date of admission, and length of stay. Pertinent past medical history included previous SBOs, inflammatory bowel disorders, past abdominal surgeries, anatomical anomalies, and malignancies. We also included parameters that comprise the Charlson Comorbidity Index (CCI), while excluding connective tissue diseases. We had one attending emergency

radiologist review all CT images to identify the following features: presence of a transition point; free intraperitoneal fluid; debris and gas bubbles within the dilated small bowel lumen (small bowel feces sign); mesenteric edema; and closed-loop obstruction or volvulus to ensure consistent wording throughout the radiographic reports. We additionally noted whether oral, water-soluble radiological contrast, specifically gastrografin, had been used during their hospitalizations. We coded for non-operative surgical management, as well as complications such as sepsis, intubation, vasopressor-dependent shock, anatomic surgical alterations, and bowel perforation.

These data points were abstracted from ED records, inpatient hospital records, and discharge summaries. A trained, experienced researcher underwent rigorous training on our explicit protocol, including clearly defined variables and standardized coding methods, and performed the systematic data abstraction. The abstractor flagged ambiguous charts for additional review by an emergency medicine senior resident physician and a board-certified emergency attending physician.

Outcomes of Interest

The primary outcome was surgical intervention, defined as surgery during initial hospital admission. The secondary outcome was SBO-related complications during initial hospital admission. Complications were also looked for after 90 days after discharge but using solely our hospital system health records. Complications included sepsis, intubation, vasopressor-dependent shock, anatomic surgical alterations, and bowel perforation.

Data Analysis

We employed chi-square tests for categorial variables and *t*-tests for continuous variables to identify univariate associations of outcomes. The Fisher exact test was used instead of chi-square test when the sample number was low. Factors associated with surgical intervention were determined with a multivariate logistic regression model. We employed a multistage process to determine the covariates to include in the model. Possible associations were included in the model if the *P*-value for the univariate analysis was <0.10 and the prevalence was sufficiently high to allow for model convergence. Finally, backwards selection was used to determine the final model, with an alpha for exit of 0.05. The odds ratios (OR), 95% confidence intervals (CI), and area under the curve (AUC) were calculated.

RESULTS

There were 690 patients identified and reviewed for eligibility. A total of 530 patients (76.8%) met the inclusion criteria and were included in the study. The patient population tended to be older, had a history of abdominal surgeries, and previously diagnosed SBOs (Table 1). Of the 530 eligible patients, 148 (27.9%) underwent surgery under

Table 1. Baseline characteristics of the patients included in the study, overall and by outcomes.

Characteristic	Overall (N = 530)	Surgery			Complications		
		Yes (n = 148)	No (n = 382)	*P*-value	Yes (n = 35)	No (n = 495)	*P*-value
Demographics							
Age, mean (SD)	63.9 (15.9)	65.1 (15.2)	63.4 (16.2)	0.28	66.5 (14.8)	63.7 (16.0)	0.32
Female, n (%)	297 (56%)	89 (60.1%)	208 (54.5%)	0.24	18 (51.4%)	279 (56.4%)	0.57
Symptoms reported							
Constipation, n (%)	34 (6.4%)	11 (7.4%)	23 (6.0%)	0.55	0 (0.0%)	34 (6.9%)	0.15*
Abdominal pain, n (%)	496 (93.6%)	136 (91.9%)	360 (94.2%)	0.32	32 (91.4%)	464 (93.7%)	0.48*
Abdominal distension, n (%)	68 (12.8%)	9 (6.1%)	59 (15.5%)	0.004	3 (8.6%)	65 (13.1%)	0.60*
Nausea, n (%)	325 (61.3%)	88 (59.5%)	237 (62.0%)	0.58	23 (65.7%)	302 (61.0%)	0.58
Fever, n (%)	16 (3.0%)	4 (2.7%)	12 (3.1%)	1.0000*	3 (8.6%)	13 (2.6%)	0.08*
Vomiting, n (%)	357 (67.4%)	87 (58.8%)	270 (70.7%)	0.01	25 (71.4%)	332 (67.1%)	0.60
Medical history							
CCI score, mean (SD)	4.2 (3.1)	3.7 (2.8)	4.5 (3.2)	0.01	5.3 (3.4)	4.2 (3.0)	0.04
Previous SBO, n (%)	263 (49.6%)	52 (35.1%)	211 (55.2%)	<0.0001	10 (28.6%)	253 (51.1%)	0.01
Crohn's disease, n (%)	53 (10.0%)	7 (4.8%)	46 (12.0%)	0.01	2 (5.9%)	51 (10.3%)	0.56*
Ulcerative colitis, n (%)	42 (7.9%)	9 (6.1%)	33 (8.6%)	0.34	0 (0.0%)	42 (8.5%)	0.10*
Intestinal cancer, n (%)	67 (12.6%)	9 (6.1%)	58 (15.2%)	0.005	3 (8.6%)	64 (12.9%)	0.60*

(*Continued on next page*)

Table 1. Continued.

Characteristic	Overall (N = 530)	Surgery			Complications		
		Yes (n = 148)	No (n = 382)	*P*-value	Yes (n = 35)	No (n = 495)	*P*-value
Solid tumor malignancy, n (%)	195 (36.8%)	37 (25.0%)	158 (41.4%)	0.0005	15 (42.9%)	180 (36.4%)	0.44
Previous abdominopelvic surgeries, n (%)	444 (83.8%)	117 (79.1%)	327 (85.6%)	0.07	20 (57.1%)	424 (85.7%)	<0.0001
Anatomic differences, n (%)	389 (73.5%)	95 (64.6%)	294 (77.0%)	0.004	17 (48.6%)	372 (75.3%)	0.001
Diabetes, n (%)	92 (17.4%)	32 (21.6%)	60 (15.7%)	0.11	6 (17.1%)	86 (17.4%)	0.97
Moderate to severe kidney disease, n (%)	25 (4.7%)	5 (3.4%)	20 (5.2%)	0.37	4 (11.4%)	21 (4.2%)	0.07*
Leukemia or lymphoma, n (%)	16 (3.0%)	3 (2.0%)	13 (3.4%)	0.57*	3 (8.6%)	13 (2.6%)	0.08*
Peptic ulcer disease, n (%)	18 (3.4%)	5 (3.4%)	13 (3.4%)	0.99	0 (0.0%)	18 (3.6%)	0.62*
Visit measures							
Triage heart rate >110 bpm, n (%)	42 (8.0%)	16 (10.9%)	26 (6.8%)	0.12	4 (11.4%)	38 (7.7%)	0.51*
Triage respiratory rate >20, n (%)	23 (4.4%)	5 (3.4%)	18 (4.7%)	0.50	6 (17.1%)	17 (3.5%)	0.003*
Triage SBP <100 mm Hg, n (%)	28 (5.3%)	12 (8.1%)	16 (4.2%)	0.07	3 (8.6%)	25 (5.1%)	0.42*
Triage temp >100.4 °F, n (%)	4 (0.8%)	3 (2.1%)	1 (0.3%)	0.07*	1 (3.0%)	3 (0.6%)	0.23*
Triage O_2 <90%, n (%)	10 (1.9%)	4 (2.7%)	6 (1.6%)	0.48*	2 (5.7%)	8 (1.6%)	0.14*
Nasogastric decompression, n (%)	342 (64.5%)	106 (71.6%)	236 (61.8%)	0.03	24 (68.6%)	318 (64.2%)	0.60
Gastrografin administration, n (%)	83 (15.7%)	14 (9.5%)	69 (18.1%)	0.01	7 (20.0%)	76 (15.4%)	0.46
Focal tenderness on examination, n (%)	206 (38.9%)	57 (38.5%)	149 (39.0%)	0.55	13 (37.1%)	193 (39.0%)	0.97
Rebound tenderness/ peritonitis on examination, n (%)	13 (2.5%)	3 (2.0%)	10 (2.6%)	0.90	0 (0.0%)	13 (2.6%)	0.14
Distension on examination, n (%)	228 (43.0%)	62 (41.9%)	166 (43.5%)	0.39	19 (54.3%)	209 (42.2%)	0.24
Diffuse tenderness on examination, n (%)	277 (52.3%)	73 (49.3%)	204 (53.4%)	0.14	16 (45.7%)	261 (52.7%)	0.64
CT findings							
Presence of a transition point on CT, n (%)	475 (95.0%)	134 (97.1%)	341 (94.2%)	0.18	30 (88.2%)	445 (95.5%)	0.08
Presence of free intraperitoneal fluid on CT, n (%)	278 (55.5%)	80 (57.6%)	198 (54.7%)	0.56	22 (64.7%)	256 (54.8%)	0.26
Debris and gas bubbles within the dilated small bowel lumen on CT, n (%)	174 (35.2%)	37 (27.4%)	137 (38.2%)	0.03	8 (23.5%)	166 (36.1%)	0.13
Mesenteric edema on CT, n (%)	183 (36.8%)	53 (38.4%)	130 (36.1%)	0.63	11 (32.4%)	172 (37.1%)	0.58
Volvulus or closed-loop obstruction on CT, n (%)	61 (12.2%)	42 (30.4%)	19 (5.2%)	<0.0001	5 (14.7%)	56 (12.0%)	0.59*

*P-value calculated by the Fisher exact test.

CCI, Charlson Coborbidity Index; *SBO*, small bowel obstruction; *CT*, computed tomography; *bpm*, beats per minute; *SBP*, systolic blood pressure; *mm Hg*, millimeters of mercury; O_2, oxygen saturation.

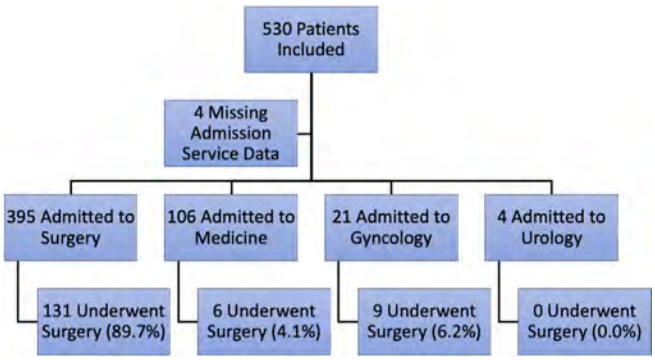

Figure 1. Admitting service and rates of surgery.

various admitting services (Figure 1) and 35 (6.6%) had at least one complication (Table 2).

We identified univariate associations of the decision for surgical intervention (Table 1). In our multivariable analysis, we identified three independent factors associated with a higher odd of surgical intervention: fluid or volvulus/closed-loop obstruction on CT (OR 7.95, 95% CI 4.25–15.39), nasogastric decompression (OR 2.04, 95% CI 1.25–3.39), and initial systolic blood pressure <100 millimeters of mercury (OR 2.65, 95% CI 1.05–6.53) (Table 3). Four factors were associated with lower odds of surgical intervention: Higher CCI score (OR 0.87, 95% CI 0.80–0.95), abdominal distension in history (OR 0.27, 95% CI 0.10–0.62), previous SBO (OR 0.42, 95% CI 0.26–0.66), and gastrografin administration (OR 0.41, 95% CI 0.20–0.81). The AUC for the logistic regression was 0.73.

Table 2. Occurrence of outcomes.

Outcome	N (%)
Surgery	148 (27.9%)
Complication	35 (6.6%)
Sepsis	16 (3.0%)
Intubation	12 (2.2%)
Vasopressor dependent shock	11 (2.0%)
Anatomic surgical alteration	1 (0.2%)
Bowel perforation	8 (1.5%)

Table 3. Results of multivariable logistic regression analysis for decision for surgery.

Variable	Odds ratio (95% CI)
History of abdominal distension	0.27 (0.10–0.62)
Gastrografin	0.41 (0.20–0.81)
Previous SBO	0.42 (0.26–0.66)
Higher CCI score	0.87 (0.80–0.95)
Nasogastric decompression	2.04 (1.25–3.39)
Initial systolic blood pressure <100 mm Hg	2.65 (1.05–6.53)
Free fluid or volvulus/closed-loop obstruction on CT	7.95 (4.25–15.39)

CI, confidence interval; *SBO*, small bowel obstruction; *CCI*, Charlson Comorbidity Index; *mm HG*, millimeters of mercury; *CT*, computed tomography.

DISCUSSION

The general treatment method of SBOs is shifting toward non-operative management. While there have been attempts to construct better guidelines such as the Bologna guidelines, there is still no definitive consensus.[5] We propose that these clinical decision algorithms can be strengthened by incorporating specific factors. An example of a simple predictor model is seen in the retrospective study by Komatsu et al, where they created a four-point system scoring the risk for surgery in patients undergoing conservative strategy with their three variables.[11] Past studies regarding surgical associations for SBOs have mixed results. Free fluid on CT was found as a positive predictor for surgery in some studies.[3,6,12] However, a later prospective validation study found that free fluid was not a predictor.[13]

Our results demonstrated that free fluid or volvulus/closed-loop obstruction was positively associated with an OR of 7.95 (95% CI 4.25–15.39). It is important to note that our result is a combination of two distinct variables; we found that one was found to be completely predictive of the other and, therefore, we merged the two variables. Another CT finding, namely mesenteric edema has previously been attributed as a positive predictor.[13] Our results, however, did not identify mesenteric edema as significant in the univariant analysis and was not included in the multivariant model.

Interestingly, we found prior SBO to be an independent association, which is protective for the decision for surgery with an OR of 0.42 (95% CI 0.26–0.66). In both Zielinski et al studies prior SBOs were seen as protective for operative management in their univariate analysis, but it was not significant in their regression models.[3,13] Prior SBO was also found to be significant in the bivariate analyses in the O'Daly et al study but was not significant in their regression model.[12] This is in contrast to the results of another study that did not find prior SBOs to be significant in their univariate analysis with a *P*-value of 0.93.[6] A possible explanation for why prior SBOs is protective in the decision for surgery is that there might be a higher risk of recurrence in patients who received conservative treatment, while the need for surgical re-intervention was not different between non-surgical and surgical management.[7] This coupled with a possible bias on the clinician's part that if a previous management worked the clinician might favor it again, would influence the number of patients who received conservative treatment in our study time frame. There will simply be more patients with previous SBOs that have been treated conservatively in that given time.

Gastrografin has recently been included in some evidence-based papers regarding SBO management and decision-making.[5,14] It is a hyperosmolar water-soluble contrast medium shown to have a diagnostic and prognostic, as well as a potential therapeutic, effect for patients with SBO.[15–17] The prognostic and therapeutic properties of gastrografin have been appreciated during a gastrografin challenge, when the patient ingests gastrografin either orally or through a nasogastric tube, and multiple radiographs are taken in the span of 24 hours to assess passage of contrast. Three large systematic reviews and meta-analyses have determined when gastrografin has passed through the patient's gastrointestinal tract and reached the colon within 24 hours, the patient most likely does not need surgery and can, therefore, be treated conservatively. Additionally, all three studies found that the admission of gastrografin shortened the duration of hospitalization.[15–17]

We found that gastrografin was an independent negative association for surgery (OR 0.41, 95% CI 0.20–0.81). While there may be selection bias for less acutely ill patients, it is hypothesized that there is a therapeutic effect of gastrografin, which may decrease the need for surgery. A large systematic review and meta-analysis involving 1,216 patients from 12 studies found the OR for surgery intervention after gastrografin administration to be 0.55 (95% CI 0.32–0.37, $P = 0.003$)[15]. This is in line with another systematic review and meta-analysis finding the OR to be 0.62 (95% CI 0.44–0.88, $P = 0.007$)[16].

LIMITATIONS

The primary limitation to our study is its retrospective, single-center design, which left us open to selection bias. Another limitation is that surgeon practice variability may not be generalizable to other institutions. In addition, our chart review methodology to collecting data inherently made us susceptible to misclassification bias. It is also possible that patients may have re-presented to another hospital without our knowledge and those potential complications and outcomes were lost to follow-up. Our study is further limited by our small sample size, and we were unable to incorporate all variables and complications we found significant into the multivariant model. Additionally, by using surgery as an endpoint, we may have captured patients who received surgery but did not unequivocally need surgery. Finally, we did not classify which patients were admitted to a surgical service as that may have impacted the decision to perform surgery if they were not on a surgical service.

CONCLUSION

We found seven independent factors associated with surgery. We believe that these may help clinicians determine which ED patients require surgical intervention. There are conflicting results in the current literature and further research is needed to determine more accurate algorithms and patient management of patients with small bowel obstruction. We believe our larger retrospective study provides an important advancement in potentially formulating better prediction models to prevent unnecessary surgery. This research is imperative for the management of SBOs, as unnecessary surgery yields a higher resource utilization and can lead to further complications.[2–4,7]

Future studies should include large, prospective, multi-institutional studies encompassing a wide range of variables and CT parameters, as current literature is limited. Additional prediction models and algorithms should be tested in combination with the administration of gastrografin to build a comprehensive management plan for patients with SBO.

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Survey of Firearm Storage Practices and Preferences Among Parents and Caregivers of Children

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Introduction: The American College of Emergency Physicians supports community- and hospital-based programs that intervene to prevent firearm-related injury. To this end, the distribution of firearm locks or storage devices in the emergency department (ED) may help achieve this target. To inform secure firearm storage programs for households with children and firearms, we examined firearm storage practices, device preferences, and cost tolerance among parents/caregivers of children.

Methods: Between April 2018–November 2019, we conducted and analyzed an in-person survey of 294 caregivers, aged ≥18, with both children and firearms in the home. Surveys assessed reasons for firearm ownership, storage practices and device preferences among five storage-device options, and prices participants were willing to pay for devices. Practices and preferences were examined by participant characteristics. We used logistic regression to estimate odds ratios and 95% confidence intervals for associations of interest.

Results: Most participants (73%) reported personal protection as a reason for owning firearms, and nearly 80% owned at least one firearm storage device. Over half (55%) owned cable locks, but only 36% of owners reported regularly using them. Rapid-access devices (electronic and biometric lockboxes) were less commonly owned (26%) but more likely to be regularly used (73%). The most highly rated storage device features were the following: the ability to store the firearm unloaded (87.3%); the ability to store the firearm loaded (79.1%); and device affordability (65%). Most participants (78%) preferred rapid-access devices over other options. Participants were willing to pay more for products that afforded rapid access to the firearm. Participants reported they would pay a median of $100 for a pushbutton rapid-access product ($80 retail), and $150 for a biometric lockbox ($210 retail).

Conclusion: Understanding the storage practices and preferences among firearm-owning households with children can help inform ED injury-prevention screening and firearm safety practice implementation. Our results suggest that rapid-access devices may be the most preferable firearm storage devices for distribution by secure storage programs, and costs are likely minimal given parental/caregiver willingness to pay. [West J Emerg Med. 2025;26(1)142–146.]

INTRODUCTION

Firearm injuries are the single leading cause of death for children in the United States.[1] Despite their inherent risk, firearms remain accessible to many children: estimates suggest that one in three US homes have at least one firearm, the majority of which are not stored securely.[2,3] The American College of Emergency Physicians (ACEP) supports community- and hospital-based programs that intervene to prevent firearm-related injury. To this end, the distribution of firearm locks or storage devices in the emergency department (ED) may be effective.[4] However, underutilization of these devices suggests that current distribution strategies do not meet the needs of firearm owners.[5–7]

Currently, there is limited knowledge about firearm storage preferences among caregivers of children. While prior literature has indicated that the costs of firearm safes can be a deterrent to their use, to our knowledge there is no published research regarding firearm owners' willingness to pay for other types of storage devices or locks.[8,9] This is critical to understand the costs and feasibility of implementation of firearm injury prevention programs. Our aim was to describe caregiver firearm owners' preferences for, current use of, and willingness to pay for storage devices to inform prevention strategies.

METHODS

Study Design

We conducted an in-person, cross-sectional survey of firearm-owning parents/caregivers of children between April 2018–February 2019. We surveyed a convenience sample of caregivers of children at 10 community sites. These sites were geographically clustered in two major metropolitan areas with participants drawing mainly from two western states. Sites included an outdoor sporting activities fair, regional firearm show, academic children's hospital safety center event, and multiple large community events across two metropolitan areas. Eligibility criteria for caregivers included the following: 1) aged $\geq$ 18 years; 2) having children (aged < 18 years) spending time in the home; 3) current or near-future possession of firearm(s); and 4) English language proficiency. Approval for the study was obtained from our local institutional review board (IRB#00017762).

Procedures

Participants were recruited by tabling, and all surveys were conducted in person by members of the research team. Interested parents/caregivers, of whom 294 met eligibility criteria, completed an online consent form and anonymous survey electronically or on paper, which were stored via Research Electronic Data Capture (REDCap), hosted at Oregon Health & Science University.[10,11]

Measures

Survey measures were adapted from an instrument used in a firearm storage preference survey at another institution.[7] The survey assessed participants' sociodemographic characteristics, firearm ownership, firearm and ammunition storage practices, and their storage device preferences and features that influenced their preference. The survey asked participants to consider five different firearm storage devices: 1) cable lock; 2) Life Jacket trigger lock; 3) lockbox with combination access; 4) electronic pushbutton-access lockbox; and 4) biometric-access (fingerprint) lockbox. Participants were asked to rate the importance of device features. The amount of money participants would be willing to pay for each device was then elicited using a sliding scale.

Statistical Analyses

Using descriptive analyses, we examined participants' storage practices, device preferences, and willingness to pay by their sociodemographic characteristics and reasons for firearm ownership. Medians are reported for the nonparametric willingness-to-pay data. Bivariable logistic regression analyses were performed to estimate associations between participant characteristics and likelihood of the following: 1) storing firearms locked; 2) storing firearms unloaded; and 3) storing ammunition locked separately at all times. Associations are reported as odds ratios (OR) with 95% confidence intervals (CI).

RESULTS

Study Sample

Participants predominantly were aged 25–34 (40.3%), White (81.1%) and owned both handguns and long guns (68.3%). Socioeconomic factors including income and education level were not statistically different among tabling sites (Table 1). Among those who responded to the open-ended question assessing primary reason for firearm ownership, most (72.7%) reported personal/home protection, while hunting/recreation was the exclusive reason for a minority (20.2%). We estimate a 15% response rate of all event participants and 40% of participants who were approached.[12]

Firearm Storage Practices

Nearly 80% of participants reported owning one or more of the five displayed firearm storage devices (Table 2). The most frequently owned device was a cable lock (55.3%); fewer owned rapid-access pushbutton or biometric storage devices (26.5% and 24.5%, respectively). Only 36.3% of cable lock owners reported always using their device, whereas 73.4% and 73.3% of pushbutton and biometric lockbox owners, respectively, reported always using their devices. Only 28.5% of participants reported compliance with American

Table 1. Characteristics of 259 survey participants, by most preferred firearm storage device.

		Preferred storage device					
	Total[a] N (%)	**Cable lock n (%)**	**Life jacket n (%)**	**Combination lockbox n (%)**	**Pushbutton lockbox n (%)**	**Biometric lockbox n (%)**	***P*[b]**
Total	259 (100)	13 (5.0)	7 (2.7)	12 (4.6)	48 (18.5)	152 (59.1)	-
Age	-	-	-	-	-	-	0.06
18–24	15 (6.3)	2 (13.3)	1 (6.7)	2 (13.3)	0	10 (66.7)	-
25–34	96 (40.3)	5 (5.4)	5 (5.4)	2 (2.2)	24 (26.1)	56 (60.9)	-
35–44	81 (34.0)	4 (5.2)	0	5 (6.5)	13 (16.9)	55 (71.4)	-
45+	46 (19.3)	1 (2.4)	1 (2.4)	2 (4.9)	10 (24.4)	27 (65.9)	-
Sex	-	-	-	-	-	-	**0.05**
Female	141 (56.9)	9 (6.9)	7 (5.3)	8 (6.1)	28 (21.4)	79 (60.3)	-
Male	107 (43.2)	3 (3.0)	0	4 (4.0)	20 (19.8)	74 (73.3)	-
Race	-	-	-	-	-	-	0.25
White	201 (81.1)	8 (4.3)	6 (3.2)	12 (6.4)	37 (19.7)	125 (66.5)	-
Other than White	47 (19.0)	4 (9.1)	1 (2.3)	0	11 (25.0)	28 (63.6)	-
Education	-	-	-	-	-	-	0.39
High school or less	34 (13.8)	3 (10.3)	1 (3.5)	4 (13.8)	2 (6.9)	19 (65.5)	-
Vocational school/some college	70 (28.3)	3 (4.5)	2 (3.0)	1 (1.5)	14 (20.9)	47 (70.2)	-
College	97 (39.3)	4 (4.4)	3 (3.3)	4 (4.4)	23 (25.0)	58 (63.0)	-
Graduate/professional school	46 (18.6)	2 (4.7)	1 (2.3)	3 (7.0)	9 (20.9)	28 (65.1)	-
Income	-	-	-	-	-	-	0.94
$49,999 or less	59 (22.8)	4 (7.4)	1 (1.9)	3 (5.6)	11 (20.4)	35 (64.8)	-
$50,000 or more	200 (77.2)	9 (5.0)	6 (3.4)	9 (5.0)	37 (20.7)	118 (65.9)	-
Military or law enforcement in home	-	-	-	-	-	-	0.62
Yes	53 (22.4)	3 (4.2)	1 (1.4)	3 (4.2)	19 (26.4)	46 (63.9)	-
No	184 (77.6)	8 (5.2)	6 (3.9)	9 (5.8)	28 (18.2)	103 (66.9)	-
Reason for firearm ownership	-	-	-	-	-	-	0.70
Personal protection only	83 (41.9)	3 (4.0)	3 (4.0)	3 (4.0)	18 (24.0)	48 (64.0)	-
Hunting/recreation only	40 (20.2)	3 (7.9)	1 (2.6)	2 (5.3)	7 (18.4)	25 (65.8)	-
Both	61 (30.8)	2 (3.4)	1 (1.7)	3 (5.1)	11 (18.6)	42 (71.2)	-
Other	14 (7.1)	2 (14.3)	1 (1.7)	1 (7.1)	4 (28.6)	6 (42.9)	-

[a]Total n may not equal sum of preferred storage device selections due to missing responses.
[b]All *P*-values based on Fisher exact test.
Boldface indicates statistical significance ($P \leq 0.05$).

Academy of Pediatrics (AAP) recommendations, storing firearms unloaded and locked, and with ammunition locked separately. Those reporting firearm ownership for personal protection and those with a household member with current/past military/law enforcement service were less likely to practice secure storage (OR 0.4, 95% CI 0.2–0.7) and (OR 0.5, 95% CI 0.3–0.9), respectively (Table 1).

Storage Device Preferences

The largest proportions of participants endorsed biometric (59.1%) and pushbutton rapid-access (18.5%) lockboxes as their most preferred storage devices (Table 1). The most highly rated storage device features—with >60% of the sample indicating they were either "very important" or "absolutely essential"— were the ability to store the firearm unloaded (87.3%), the ability to

Table 2. Firearm storage device ownership, use, and willingness to pay thresholds.

	Cable lock n (%)	Life jacket n (%)	Combination lockbox n (%)	Pushbutton lockbox n (%)	Biometric lockbox n (%)
Own device	136 (55.3)	19 (7.6)	92 (37.1)	66 (26.5)	61 (24.5)
Use all the time[a]	49 (36.3)	6 (33.3)	49 (53.3)	47 (73.4)	44 (73.3)
Price willing to pay					
Median (IQR)	$20 (5–30)	$30 (15–50)	$50 (40–95)	$100 (60–120)	$150 (100–150)
% Retail cost	133%	67%	200%	125%	71%

[a]Among those who own respective device.
IQR, interquartile range.

store the firearm loaded (79.1%), and device affordability (65.0%).

Willingness to Pay

Across demographic groups, participants were willing to pay more than retail price for combination lockboxes (median willingness to pay = $50, vs $25 actual retail cost) and pushbutton rapid-access lockboxes (median = $100, vs $80 retail; Table 2). For the most desired storage option, biometric lockboxes, survey participants indicated the highest willingness-to-pay dollar amount ($150 vs $210 retail).

DISCUSSION

This study examines firearm storage-device preferences among firearm-owning parents/caregivers of children, describes how storage practices vary with their reasons for firearm ownership, and reports prices they are willing to pay for these devices. This unique data adds important context to interventions focused on the provision of firearm storage devices to families. Previous interventions have primarily focused on distributing cable locks, likely due to cost.[4,5,7] However, there is limited data demonstrating sustained behavior change after distribution of cable locks, and surveys of firearm owners on device preference suggest they are undesirable.[6,9,13,14] Results of our study suggest that most parents/caregivers who own firearms do so for reasons of personal protection, and that storage options that provide rapid access may be most desirable.

Our study continues to highlight the need for improved firearm storage in homes with children. Although 73.1% of respondents endorsed storing all firearms locked, adherence to other components of the AAP recommendations was low, with fewer than one-third of parents/caregivers in our study meeting all recommendations.

Firearm ownership among our participants was motivated by concerns about personal and family safety, consistent with prior studies.[15] More than half of the sample (53.6%) identified the ability to store a firearm loaded as "absolutely essential." Thus, it is not surprising that, while cable locks were the most frequently owned device, only one-third of cable lock owners reported regularly using them. In contrast, among rapid-access device owners, nearly three-fourths reported regular use. Rapid-access devices offer parents/caregivers an opportunity to securely store their firearms when not in use, which may lead to a higher prevalence of locked firearms and, potentially, reduced risk to children in these homes.

To prevent unintended access of firearms by children/youth in a home, preferred secure storage options must be financially attainable. While rapid-access devices are more expensive than other modalities, our respondents placed greater value on them, as demonstrated by the median amount they were willing to pay: $100 for push-button lockboxes and $150 for the biometric lockboxes. Since our survey collection, market forces have driven down costs, with biometric lockboxes routinely being sold for less than $100. This data has informed our institution's own firearm storage device offerings by stocking biometric and rapid-access lockboxes. Future studies should focus on identifying groups that may benefit most from education on gun safety devices. This includes investigating the relationship between child age and motivation to use storage devices and expanding the survey into more geographically, racially, and socioeconomically diverse communities.

The ACEP states that "emergency physicians should advocate for evidence-based injury prevention policies." Our data suggests that rapid-access storage devices are a desired and valued prevention strategy that can be employed by EDs. Integrated into a standard intake process, non-partisan discussion around firearm storage and providing access to these devices could be a meaningful method for EDs to meet advocacy goals.

LIMITATIONS

There are several limitations of this research. First, this descriptive study involved a convenience sample of individuals attending healthcare appointments or community events in a predominantly urban area. However, we collected data from a wide variety of events to increase the diversity of participants. Second, our small sample size limited the precision of our estimates. Third, social

desirability may have influenced participants' responses. We mitigated this limitation by conducting anonymous surveys, which was emphasized during survey procedures. Lastly, our estimated response rates were low. This was mitigated by employing a short survey and offering a $5 gift card upon completion.

CONCLUSION

Existing firearm storage-device distribution programs and practices may not meet the needs of all firearm owners. Parents/caregivers who own firearms may most prefer, and be most likely to use, rapid-access options. While these devices have higher costs, they are more likely to have sustained use and their costs are aligned with perceived value. We advocate that ED firearm intervention programs focus on devices that align with families' priorities, which may improve sustained use and, ultimately, help decrease the rates of firearm-related mortality and morbidity among children.

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Electroencephalography Correlation of Ketamine-induced Clinical Excitatory Movements: A Systematic Review

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Background: This is a systematic review investigating the correlation between seizures identifiable on electroencephalogram (EEG), clinical excitatory movements (CEM), and ketamine administration for procedural sedation.

Methods: We searched MEDLINE, EMBASE, Cochrane CENTRAL, and Web of Science in April 2021. Search terms included variations for ketamine, myoclonus, seizures, status epilepticus, and electroencephalography. Two independent reviewers assessed papers based on eligibility criteria, which included human studies where EEG recordings were obtained during ketamine administration.

Results: Eight papers were eligible for inclusion with 141 subjects (24 children). Seven studies (133 subjects) reported epilepsy history; 70% (94/133) of these subjects had a pre-existing epilepsy diagnosis. No (0/39) subjects without epilepsy and 28% (26/94) of subjects with epilepsy had electrographic seizures after ketamine administration. In four studies where pediatric and adult subjects could be separated, children with epilepsy had electrographic seizures in 60% (3/5) of cases compared to 28% (6/33) of cases of adults with epilepsy. Of the subjects with epilepsy, 14% (10/74) had CEMs vs 5% (1/21) in subjects without epilepsy. Most CEMs (9/11) were temporally correlated with electrographic seizures.

Conclusions: Our findings indicate that in subjects with epilepsy, electrographic seizures were frequently seen with ketamine administration and were correlated with CEMs. No seizure activity after ketamine was seen in subjects without epilepsy. While the clinical significance of these findings needs further investigation, clinicians may want to consider patients' seizure history when providing counseling on the risks and benefits of ketamine sedation. [West J Emerg Med. 2025;26(1)147–154.]

INTRODUCTION

Background

Ketamine is one of the most used anesthetic medications for procedural sedation. In children, ketamine is the sedative of choice in up to 80% of children in the emergency department (ED),[1] while in adults ketamine is gaining increasing favor based on its desirable safety profile.[2] It is a dissociative anesthetic that creates a perception of detachment from environment and self.[3] Low rates of respiratory and cardiovascular adverse events make ketamine a favorable preferred for procedural sedation compared to other popular anesthetic medications.[1,2]

One of the associated side effects of ketamine, recognized since it was first discovered in 1960s, are excitatory movements such as twitching and hypertonicity.[4] In 2009, based on the consensus guidelines on reporting adverse events during procedural sedation, these movements were termed as clinical excitatory movements (CEM) and classified into three groups: myoclonus; muscle rigidity; and generalized motor seizures.[5] Most CEMs are of short duration, but even when self-limited these movements may cause distress to caregivers or staff as they resemble seizures. It is unclear whether CEMs are epileptic or are unrelated to seizure activity. Given this ambiguity, it is important to understand the risk of seizures with ketamine administration such that clinicians can better weigh the risks and benefits of this medication.

The underlying etiologies of CEMs are unknown. To determine whether CEMs are seizure related, a concurrent electroencephalogram (EEG) is necessary, particularly as sedation may alter distinguishing epileptic features such as pupillary changes or eye movements (ie, nystagmus), alterations in mentation, or motor manifestations.[6] We conducted a systematic review to answer two questions: 1) Does ketamine induce electrographic seizures; and 2) are ketamine-induced CEMs associated with electrographic seizures with special attention to pediatric subjects?

METHODS

Study Design

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for this systematic review.[7] A search strategy was developed in conjunction with a medical librarian. We searched Ovid MEDLINE (1946 to April 27, 2021), Elsevier EMBASE (1974 to April 2021), Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library*, Issue 3 of 12, March 2021) and Web of Science Core Collection, Science Citation Index (1985 to April 2021). The MEDLINE search was performed using Medical Subject Headings and text words for ketamine, myoclonus, seizures, status epilepticus, and EEG. The MEDLINE strategy was adapted to search the other databases. Results were limited to English-language publications. Inclusion criteria were the use of human study subjects and the use of EEG testing during ketamine administration. We excluded studies using ketamine for patients with ongoing seizures. Comments, editorials, letters, notes, and conference abstracts were excluded in MEDLINE and EMBASE. The details of the search strategy can be accessed in Supplement 1.

Records were screened by title and abstract, and all potentially relevant papers were obtained for full-text review. Full-text papers were included based on the inclusion criteria. We included additional reports based on review of included paper citations. Each manuscript was abstracted by investigators ET and NU independently, and discrepancies were resolved by consensus.

Outcome Measures

There were two primary outcomes: 1) the frequency of electrographic seizures recorded on surface and/or deep electrodes following ketamine administration (excluding studies using ketamine for patients with ongoing seizures) and 2) the prevalence of concurrence of ketamine-induced CEMs with electrographic seizures.

We identified electrographic seizures as EEG recordings with concurrent electrographic seizure activity, as defined by the EEG definition at the time of the paper publication. The EEG recordings were rarely available in the manuscripts and, when available, only included a few seconds of the recording. Thus, EEGs were considered positive for seizures based on the authors' report. A variety of ketamine-induced CEMs were reported that included twitching, myoclonic jerks, extremity tonic movements, generalized tonic-clonic movements, and major motor convulsions. Increased muscle tone or orofacial dyskinesias (nystagmus, tongue fasciculations) were not considered CEMs.

We defined subjects as children younger than 18 years of age.

RESULTS

Literature Search

The initial literature search resulted in 583 individual records. After reviewing titles and abstracts, 20 potentially eligible papers qualified for full-text review. Review of the citations for the 20 reviewed papers resulted in an additional five potentially eligible papers, which were also retrieved for full text review. After the review of all 25 full-text papers, eight[8–15] were included in the study (Figure).

Study Characteristics

These eight studies encompassed 141 subjects, including 24 children. In four[8–10,14] of the studies (involving 12 adults and 24 children) ketamine was used for procedural sedation; in three[12,13,15] studies (involving 56 adults and 40 subjects whose sex was not specified), ketamine was administered to volunteers for research purposes only, and in one[11] study of 30 adults, the purpose was not explicitly stated. Six of eight studies were specifically designed to assess ketamine's effect on electrographic seizures.[8,9,12–15] All studies used conventional EEG with surface electrodes. Surface electrodes were placed to the skull in the international 10–20 EEG distribution. In one study with nine epileptic subjects in addition to surface electrodes, deep electrodes were surgically implanted "bilaterally to limbic region (amygdala), hippocampus (anterior, middle and posterior pes), and hippocampal gyrus (anterior, middle and posterior

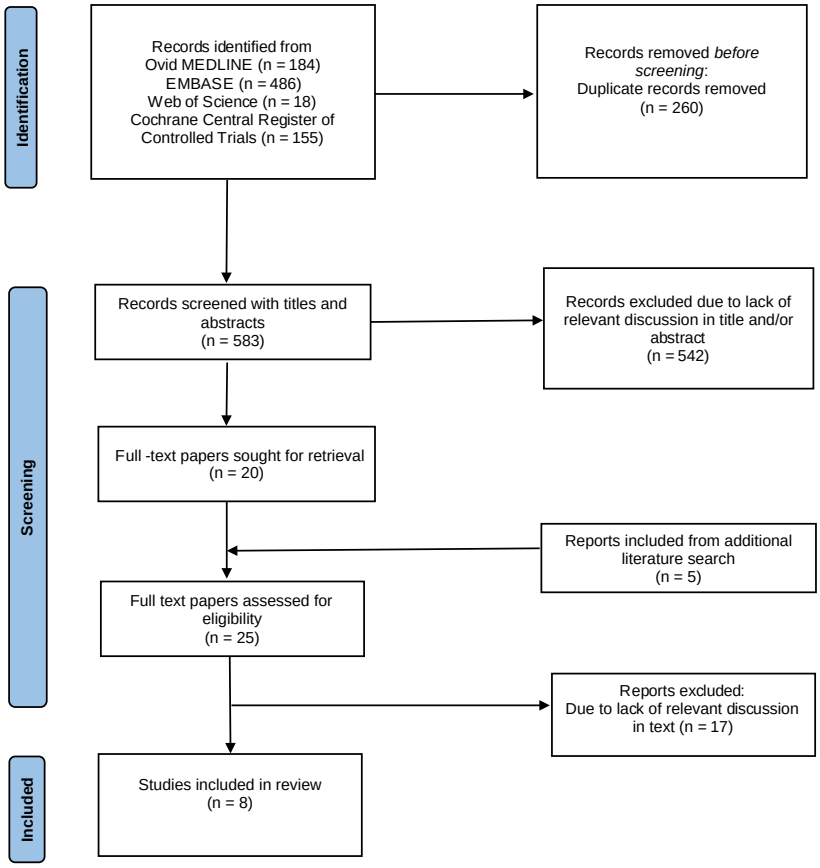

Figure. Flow of study selection reported according to PRISMA 2020 guidelines.

gyrus).” The deep electrodes recorded electrographic seizures in all subjects receiving more than 2 milligrams per kilogram (mg/kg) ketamine; however, this activity did not spread to the cortex, as surface electrodes did not record any electrographic seizures[9] (Table 1).

Four studies provided age data such that pediatric (16 in three studies) and adult subjects (63 in four studies) could be reported separately.[9–12] The age range for pediatric subjects in these studies was 3–17 years.

Electrographic Seizures

Data on electrographic seizures were reported for all subjects. All but one study[14] provided information on subjects’ epilepsy status (Table 1). Seventy percent of the subjects (94/133) had a diagnosis of epilepsy. Only subjects with epilepsy (28%, 26/94) had electrographic seizures. This was observed for both adult and pediatric subjects (Table 2). One fourth of those seizures (7/26) were recorded on deep electrodes where simultaneous surface EEG did not show electrographic seizures. Duration of electrographic seizures was seldom reported, but in the five cases in which duration was provided it ranged from 20 seconds to 3.5 minutes.[9,15]

Clinical Excitatory Movements

The presence or absence of CEMs was reported for 94 subjects (66.7%). The CEMs were more common in subjects with epilepsy (14% 10/24) than subjects without epilepsy (5%, 1/21). The subjects who had both CEMs and electrographic seizures were reviewed for the type, duration, and quality of their events (Tables 3 and 4). Types of CEMs were either focal motor movements or generalized tonic-clonic motor activity, and rarely myoclonus or jerking movements. In the 11 subjects with CEMs, 9 had temporally correlating electrographic seizures, and all these patients had a history of epilepsy. Four of the aforementioned patients with electrographic seizures were identified on deep-electrode recordings only, and not on the simultaneous recording with surface electrodes. Only one patient without epilepsy was described as having CEMs, and they were not associated with epileptiform discharges on the EEG recording. For the one remaining patient with CEM, there wasn’t information on correlation with EEG seizure.

There were some behavioral changes reported in two studies that were not included as CEMs in our systematic review given they were not associated with rhythmic movements. Venkataraman et al reported increased “muscle tone” in 24 and “orofacial dyskinesias” in 22 of 30 patients.

Table 1. Characteristics of study subjects.

Author, year	Total subjects (n)	Age range (years)	Pediatric subjects (%)	Subjects with epilepsy (%)	Indication of ketamine	Route	Dose (mg/kg per dose)	Number of doses	EEG type	Electrographic seizures (n/total)	Clinical excitatory movements
Corssen, 1969[8]	11	3–13	100	0	Elective surgery	IV	2.2	2	Surface	0/11	1 /11
Bennett, 1973[9]	8	5–27	50	100	Dental procedure	Initial IM, then IV	IM - 6.5–13 IV - 1–4.5	1 to 6	Surface	3/8	2/8[a]
Ferrer-Allado, 1973[10]	9	17–37	11	100	Localization of seizure focus	IV	1/9 – 0.5 2/9 –1 4/9 – 2 2/9 – 4	1	Surface deep (simultaneously recorded)	Surface electrodes: 0/9 deep electrodes with 0.5 mg/kg: 1/1 with 1 mg/kg: 0/2 with > = 2 mg/kg: 6/6	0/3 at ≤ 1 mg/kg 2/4[a] at 2 mg/kg 1/2[a] at 4 mg/kg
Schwartz, 1974[11]	9	18–56	0	0	Unknown	IV	2	2	Surface	0/9	Unknown
Corssen, 1974[12]	30	19–68	0	70	Research	IV	2.2	1	Surface	With epilepsy: 1/21 increased from baseline without epilepsy: 0/9	Unknown
Celesia, 1975[13]	26	17–58	Unknown	100	Unknown	IV	4 pts-0.5 followed by 1 22 pts- 2	4 pts 2 22 pts 1	Surface	8/26 (15/26 subjects had while asleep)	1/26
Rosen, 1976[14b]	8	Unknown	100	Unknown	Procedural sedation	IM	5–15	1	Surface	1/8	Unknown
Venkataraman, 1983[15]	40	Unknown	Unknown	75	Research	IV	2 followed by 1	2	Surface	With epilepsy: 8/30 without epilepsy: 0/10	4/30[a] with epilepsy

[a]Clinical excitatory movements associated with electroencephalography seizures.
[b]Not included in Table 2 due to unknown epilepsy status.
EEG, electroencephalography; *IM*, intramuscular; *IV*, intravenous; *mg/kg*, milligrams per kilogram.

Table 2. Summary of electrographic seizures.

	Subjects with epilepsy	Subjects without epilepsy
All subjects		
Number of subjects	94	39
Electrographic seizures	26 (28%)	0
Adult subjects[a]		
Number of subjects	33	30
Electrographic seizure	6 (28%)	0
Pediatric subjects[b]		
Number of subjects	5	11
Electrographic seizures	3 (60%)	0

EEG, electroencephalography.
[a]Included papers: Bennett 1973,[9] Ferrer 1973,[10] Schwartz 1974,[11] Corssen 1974.[12]
[b]Included papers: Corssen 1969,[8] Bennett 1973,[9] Ferrer 1973.[10]

Celesia et al reported "unusual postures" in 12 and "motor hyperactivity" in 5 of 26 patients. The presence of electrographic seizures in correlation with these movements were not specified in these studies.

Table 3. Summary of clinical excitatory movements.

	Subjects with epilepsy	Subjects without epilepsy
All subjects		
Number of subjects	73	21
Clinical excitatory movements		
Positive	10[a] (14%)	1 (0.5%)
Negative	63 (86%)	20 (99.5%)
Adult subjects[b]		
Number of subjects	12	12
Clinical excitatory movements		
Positive	3[d] (25%)	0
Negative	9 (75%)	12 (100%)
Pediatric subjects[c]		
Number of subjects	5	11
Clinical excitatory movements		
Positive	2[d] (40%)	1 (9%)
Negative	3 (60%)	10 (81%)

[a]Nine subjects also had electrographic seizures.
[b]Included papers: Bennett 1973,[9] Ferrer 1973.[10]
[c]Included papers: Corssen 1969,[8] Bennett 1973,[9] Ferrer 1973.[10]
[d]Clinical excitatory movements associated with electroencephalography seizures.

DISCUSSION

We found that in subjects with epilepsy there is some evidence of ketamine provoking electrographic seizures. In subjects without epilepsy, no electrographic seizures were seen with ketamine administration. Most of the subjects who had CEMs also had temporally correlated electrographic seizures. Given the infrequency of myoclonic jerks observed in this study, it remains unclear whether this activity may be epileptiform. This relationship between ketamine and electrographic seizures may be dose dependent. In Ferrer-Allado et al the patients with electrographic seizures were given higher doses (2 and 4 mg/kg) of ketamine rather than the more typical induction doses of 1–2 mg/kg used at the start of procedural sedation.[10,16,17]

There is a growing body of literature on the use of ketamine for refractory status epilepticus (RSE) in adults and children. Ketamine has a reported efficacy in stopping seizures of up to 73% for adult and 74% for pediatric patients.[18] Although the mechanism of action is not exactly known, it is hypothesized that ketamine as a non-competitive antagonist of N-methyl-D-aspartate (NMDA) receptors can deactivate NMDA receptors that are activated by glutamate overflow during RSE. Considering ketamine's documented antiseizure effects, it would be unexpected for ketamine to additionally be associated with epileptogenic activity. Our primary outcome was to evaluate EEG changes following ketamine administration during the neutral state of the brain.

One could speculate that a neutral/non-excitatory state of the brain may respond to ketamine differently than the brain in the excitatory state that is seen during RSE. There is evidence in animal studies that as seizures prolong, numbers of NMDA receptors increase, and gamma-aminobutyric acid receptors decrease on the postsynaptic surface. This changing cellular structure might play a role in the effectiveness of ketamine, an NMDA receptor antagonist, in halting RSE.[19] Another possible explanation is that observed electrographic seizures in subjects with epilepsy during ketamine may be confounded by the frequency of electrographic seizures at baseline in these subjects. However, described electrographic seizures with ketamine were not always identical with baseline epileptiform discharges, which may suggest that these were separate electrographic seizures provoked by ketamine.[9,10,12]

The association of seizures and decreased cognitive function has long been recognized.[20] These effects have mainly been shown with prolonged seizures or epilepsy disorders.[20,21] The effects of a single seizure on cognition in children seem to be insignificant, whereas effects in adults are unclear.[22,23] Furthermore, for electrographic-only seizures, data suggests that high seizure burden is required to cause clinical impact.[22] Thus, even though there is some evidence that ketamine may be provoking brief electrographic

Table 4. Subjects with clinical excitatory movements.

	Age	Electrographic seizures immediately after ketamine administration	Type of CEM	Baseline EEG	Baseline seizure semiology
Corssen, 1969[8]					
No ID	<13	None	Twitching of the arms and legs	N/A	None
Bennett, 1973[9]					
Case 2	27	Polyspike and wave discharges, maximal over the left anterior temporal region (increase in baseline EEG discharges)*	Brief clonic movements of the right hand and face followed by 1 minute right tonic [adversive] seizure	Slow posterior rhythms, decreased amplitude over left temporal area, left frontotemporal spikes and sharp and slow waves	Focal and generalized motor seizures
Case 7	17	Right temporal focal discharges (different than baseline discharges)*	Left tonic [adversive] seizure	Left temporal spike and slow waves with secondary synchrony, slow posterior rhythms	Generalized motor seizures
Ferrer-Allado, 1973[10]					
Subject 1	17	Seizure activity in deep electrodes*	Tonic-clonic motor activity	Unknown	Unknown type
Subject 7	20	Seizure activity in deep electrodes*	Tonic-clonic motor activity	Unknown	Unknown type
Subject 8	33	Seizure activity in deep electrodes*	Jerking motor movements, clonic motor activity	Unknown	Unknown type
Celesia, 1975[13]					
No ID	Unknown	Unknown if the same subject had electrographic seizures	Sporadic myoclonic jerks	Unknown	Psychomotor seizures
Venkataraman, 1983[15]					
No ID	Unknown	Seizure discharges*	Tonic-clonic motor activity lasting 3 min	Unknown	Unknown type
No ID	Unknown	Seizure discharges*	Tonic-clonic motor activity lasting 3 min	Unknown	Unknown type
No ID	Unknown	Seizure discharges*	Tonic-clonic motor activity lasting 3 min	Unknown	Unknown type
No ID	Unknown	Increased seizure discharges from baseline*	Clinical seizure	Generalized spike and wave discharges	Unknown type

[] old terminology
*CEM correlated with electrographic seizures.
CEM, clinical excitatory movement; *EEG*, electroencephalography; *ID*, identity; *N/A*, not applicable.

seizures, the effect of these seizures on cognition is likely not clinically significant.

Seven of 26 subjects who had electrographic seizures were recorded via deep electrodes that were not captured by surface electrodes. Similarly, studies using deep electrodes in animals with epilepsy have also shown electrographic seizures during ketamine administration,[24,25] whereas animals without history of epilepsy did not show any electrographic seizures.[26] The involvement of subcortical structures in modulation and propagation of seizures has been described; however, the incidence and clinical significance of the deep electrographic seizures is unknown compared to surface electrographic seizures.[27]

LIMITATIONS

There are several limitations of this systematic review. Because this study was limited to English-language studies, we could have missed studies in other languages. The number of subjects in each study was small, and there were differences in design and patient populations between studies. In only three of the studies was ketamine used for procedural sedation; in the other studies ketamine was administered to

volunteers, which may limit generalization to ketamine use in procedural sedation. The eligible studies were performed between 40–50 years ago when EEG capabilities were less advanced than today.[28,29] Finally, most of the EEG recordings described in the studies were not available for review. The CEMs were described in generalized terms, and exact semiology often was not described.

CONCLUSION

This is the first systematic review to document the relationship between ketamine and clinical excitatory movements. The limited available data is insufficient to make strong conclusions on the risk and clinical significance of seizures with ketamine, and the correlation of CEMs with electrographic seizure. All observed seizures were brief, with none meeting the definition of status epilepticus.[30] While CEMs correspond to electrographic seizure in patients with a history of seizures, it is unclear whether this is clinically important. Based on our findings, we recommend that clinicians who administer sedation ask about a patient's history of epilepsy during their pre-sedation assessment to inform their assessment of the risks and benefits of ketamine sedation and discuss the potential risk of increased electrographic seizures. Further studies, especially with video-EEG monitoring during ketamine sedation in epilepsy patients, are needed.

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#emergencymedicine: A TikTok Content Analysis of Emergency Medicine-related Content

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Background: TikTok has rapidly become one of the most extensively downloaded and used social media platforms worldwide. Our focus on emergency medicine (EM)-related content on TikTok is to identify what specific video characteristics result in higher degrees of audience engagement, defined in this study as a total of video likes, comments, and shares.

Methods: Five second-year medical students using newly created TikTok accounts independently downloaded the first 100 videos to appear using the hashtag #emergencymedicine. The videos were reviewed for 52 variables. We performed a multiple linear regression analysis to examine the relationship between the variables and video engagement.

Results: Of the examined videos, 45.8% (222/484) were produced by physicians (MD or DO). Approximately half, 50.0% (242/484), had an educational component, while 55.4% (268/484) of videos were judged to have an entertainment component. Preliminary findings indicate that among TikTok videos featuring #emergencymedicine, a statistically significant positive correlation exists between video engagement and the presence of a healthcare identifier, (ie, individuals wearing white coats or scrubs). No significant correlation was observed between video engagement and video creators' self-identification as a healthcare professional, use of entertainment, or use of education. A notable negative correlation was identified between video engagement and the inclusion of music.

Conclusion: We identified qualities associated with negative and positive correlation with video engagement. For the 100 videos, only healthcare attire, such as wearing a white coat or scrubs, showed a significant positive correlation with engagement, while those with background music showed a negative correlation. Our study offers insight into how EM professionals can effectively use characteristics associated with higher engagement rates to relay information to a wider audience on TikTok. [West J Emerg Med. 2025;26(1)155–160.]

INTRODUCTION

In the past several decades, social media has become an integral part of society, with its prominence continuing to grow. Consequently, the public has started to use social media as a resource for obtaining medical information regarding one's own health, details on a specific condition, how to develop healthy lifestyles, etc.[1] Given the relative ease of searching for information online or on social media and

the amount of information available, over 80% of people with internet access now seek healthcare information online.[2] The world of healthcare information has grown to be a large presence in the online world, but as the modalities of online information continue to change and grow, the question remains how to effectively disseminate information on these various platforms. Recently, researchers for the Royal College of Physicians using education theory explored the risks and benefits of using social media for medical education and ascertained its use as positive and "here to stay."[3]

TikTok has rapidly emerged as the fastest-growing social media platform currently in use. With availability in over 150 countries and over two billion downloads, it superseded Facebook, Twitter, and Instagram in 2018 and 2019 as the most frequently downloaded application.[4] Currently, 12% of the global population uses the app monthly.[5] TikTok operates on the premise of short-form video content where users can create and share videos, which typically last between 15–60 seconds, covering a wide range of topics, from entertainment and humor to education and creativity.[6] The app's algorithm employs a recommendation system that analyzes user behavior, such as the videos they like, share, and comment on, to curate a personalized "For You Page" (FYP).[7] This FYP showcases content tailored to each user's interests, ensuring a highly engaging experience as it constantly introduces users to new and relevant content from creators worldwide. TikTok also has a variety of creator tools, including filters, effects, and soundtracks, that allows creators to produce visually appealing and entertaining content in multiple forms. The platform's emphasis on discoverability and "going viral" has led to the rapid rise of internet sensations and trends, making TikTok a dynamic and influential force in the world of social media.[8] Limited research has been conducted on the potential role it will play in healthcare information.

While prior analyses of social media health campaigns primarily focused on Facebook or Twitter, younger generations have begun to use image- and video-based platforms such as Instagram, Snapchat, or TikTok.[9] Very little data has been gathered pertaining to the effectiveness of engagement and accuracy of using these novel platforms to communicate health information to the general population. The use of TikTok has proven to be a source of some health information, such as sex education,[10] but no studies have been directed toward emergency medicine (EM) specifically. A study directed toward the validity of TikTok videos about diabetes education found the videos to be of an acceptable level of accuracy.[11] However, neither of these studies addressed what made an engaging video. A recent study by Kassamali et al[12] found that videos containing on-screen text, music, and healthcare attire showed the highest rates of engagement on TikTok videos related to dermatology. Additionally, Barta et al investigated influencer content on TikTok, and their study suggested that humor, originality, quality, and quantity of videos correlated with increased rates of engagement.[13]

Population Health Research Capsule

What do we already know about this issue?
TikTok is a rapidly growing social media platform. Healthcare information increasingly permeates online media.

What was the research question?
Which specific characteristics of TikTok videos lead to increased engagement (total likes, comments, and shares)?

What was the major finding of the study?
There was a positive correlation with engagement and healthcare identifiers such as white coats or scrubs, and a negative correlation with engagement and music, $P < 0.05$.

How does this improve population health?
Our study provides insights into how EM professionals can use engagement-driving features to effectively reach a broader audience on TikTok.

With nearly 72% of Americans using some form of social media,[14] and with TikTok videos being so short and easy to view, TikTok is a potential vehicle for EM education especially in the acute setting. Recent research has explored the concept of microlearning, which involves breaking down information into small, manageable segments that allow learners to absorb knowledge at their own pace. Preliminary findings indicate that microlearning enhances both learning outcomes and long-term memory retention compared to traditional learning methods. Given the concise nature of TikTok videos, this platform could potentially be used to facilitate microlearning.[15] While there is a growing presence of physicians using social media, very few use them as a public platform to make educational videos.[16] With so many different variables in video characteristics, the question raised is whether certain videos created by healthcare content creators have a higher impact on the general public. Such information could allow for the use of TikTok to become an effective educational platform for learners and patients alike to gain valuable knowledge about medical-related matters in a timely manner. In this study we sought to investigate whether specific factors present in TikTok videos related to EM correlate with higher levels of likes, comments,

and shares, thereby reinforcing strategies for enhancing engagement and disseminating content to the public.

METHODS

Data Search and Collection

Data used in this analysis was used for qualitative research and was collected on December 4, 2022, at 8 PM by five separate medical students using newly created TikTok accounts to minimize the variation due to the TikTok algorithm. Videos were downloaded on the same date and time to ensure the least amount of variability of content available. Each account searched "#emergencymedicine" and downloaded the first 100 videos that were listed. This created a sample size of 500 videos to analyze. Despite these being new accounts and having no prior interaction, there was variation among the videos that were downloaded. Videos were excluded from the sample if likes, comments, or shares were not available. This reduced the total sample size to 484 videos. These videos were saved independently for later review and record, and all videos were saved with the watermark including views, likes and shares which was located on the left side of the video, and username of the original content creator. Once they were downloaded, students reviewed the spreadsheet together and assessed several sample TikTok videos together to ensure each video would be analyzed similarly to reduce variability in data collection. Each student used an Excel spreadsheet (Microsoft Corp, Redmond, WA) to collect the required information; this was sent for statistical analysis once complete.

Data Coding

For each video, 52 characteristics were recorded based on the methods used by Raber et al[17] who studied TikTok content related to #mediterraneandiet. These included descriptive characteristics including upload date, number of likes, number of comments, number of shares, total length of video, and other hashtags included in the video description. Creator information was collected and recorded using information from the creator's TikTok page or linked social media. Creator characteristics recorded included poster name, username, number of followers, account description or tagline, account type (private, sponsored, company), hyperlinks to other social media or storefronts, and any medical or professional credentials. After collection, the content of each TikTok was assessed separately and scored by the student using a numeric system with 0 representing "no" and 1 representing "yes." General characteristics assessed included use of music, use of humor, text overlay, presence of infographics, presence of educational information, attempt to directly sell a product or service, and presence of any promotion for a service or company. All content was also rated based on inclusion of personal anecdotes, conspiracy theories, the creator having MD/DO credentials, or study/data usage.

Some categories did not fit into the above coding style and had distinct numeric scales such as main message of the video (educational, entertainment, other), video structure (original content, stitch, response to comment, or other), video style (talking to camera, role-playing, dancing, emergency department (ED) with no host, or other), and whether a specific acute or chronic disease was mentioned in the video. The final part of the coding for each video included assessing whether there was any educational or entertainment aspect to the video. Per the spreadsheet based on Raber et al's methods, we defined educational videos as video that primarily contains a medically educational aspect, or content offers medical information, to include aspects specific to EM; this included but was not limited to defining what happens in the ED or defining a medical condition. We defined entertainment videos as including humor, making jokes about medicine, dancing, or a song. These were discussed with the raters ahead of time to prevent confusion. Raters then typed a brief description in the spreadsheet.

Statistical Analysis

The data for each of the spreadsheets was combined in a master spreadsheet and analyzed using a multiple regression model with SPSS software version 28.0.1.1 (SPSS Statistics, IBM Corp, Armonk NY). We compared all using P-value <0.05. The independent variable for each video was the sum of likes, comments, and shares recorded in the spreadsheet, referred to as the average total engagement for that video. The dependent variables included in this analysis were the presence of background music, video creator attire, identification as a healthcare professional, account designation of healthcare professional, message of the video (education or entertainment), humor, and the presence of text overlays.

RESULTS

Results of the average engagement (ie, total likes, comments, and shares) are shown in the Table and Figure. These were separated into the presence or absence of healthcare attire, entertainment, education, music, in-video credentials, humor, account designation of MD/DO, and text overlay for further evaluation through linear regression analysis.

An elevated level of video engagement exhibited a direct positive correlation with videos featuring creators wearing healthcare identifiers such as a white coat or scrubs, with a statistically significant P-value of less than 0.02. Moreover, the analysis indicated a decrease in video engagement when background music was present, with a P-value of less than 0.03. Conversely, there was a lack of compelling evidence supporting the notion that indicators such as the creator's

Table. Average engagement levels (likes, comments, shares) of TikTok users based on various video characteristics.

	Present	Absent
Healthcare attire*	130,725.00	49,262.05
Entertainment component	93,574.84	120,774.50
Music**	68,745.16	145,558.08
In-video credentials	93,988.79	123,699.12
Humor	120,769.56	92,047.63
Account designation of MD/DO	125,201.33	89,126.45
Text overlay	110,236.07	107,255.79

*Positive correlation with creators wearing white coats/scrubs.
**Negative correlation with background music.

age, explicit self-identification as a healthcare professional within the video, or the account's designation as a healthcare-related profile had a significant impact on overall video engagement. Furthermore, no statistically significant correlations were observed between an increased amount of engagement and various other factors including the presence of education, entertainment, humor, or the presence of text overlays.

DISCUSSION

As in the field of medicine, the landscape of social media is in a constant state of evolution, continuously introducing and expanding novel information distribution methods. This study has provided valuable insights into the utility of TikTok and its effective application in increasing engagement in videos pertaining to EM. By creating new accounts, the investigation tried to mimic a FYP free of healthcare content bias to further understand what a general user may see on their page by searching the hashtag, #emergencymedicine. Furthermore, the research delved into the strategies available to emergency healthcare professionals for leveraging TikTok as a medium to disseminate educational content to the general public.

Interestingly, it was discovered that the primary factor influencing the engagement of a TikTok video is neither the credentials nor the message of the content, but rather the attire of the video creator. There was no benefit to the creator stating whether they were a licensed professional. Further, there was no discernable inclination toward either educational or entertaining content. This suggests that users are openly receptive to digesting educational and entertaining medical content on the platform. This offers guidance on how to engage effectively with the broader

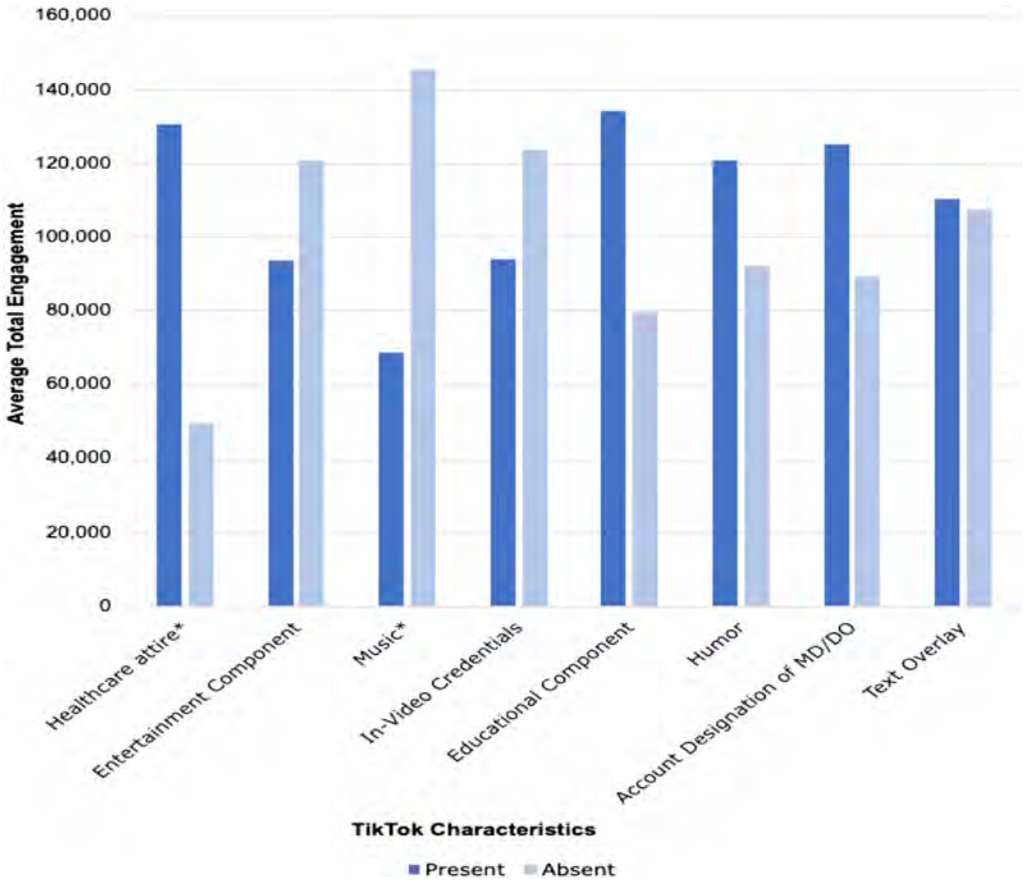

Figure. Total Average engagement of TikTok content based on the presence or absence of specific video characteristics.

audience in the medical domain through utilization of the FYP. It also underscores the unique nature of contemporary social media platforms, where rapid, split-second judgments play a critical role, emphasizing the need to capture viewers' attention swiftly to achieve engagement.

The level of engagement of TikTok videos may prove to be content dependent on which variables matter most in levels of engagement. For instance, Barta et al discovered that incorporating humor was advantageous in creating videos to be a successful influencer.[13] However, when assessing engagement specifically within the subject matter of EM, humor did not demonstrate any beneficial impact when added to the videos. Our findings further support the study done in 2021 by Kassamali et al as they investigated the "virality" of TikToks relating to dermatology education videos and found that medical attire was positively correlated with overall virality.[12] Additionally, the study suggested increased engagement with videos that contained music in the TikTok video.

Conversely, the findings in this study suggest that TikTok videos related to EM with background music acted as deterrents for viewers, implying educators might achieve greater effectiveness by speaking directly to the camera. Consequently, some aspects of TikTok videos may be content-dependent even within the healthcare field. One pioneering aspect of social media is the ability to connect ideas. Aside from content creators accessing their intended audiences, it also allows for content creators to connect with one another, collaborating for the best outcome. Thus, creators can share ideas not only regarding their content but also how to best engage general audiences.

According to recent data, 42% of all users are between the ages of 18–24, followed by users between the ages of 13–17 (27%).[8] In light of the continued surge in popularity of this social media platform, it becomes increasingly imperative to refine approaches aimed at effectively engaging TikTok's diverse audience. Given that the majority of TikTok users fall within the age range of 13–24, it presents a distinctive and valuable opportunity to connect with this demographic in the realm of health engagement. Using a widely adopted communication medium, EM professionals could effectively employ this platform to disseminate instructive information to the population. This research has opened the door to many of the possible merits of social media in medical academia and outreach. This research has demonstrated what elements to incorporate and avoid when creating content with the goal to encourage engagement. It has illustrated which characteristics of content within EM are most likely to draw significant engagement. Notably, wearing healthcare attire appears to enhance the likelihood of the public encountering the video. This proved to be more advantageous compared to other factors presumed to be influential such as explicitly stating one's healthcare profession, incorporating entertainment elements, or displaying professional credentials such as MD or DO next to one's name.

Our research opens the door for many new avenues of the intersection of social media and medicine, specifically medical content and how general public users can interact with it. Further analysis could be determined to see what makes social media videos not only engaging but effective teaching tools. Other potential research could include assessing the medical content of other social media sites such as Instagram and Twitter, given their large presence. Other metrics of medical videos on social media could be analyzed as well, including an exploration of the user demographics that engage with various types of EM content. Additionally, this could include video accuracy, potentially looking at more specific medical conditions, procedures, or quality improvement. Generally, our research goal is to reach out to a wide group of people, supporting accurate EM content and encouraging active participation in a technology-centered world.

LIMITATIONS

For this research study we engaged five autonomous assessors, each equipped with newly established accounts, to evaluate content simultaneously on a specific day. The aim was to manipulate an impartial search, recognizing that the TikTok algorithm dynamically alters the content presented to viewers, contingent on their previously indicated preferences and the prevailing time of the year. By employing this methodology, we sought to mitigate the influence of personalized user history and seasonal variations, thereby facilitating a more unbiased assessment of the platform's content dissemination mechanisms. Nonetheless, the study encountered certain limitations.

Due to feasibility purposes, the study relied on medical students to collect the data. The reliance on a relatively small cohort of only five assessors, whose medical education level was at the second or third year, may have imposed constraints on their ability to accurately interpret the information presented, given their training had yet to be fully comprehensive and specific to the ED domain. Further, there was not an analysis performed on the raters' inter-rater reliability in performing the analysis of the videos. Secondly, the evaluation of merely 100 videos per assessor raises the possibility of potential overlap in the video samples observed, which could inadvertently have affected the diversity of the data pool. The study also reviewed only videos that used #emergencymedicine, assuming the content users appropriately used the hashtag for content relevant to EM, and that it is the preferred hashtag used. Lastly, an inherent in-group bias might have been introduced, as the assessors may have tended to perceive the videos as targeted toward other healthcare professionals, despite their intended audience being the public. These limitations warrant careful consideration when interpreting the findings and underscore

the necessity for prudently addressing them in future research in this domain.

CONCLUSION

TikTok is a platform that uses videos to relay messages in a restricted amount of time, emphasizing how important it is for content creators to use time and video characteristics wisely to engage the audience before their attention may be diverted elsewhere. This suggests videos containing a quality that significantly increases total engagement may be used to share information to a greater audience. In addition, avoiding characteristics associated with negative engagement can contribute to reaching a wider audience. Based on our findings, wearing healthcare-related attire, such as a white coat or scrubs, showed a statistically significant increase in total engagement. Conversely, background music in the videos decreased the total engagement. We believe these results suggest EM professionals can create videos using certain approaches, such as wearing healthcare attire, to share healthcare information to a greater number of individuals on the TikTok platform. While it may not be immediately clear how TikTok can be used to disseminate healthcare information, our findings provide some much-needed insight into the current relationship between TikTok and #emergency medicine.

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A Machine Learning Algorithm to Predict Medical Device Recall by the Food and Drug Administration

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Introduction: Medical device recalls are important to the practice of emergency medicine, as unsafe devices include many ubiquitous items in emergency care, such as vascular access devices, ventilators, infusion pumps, video laryngoscopes, pulse oximetry sensors, and implantable cardioverter defibrillators. Identification of dangerous medical devices as early as possible is necessary to minimize patient harms while avoiding false positives to prevent removal of safe devices from use. While the United States Food and Drug Administration (FDA) employs an adverse event reporting program (MedWatch) and database (MAUDE), other data sources and methods might have utility to identify potentially dangerous medical devices. Our objective was to evaluate the sensitivity, specificity, and accuracy of a machine learning (ML) algorithm using publicly available data to predict medical device recalls by the FDA.

Methods: We identified recalled medical devices (RMD) and non-recalled medical devices (NRMD) using the FDA's website and online database. We constructed an ML algorithm (random forest regressor) that automatically searched Google Trends and PubMed for the RMDs and NRMDs. The algorithm was trained using 400 randomly selected devices and then tested using 100 unique random devices. The algorithm output a continuous value (0–1) for recall probability for each device, which were rounded for dichotomous analysis. We determined sensitivity, specificity, and accuracy for each of three time periods prior to recall (T-3, 6, or 12 months), using FDA recall status as the reference standard. The study adhered to relevant items of the Standards for Reporting Diagnostic accuracy studies (STARD) guidelines.

Results: Using a rounding threshold of 0.5, sensitivities for T-3, T-6, and T-12 were 89% (95% confidence interval [CI] 69–97), 90% (95% CI 70–97), and 75% (95% CI 53–89). Specificity was 100% (95% CI 95–100) for all three time periods. Accuracy was 98% (95% CI 93–99) for T-3 and T-6, and 95% (95% CI 89–99) for T-12. Using tailored thresholds yielded similar results.

Conclusion: An ML algorithm accurately predicted medical device recall status by the FDA with lead times as great as 12 months. Future research could incorporate longer lead times and data sources including FDA reports and prospectively test the ability of ML algorithms to predict FDA recall. [West J Emerg Med. 2025;26(1)161–170.]

INTRODUCTION

In our institution we have encountered multiple safety events associated with medical devices including chest tubes and vascular catheters, which we reported to the manufacturers and the US Food and Drug Administration (FDA).[1–3] Our experience inspired an interest in understanding the FDA recall process and developing methods to improve the efficiency of post-market, device safety evaluation. Medical device recalls are important to the practice of emergency medicine, as they affect patients, emergency physicians and other practitioners, health systems, and manufacturers. Unsafe devices and recalls include many ubiquitous items in emergency care, such as vascular access devices, ventilators, infusion pumps, video laryngoscopes, pulse oximetry sensors, and implantable cardioverter defibrillators.[4]

Appropriate recall of dangerous devices at the earliest possible time limits further patient harm, while failing to recall an unsafe device exposes patients to potential injury or death. Inappropriate or excessively conservative device recalls harm patients by depriving them of device benefits; even appropriate recalls may leave no clinical alternative, creating potential harm. Product recalls impose a considerable burden on health systems and manufacturers by incurring costs of investigations for potential recalls, recalling those devices, and developing and buying substitute devices to fill a post-recall vacuum. Regulatory agencies face the challenges of investigative costs with finite resources, ongoing harms prior to recall (or even post-recall, as some products such as implanted devices may still be in use), and costs related to removing those devices and evaluating and approving alternatives. Therefore, developing and investigating automated methods to predict such recalls are a crucial area of study.

An optimal monitoring and recall system would identify all dangerous devices without errors (ie, no false positives or negatives) as early as possible, with human intervention required only to validate the findings. In the United States, the FDA approves medical devices and conducts recalls of unsafe devices.[4] Currently, the FDA has a passive, post-market approval system (MedWatch) where patients, clinicians (including emergency physicians), and healthcare systems can submit reports of medical device-associated adverse events, and a publicly available, searchable monitoring database MAUDE (Manufacturer and User Facility Device Experience), where reports are logged.[5,6] The FDA acknowledges that the accuracy of submitted data and causal relationships are unknown.[7] Most device recalls occur voluntarily by manufacturers and are governed by Title 21 of the Code of Federal Regulations (CFR) 7.[8]

The FDA also evaluates medical device recalls through 21 CFR 810 and 21 CFR 806.[9] Part 810 outlines the recall process, including evaluating health risks and defining the recall's extent. This section designates devices into three classes based on potential risk severity. Class I includes devices that have the potential to cause serious risks of harm or death; II designates those that may cause temporary or reversible risks and pose a slight chance of more serious harm or death; and III includes devices not likely to cause health problems or injury. Part 806 focuses on reporting requirements for manufacturers initiating a recall or correction. Manufacturers must report any device correction or removal to reduce health risks, including the reason for the recall and the total quantity produced. Together, 21 CFR 7, 810, and 806 provide a framework for identifying and rectifying issues, with the goal of ensuring medical devices' ongoing safety and effectiveness in the marketplace. The FDA considerations include the nature and potential health risk of the device, the extent and cause of the defect, the likelihood of occurrence, the manufacturer's recall strategy, the number of affected products, the distribution pattern, and the level of hazard presented to patients.

From 2018–2023, the FDA approved or cleared more than 250 medical devices.[10] The FDA receives approximately one million reports annually through the MedWatch and MAUDE systems.[7] From September 2018–September 2023, 234 serious device recalls were issued by the FDA, with thousands of additional recalls during that period.[4,11] Among devices reaching the market between 2008–2017, 10.7% of devices with 510(k) clearance (FDA pre-market review process) and 27.1% of those with

Population Health Research Capsule

What do we already know about this issue?
Identification of dangerous medical devices by the US Food and Drug Administration is essential to minimize patient harms while avoiding unnecessary recalls.

What was the research question?
We evaluated the performance of a machine learning algorithm to predict recalls using publicly available data.

What was the major finding of the study?
Sensitivity for recall was 75% (95% CI 53–89) with specificity 100% (95% CI 95–100) with a 12-month lead time.

How does this improve population health?
Machine learning algorithms might risk-stratify devices for further FDA investigation, improving resource allocation while allowing safe devices to remain in use.

pre-market approval were recalled.[12] To address recalls and its other missions, the FDA has approximately 18,000 employees, including 1,887 employed by the Center for Devices and Radiological Health in 2020.[13,14] Safety monitoring is thus a logistical challenge because of the disparity between resources and devices to be monitored, as well as the labor-intensive job of evaluating each device's merit for recall.

An automated tool to assist in device risk stratification would be invaluable, and machine learning (ML) could be employed for this purpose. Machine learning is a field of artificial intelligence in which large datasets are used to train an algorithm to categorize or analyze new data. ML follows two sequential phases. In the initial training phase, labeled data is supplied to enable the algorithm to learn to differentiate between relevant classes (eg, "this is a dog, this is a cat," or "this is a dangerous medical device, this is not"). In a subsequent testing phase, the algorithm is presented with new, unlabeled data and asked to differentiate between classes (eg, "is this a cat or is it a dog?"; "will this medical device be recalled or not?").

Large data sources external to the FDA system might provide useful signals of device dangers for use in ML algorithms. PubMed is a free database with more than 37 million citations of biomedical and life science literature, developed and maintained by the National Center for Biotechnology Information; reports of adverse events involving medical devices might be reported here.[15] Google Trends is a free tool that quantifies the frequency of search terms on Google Search, YouTube, Google News, Google Shopping, and Google Images over time.[16] The FDA itself provides a list of approved and recalled medical devices.[4]

We developed and evaluated an ML algorithm to predict medical device recalls by the FDA using publicly available data. We discuss its potential value for patient safety as well as challenges and limitations of using ML for risk stratification of medical devices.

METHODS

We conducted a retrospective, diagnostic case-control study. Actual FDA-recall status of devices was determined from FDA sources as described below. An ML algorithm was then trained to predict the probability of FDA recall using data from PubMed and Google Trends. In the testing phase, the algorithm was blinded to the FDA recall status of devices and produced a prediction of probability of recall, which was then compared to actual recall status. We tested the ability of the algorithm to predict recall with lead times of three, six, and 12 months before an actual recall by limiting the algorithm's access to search data for the corresponding time period. Our methods were consistent with relevant elements of the Standards for Reporting Diagnostic Accuracy Studies (STARD) guidelines, such as definitions of the index test and reference standard, estimates of diagnostic accuracy and precision, analyses of variability in diagnostic accuracy, blinding, and potential sources of bias (Appendix 1).[17]

Device Definitions and Identification

Two categories were defined: recalled medical devices (RMD) ("cases") and non-recalled medical devices (NRMD) ("controls"). We identified RMD through the FDA's webpage listing serious recalls.[4] The NRMD were identified by being in the medical market without being recalled by checking against the FDA list for RMD. Devices were selected from January 1, 2019–September 17, 2023, excluding repeated devices or severe acute respiratory syndrome-related coronavirus-2 (SARS-CoV-2) tests. We excluded SARS-CoV-2 tests as they were in the market for very few years and could produce anomalous Google Trends and PubMed data due to their association with COVID-19. All devices included in the study were randomly selected from the pools of identified RMD and NRMD.

Time Frame/Lead Time for Prediction

Recognizing that the FDA investigations and other processes culminating in a device recall may require a period of months or years to complete following the first reports of potential harm, we sought to develop a forecasting tool that could predict recalls up to 12 months before their occurrence. We explored data in three different sets, each lasting five years and ending months prior to the actual FDA recall: three months before recall (T-3); six months before recall (T-6); and 12 months before recall (T-12). Each of the three sets thus included five years of data.

Device Data

For each RMD and NRMD identified in the FDA webpage, PubMed and Google Trends were automatically searched by the ML algorithm using the device names (Appendix 2) and the three date ranges described above (T-3, T-6, T-12) relative to the date of recall. We included queries without Google Trends or PubMed data in the training and testing dataset to avoid selection bias.

Machine Learning Algorithm

We built an ML algorithm on Python 3.8.5 (Python Software Foundation, Wilmington, DE) using random forest regressor, an open-source algorithm.[18–20] This type of algorithm is used for large-volume, multivariable data and is suitable for sets with missing values, noisy data, and outliers. Random forest regressor typically uses 80% of data for training and 20% for testing.[21] A regressor algorithm outputs a continuous decimal value between 0 and 1; in our application, 0 represents 0% likelihood of recall, and 1 represents 100% likelihood of recall. We chose a regressor over an alternative algorithm type, a classifier. A classifier sorts the output of an algorithm into categories such as

"recalled" and "not recalled." The continuous value outputs of a regressor can be converted into discrete classifications by application of threshold values, allowing additional analysis. In contrast, if a classifier had been applied, discrete data could not be converted into continuous values.

Training and Testing Phases

For this study, we performed a training phase, where the algorithm learned to differentiate between RMD and NRMD with 400 randomly selected training data (T-3: 81 RMD, 319 NRMD; T-6 and T-12: 80 RMD, 320 NRMD), with devices labeled for the algorithm as RMD or NRMD. In the testing phase, 100 randomly selected testing data (T-3: 19 RMD, 81 NRMD; T-6 and T-12: 20 RMD, 80 NRMD) were provided to the trained ML algorithm to assess its performance in differentiating the unlabeled devices. Training and testing data were two unique sets with no overlap. Figure 1 outlines the training and testing phases.

We converted continuous decimal prediction outputs of the ML algorithm from the testing phase to dichotomous values of zero or one using two previously published strategies[22]:

1. Pre-specified: Rounding using a threshold of 0.5, where all values < 0.5 were rounded to zero and all values ≥ 0.5 were rounded to one. This approach groups valid but potentially indeterminate values (close to 0.5) with positive (1) and negative (0) results.[22]
2. Exploratory: Rounding using thresholds determined from the ML algorithm output of the training data, described below. This approach addresses values very close to 0.5 that might have little predictive value and might be better treated as uninterpretable or inconclusive. To calculate these thresholds, training data was processed by the trained ML algorithm to yield continuous decimal predictions, which were then analyzed by their actual FDA recall status (RMD or NRMD). Using the means and one standard deviation in this fashion would be anticipated to encompass 84% of the data of a normally distributed dataset, excluding values close to 0.5 (for NRMD, 50% from data below the mean and 34% from data one SD above the mean; for RMD, 50% from data above the mean and 34% from one SD below the mean).
   a. The range of $NRMD_{testing}$ was defined as zero to one SD above the mean output values of $NRMD_{training}$ (0 to $[mean_{NRMDtraining} + SD_{NRMDtraining}]$). Thus, in the testing phase, output values $\leq (mean_{NRMDtraining} + SD_{NRMDtraining})$ were rounded to zero.
   b. The range of $RMD_{testing}$ was defined as one SD below the mean of the predictions for $RMD_{training}$ to one ($[mean_{RMDtraining} - SD_{RMDtraining}]$ to 1). Thus, in the testing phase, output values $\geq (mean_{RMDtraining} - SD_{RMDtraining})$ were rounded to one.
   c. Intermediate values between $(mean_{NRMDtraining} + SD_{NRMDtraining})$ and $(mean_{RMDtraining} - SD_{RMDtraining})$ were assigned to a third category, "indeterminate." These were not rounded and were not included in calculations requiring dichotomous outcomes.[22]

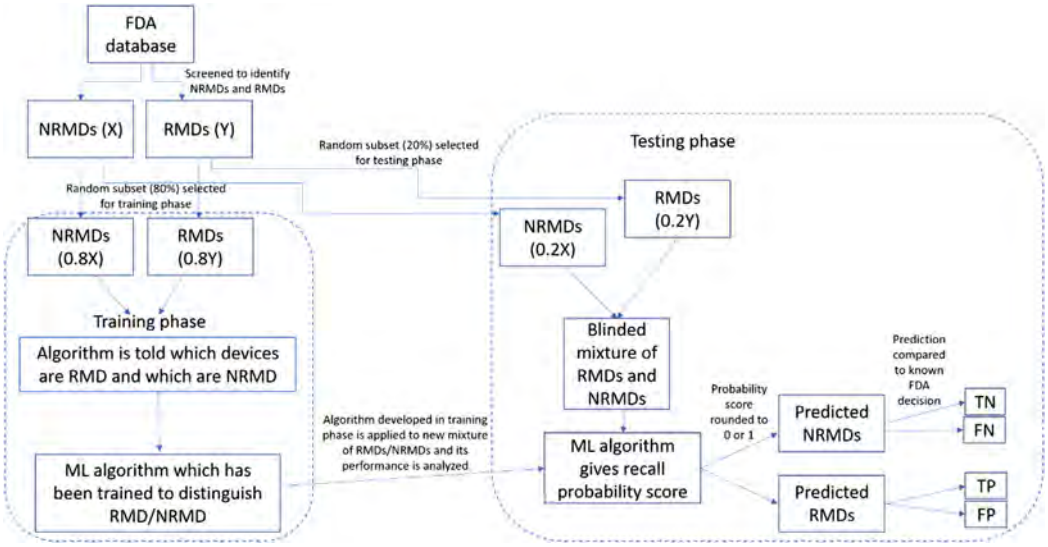

Figure 1. Flowchart for training and testing phases of the machine learning algorithm. Training and testing data were two unique sets with no overlap.
FDA, US Food and Drug Administration; *FN*, false negative; *FP*, false positive; *ML*, machine learning; *NRMD*, non-recalled medical devices; *RMD*, recalled medical devices; *TN*, true negative; *TP*, true positive.

Outcomes and Statistical Analysis

We recorded ML-algorithm-generated probability of recall and actual recall status as pre-specified outcomes. We calculated sensitivity, specificity, and accuracy as pre-specified outcomes, using pre-specified and exploratory threshold values as described above. A true positive was considered a device predicted by the ML algorithm to be recalled, which was actually recalled by the FDA. A true negative was considered a device predicted by the ML algorithm not to be recalled, which the FDA did not actually recall. A false positive was considered a device predicted by the ML algorithm to be recalled, which the FDA did not actually recall. A false negative was considered a device predicted by the ML algorithm not to be recalled, which the FDA actually recalled. We defined accuracy as (true positives + true negatives) divided by total devices. Test yield was defined as the fraction of test results included in calculation of binary outcomes (sensitivity, specificity, accuracy) after exclusion of indeterminate results.[22]

Sample Size

Because we were investigating a novel application and data sources for an ML algorithm, we had no prior data for power or sample-size calculations. Given limited FDA resources, high specificity was prioritized to avoid wasteful investigation of devices that are, in fact, safe. For a target specificity point estimate of 100%, 80 NRMD in the testing phase would yield a 95% confidence interval (CI) 0.95–1.0.[23,24] The algorithm's focus was to flag potential devices that should be recalled in a sea of medical devices, most of which do not need to be recalled. Therefore, more NRMD than RMD were required, and we selected a 4:1 ratio. As described above, the ML algorithm partitioned 20% of the sample to the testing phase and 80% to the training phase. This yielded a total sample size of 400 NRMD and 100 RMD.

RESULTS

The ML algorithm continuous prediction values for each device from testing data are plotted in Figure 2, superimposed on threshold ranges determined from training data. The performance of the algorithm using a rounding threshold for recall probability of 0.5 is shown in Figure 3 and Table 1. The performance of the algorithm using rounding thresholds for recall probability determined from training data is shown in Figure 4 and Table 2. We excluded devices in the indeterminate (yellow) zone (Figure 2) from this analysis, with test yield reported.[22]

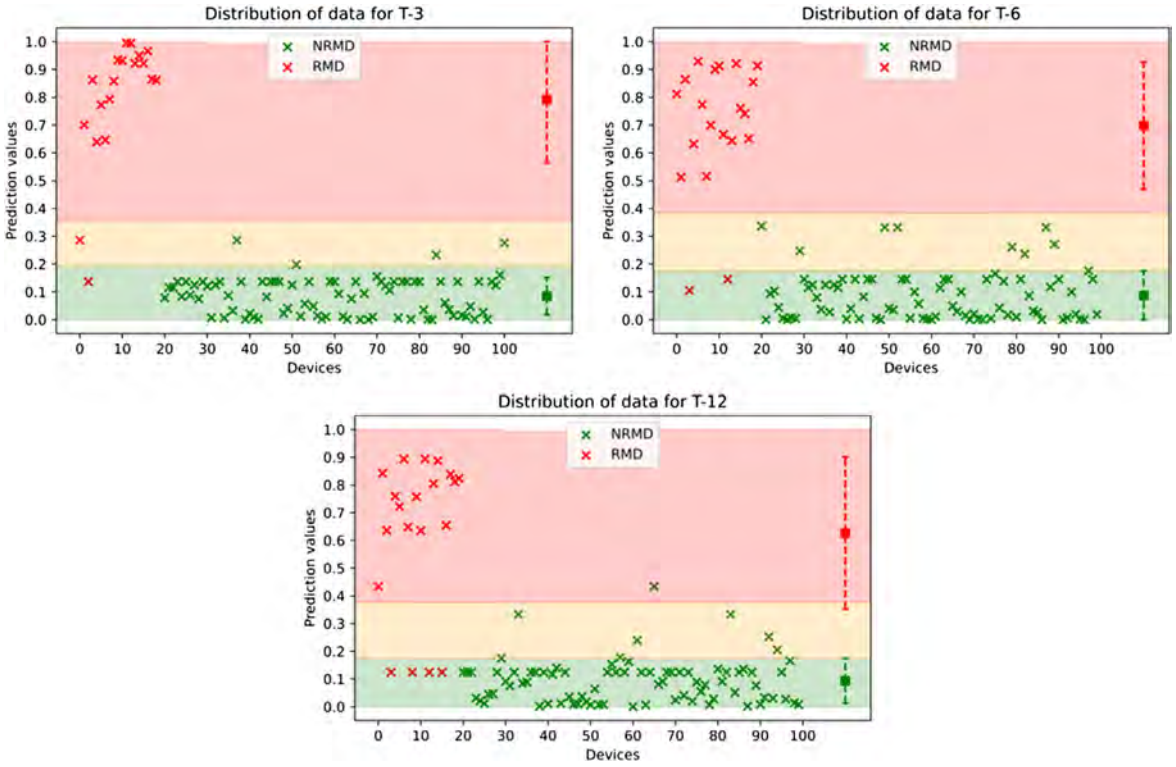

Figure 2. The distribution of devices in the testing dataset that were either recalled or not recalled by the US Food and Drug Administration with lead times of 3, 6, and 12 months. Red x's represent recalled medical devices (RMD) and green x's represent non-recalled medical devices (NRMD). The colored regions represent ranges determined from training data predictions. Thus, green x's in the green zone are true negatives; red x's in the red zone are true positives; green x's in the red zone are false positives; and red x's in the green zone are false negatives. The square represents the mean of each category; the error bars span +/– one standard deviation for the testing results.

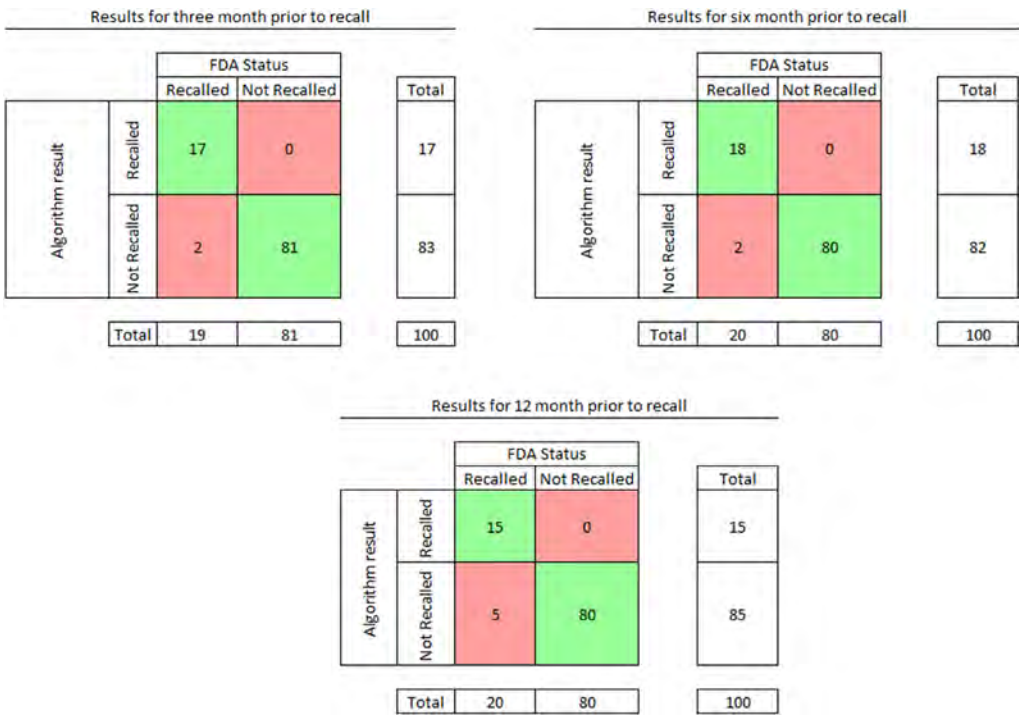

Figure 3. Results of the testing phase when rounding using 0.5, where green indicates true positive and true negative, red indicates false positives and false negatives. Zero false-positive results were encountered during the tested time periods ending 3, 6, or 12 months before US Food and Drug Administration (FDA) recall. False negative results were uncommon in all three time periods. All devices and recall predictions are included in the analysis.

Table 1. Performance of the machine learning algorithm with lead times of 3, 6, and 12 months prior to actual recall when rounding recall probability of 0.5 and above to 1, otherwise to 0.

Lead time	Sensitivity	Specificity	Accuracy
T-3	89 (95% CI 69–97)	100 (95% CI 95–100)	98 (95% CI 93–99)
T-6	90 (95% CI 70–97)	100 (95% CI 95–100)	98 (95% CI 93–99)
T-12	75 (95% CI 53–89)	100 (95% CI 95–100)	95 (95% CI 89–98)

T-3, 3 months before recall; *T-6*, 6 months before recall; *T-12*, 12 months before recall; *CI*, confidence interval.

DISCUSSION

Our development of an ML risk-stratification tool was motivated by our experience with repeated safety events with pigtail catheters and large, vascular access devices.[1–3] We reported these to manufacturers and the FDA. To our knowledge, the FDA responses were limited to written acknowledgments of our reports, with some of our suggested modifications incorporated by manufacturers as described below. Given the volume of reports annually to FDA, we conceived that better, automated methods for risk stratification might be needed.

Our study demonstrates the potential of an ML algorithm using publicly available, large datasets to predict medical device recalls with high sensitivity, specificity, and accuracy with lead times of three, six, and 12 months (Tables 1 and 2). The high specificity (ie, lack of false positives) with narrow confidence intervals as early as 12 months before recall indicates that devices flagged for recall are likely to be true-positive unsafe devices, worthy of further FDA investigation. The algorithm is unlikely to flag non-recalled devices for recall (false positive), an important feature when screening a large device pool consisting primarily of safe devices. A low false-positive rate may avoid unnecessary costs and resource utilization.

The high sensitivity with lead times of three and six months suggests that dangerous devices are likely to be identified by the algorithm; so devices that are rated as "not recalled" are likely safe and may not generally deserve additional FDA scrutiny without specific suspicion or concern (eg, reports of severe adverse events in MAUDE). The sensitivity of 75% with a 12-month lead time is less than we had hoped for but may be acceptable because of the high

Figure 4. Results of the testing phase when removing the data in the indeterminate zone and then rounding all data in the green zone to 0 and all data in the red zone to 1. Green indicates true positive and true negative; red indicates false positives and false negatives. Zero false-positive results were encountered during the tested time periods (T) ending 3, 6, or 12 months before FDA recall. False negative results were uncommon in all three time periods. Test yield (the fraction of all test results used in calculating binary outcomes after removal of indeterminate values)[22] was 95% at T-3, 91% at T-6, and 93% at T-12 months.

Table 2. Performance of the machine learning algorithm with lead times of 3, 6, and 12 months prior to actual recall when removing indeterminate devices and rounding all values that were in green to 0 and all values that were in red to 1.

Lead time	Sensitivity	Specificity	Accuracy
T-3	94 (95% CI 74–99)	100 (95% CI 95–100)	99 (95% CI 92–100)
T-6	90 (95% CI 70–97)	100 (95% CI 95–100)	97 (95% CI 91–99)
T-12	75 (95% CI 53–89)	100 (95% CI 95–100)	94 (95% CI 86–98)

T-3, 3 months before recall; *T-6*, 6 months before recall; *T-12*, 12 months before recall; *CI*, confidence interval.

specificity (100%). Even though only three-quarters of eventually-recalled devices were flagged by the algorithm at this early time-point, all flagged devices were true positives and therefore we believe would be appropriate for further FDA investigation.

The probability of recall outputs of our ML algorithm were continuous values (Figure 2). We collapsed these into binary categories for calculation of sensitivity and specificity, a common practice for diagnostic tests. Continuous variables often result in valid but indeterminate results, which can be addressed by various strategies, each with benefits and costs—and with no single agreed-upon solution.[22,25] For clinical diagnostic tests, different "rule in" and "rule out" thresholds are often used, with an indeterminate zone of test results recognized. Examples include brain-type natriuretic peptide, procalcitonin, and estimated glomerular filtration rate.

We applied two commonly used approaches as a means of sensitivity analysis: combining indeterminate results into positive and negative categories (Figure 3, Table 1), and removing indeterminate results (Figure 4, Table 2). Exclusion of indeterminate results can overestimate test performance, while combining inconclusive results can underestimate accuracy and may not be sensible in the intended application.[22] For example, characterizing a device with a 51% predicted probability of recall as an RMD would potentially result in wasteful expenditure of FDA resources for investigation. Representing a device with a 49% recall probability as an NRMD might imply greater safety than warranted. In our present study, we found no statistically significant difference in test performance by excluding indeterminate results (95% CI for all measures overlap for the two analyses), and we present both analyses for transparency. The test yield[22] was greater than 90% for all time periods, indicating that a minority of results were excluded as indeterminate values.

Device recalls can have substantial impacts in the practice of emergency medicine (and other specialties), even when appropriate. Further illustrating these diverse impacts and validating the need for enhanced tools for risk stratification is that after the initiation of our work on ML algorithms we

encountered another hazardous device in our institution. An arterial catheter used routinely in our emergency departments, operating rooms, and intensive care units was noted to create a risk of arterial embolization of catheter fragments. Removing the device from circulation, replacing it with a viable alternative, and retraining hundreds of healthcare workers occurred over a period of approximately six months—before a manufacturer urgent recall was issued on May 19, 2023, and an FDA Class I recall (the most serious type) followed.[26,27] By the date of the recall, the device had been in distribution for 4.5 years (October 26, 2018–May 10, 2023) during which time the manufacturer had received 83 complaints of related device malfunctions and 18 injuries. A total of 262,016 devices were recalled in the US. Other FDA medical device recalls relevant to emergency medicine practice in 2023 included angiography catheters (for failure to undergo sterilization), infusion pumps (for failure to detect air in line), video laryngoscopes (for stolen defective products), pulse oximetry sensors (for inaccurate readings and interference with defibrillators), implantable cardioverter defibrillators (for low or no energy output), and ventilators (for short circuits and stopping without notice).[4]

Additional literature has recently explored the impact of medical device recalls on patients and healthcare systems. In 2021, Philips Respironics recalled airway pressure devices for carcinogenic chemical emissions and significant adverse effects including respiratory distress, inflammation, hypoxia, and hypercarbia.[28] Approximately 16 million domestic and international patients were affected by the recall, resulting in organizations, including the Mayo Clinic, developing novel protocols to ensure centralized awareness of device recalls, aid staff in visualizing their proactive approaches to the situation, and efficiently communicate when informing patients about the recall.

Medical device recalls involve costs and efforts for multiple stakeholders (including patients, physicians, health systems, manufacturers, insurers, and regulators), from removing recalled devices to developing alternatives to integrate them into the market effectively. The estimated mean development cost for a novel complex medical device is $60 million (95% CI, $27 million–$209 million) after accounting for post-approval studies. Accounting for cost of capital and failed devices, the estimated mean cost per approved device is nearly 10-fold higher: $526 million (95% CI, $207 million–$3396 million). From nonclinical trials to FDA approval, the estimated development time of novel devices is 157 months (13 years).[29] Assessing the economic impact of medical device recalls in the broader healthcare ecosystem poses many challenges due to factors including regulatory conditions, the role of device integration into medical procedures, and the temporal variations in factors influencing device performance.[30] Although individual devices are most often proprietary intellectual property, because of the time and expenses borne by diverse stakeholders, complex medical devices can be considered a shared commons, and achieving appropriate medical recalls is a key shared goal.

Solutions to mitigate device risks are not limited to removal from the market, with all the potential detriments of such action. Some devices can be rendered safe (or safer) by more nuanced changes such as improved labeling, warnings, instructions for use, software updates, component redesign, or alterations in power source. For example, after we reported a device risk associated with a Heimlich valve component of a chest tube kit, the manufacturer adopted verbatim our suggestion for a safety label.[1] After we reported risk of a retained obturator component, the manufacturer also incorporated revised instructions (a banner emphasizing removal of the obturator) in an English-language training video (2 minute 33 second mark), although not in the Spanish, Italian, or German-language videos.[2,31] Such interventions may be reasonable compromises given the costs (economic and other) to various stakeholders of outright removal of a device from the market.

A risk stratification ML algorithm could assist in identifying devices for such modifications, rather than complete product recall. The implementation of an ML approach and new data sources, concurrently with the techniques already employed by the FDA, might be a crucial aid in decreasing the intensive resources required for recall investigations, allowing the FDA to either investigate a wider breadth of devices or to focus more resources on devices that have a higher risk, thus potentially increasing the overall safety of the health field. Given the complexity of the medical device ecosystem and the early stage of our ML algorithm, we are not recommending that FDA recall devices be identified by an algorithm; rather, an ML algorithm could be used as part of a larger armamentarium to address risk.

Future work could characterize the predictive performance of an ML algorithm with even greater lead times, using additional data sources such as the FDA MAUDE database, and with prospective predictions for (as-yet) unrecalled devices. Even an algorithm that does not provide greater lead time than current FDA processes might increase efficiency and resource utilization of recall processes. Comparison of an ML algorithm's warning performance with existing FDA processes, accuracy, and resource utilization would be meaningful next steps. The addition of an ML algorithm to existing FDA processes (rather than replacement of extant processes) is another potentially useful application.

LIMITATIONS

Despite promising results, our study revealed several limitations and challenges of using ML in healthcare. The algorithm relies on Google Trends and PubMed footprints to increase its accuracy, meaning it is severely limited to devices with a significant online presence. Future iterations of the

algorithm might include other free online information, such as the information in the MAUDE database, which was not incorporated into the current ML system. The lack of interpretability of ML algorithms makes it difficult to understand the underlying mechanisms behind their predictions, posing challenges in assessing their reliability and validity. An example is that while the algorithm can predict the FDA recalls, it is unclear whether it can determine if the device is dangerous for patients or will be recalled for other reasons. Another area that further challenges the reliability and validity is the content of PubMed or Google Trends searches. Authors could have only briefly mentioned a device; however, a search still yields it. Additionally, currently there is not a way to distinguish whether the mentions regarding a device are positive or negative, an area for future ML development.

The relatively small dataset of 500 devices may limit the generalizability of the algorithm and lead to a wide CI regarding both sensitivity and specificity. Future studies should consider using larger and more diverse datasets to train and evaluate the ML algorithm. Additionally, the algorithm applies FDA determinations as the reference standard. It remains to be proven that this source is the best comparator for the output provided by the algorithm since the FDA might be recalling devices unnecessarily or failing to recall dangerous devices. Although it did not occur commonly in our sample, an algorithm would be judged as failing if it did not match the FDA, even if in truth it were superior to the FDA process in recognizing dangerous devices. Our study only focused on predicting medical device recalls and did not evaluate the clinical effectiveness or safety of the devices themselves. We did not compare our algorithm performance to current FDA processes. Additionally, given how closely the ML algorithm performance matches that of the FDA, the FDA may already be using ML algorithms or similar processes.

CONCLUSION

A machine learning algorithm using PubMed and Google Trends data predicted medical device recalls by the FDA with high sensitivity, specificity, and accuracy with lead times as great as 12 months. An ML algorithm might improve patient safety by enhancing the early detection and prevention of medical device recalls. Further research is needed to improve sensitivity, extend the forecasting window, and promote the development of ML algorithms in other healthcare segments, such as food and drug safety.

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Impact of Treatment on Rate of Biphasic Reaction in Children with Anaphylaxis

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Objective: Our goal was to characterize a large group of children presenting to the emergency department (ED) with acute anaphylaxis, treated with intramuscular epinephrine (IM EPI) and a corticosteroid (CS), and to determine the impact of pharmacologic intervention on the rate and timing of biphasic reactions (BPR).

Methods: We reviewed consecutive children diagnosed with acute anaphylaxis managed in three EDs during a six-year period. All received IM EPI and CS, followed by monitoring for 4–6 hours post-treatment. We analyzed the rate and timing of BPR, comparing the intervals of 0–4 vs 4–48 hours after initiating therapy.

Results: During the study period, there were 371 cases of anaphylaxis, of which 357 (94%) received both IM EPI and CS. Of these, 49 (14%) manifested BPR [84% had received prehospital IM EPI] requiring at least one additional dose of IM EPI [14% required ≥2 additional doses]. All BPR episodes occurred within the 0–4 hour interval after initiating therapy, whereas no patient manifested a BPR requiring an additional dose of IM EPI during the 4–48 hours after initiating therapy ($P = <0.001$, 95% CI 0–1.3%). No patient returned to the ED with recurrence of anaphylaxis symptoms within 48 hours after discharge.

Conclusion: Approximately 1 in 7 children with anaphylaxis experience a biphasic reaction after receiving intramuscular epinephrine. Children with anaphylaxis who exhibit symptomatic resolution four hours following initiation of therapy have a low risk for subsequently developing BPR. Most BPR cases required only one additional dose of IM EPI to effect resolution. The rate of BPR in those receiving IM EPI and a corticosteroid is significantly lower >4 hours vs <4 hours after initiating therapy. [West J Emerg Med. 2025;26(1)171–175.]

INTRODUCTION

Anaphylaxis is a common and potentially severe, even lethal, systemic allergic reaction that is increasing in frequency.[1] In those patients who experience this condition and clinically improve after receiving medication, there is potential for a biphasic reaction (BPR) to manifest as symptomatic recurrence/exacerbation. Prior research has documented rates of BPR associated with anaphylaxis widely ranging from 1–23%.[1]

Some have recommended against routinely treating acute anaphylaxis with corticosteroids (CS) due to lack of proven efficacy.[2,3] Yet it is plausible that the anti-inflammatory qualities of this medication could potentially ameliorate the IgE-mediated anaphylaxis process.[4,5] Since the effect of intramuscular epinephrine (IM EPI) is short-lived, lasting briefly (t½ of 2–3 minutes), and CS has clinical onset approximately >4 hours following administration, lasting beyond 24 hours, it is likely that after >4 hours the IM EPI

effect wanes and any ongoing anti-allergy effect is likely due to CS. The BPR has been shown to potentially manifest at any time during the subsequent 48 hours after onset (median time 18.5 hours in one study[6]); so, it should be therapeutically advantageous to administer a longer acting anti-allergy medication like CS to help prevent this complication.

The purpose of this study was to analyze a large number of pediatric cases of anaphylaxis treated with IM EPI and CS to determine whether a correlation exists between pharmacologic intervention and the rate and timing of BPR.

Population Health Research Capsule

What do we already know about this issue?
The optimal interval of ED observation for treated children with anaphylaxis, and the impact of corticosteroids in modifying risk for biphasic reaction (BPR), are unknown.

What was the research question?
How does epinephrine and corticosteroid therapy impact the rate and timing of BPR?

What was the major finding of the study?
All BPR episodes occurred <4 hrs after initiating therapy; no BPR case required parenteral epinephrine during 4–48 hrs after initiating therapy ($P < 0.001$, 95% CI 0–1.3%).

How does this improve population health?
These results help to define optimal monitoring period for treated children with anaphylaxis and shed light on corticosteroid impact on BPR recurrence rate.

METHODS

We conducted a retrospective cohort study of consecutive children aged <19 years managed in three EDs at the Mount Sinai Medical Center in New York between January 2015–December 2022, inclusive; two are dedicated pediatric EDs, and one is a general ED also managing children (combined yearly pediatric census 55,000 child-visits). Our templated electronic health record (EHR) (Epic Systems Corporation Verona, WI) stereotypically queries an extensive roster of potential anaphylaxis symptoms, involving dermal, cardiovascular, ear nose throat, pulmonary, neurologic, and gastrointestinal systems. The EHR also documents subsequent medical visits throughout other area hospitals/clinics. Anaphylaxis was diagnosed, per previously published criteria,[7] with acute onset of multiple symptoms following exposure to allergen trigger involving at least two organ systems (Table 1).

We defined BPR as a recurrence/exacerbation of symptoms following administration of IM EPI, after a period of partial or complete recovery, without re-exposure to the trigger, indicative of anaphylaxis or generalized allergic reaction of sufficient severity to require at least one additional dose of epinephrine.

The ED management of anaphylaxis was nearly unanimous among all clinicians, consisting of IM EPI and CS in 96% of cases. The CS medications included dexamethasone, methylprednisolone, prednisolone, or prednisone (intravenously or orally) on the day of presentation. All patients with anaphylaxis received ED monitoring for 4–6 hours post-therapy initiation for BPR. Our templated discharge instructions for "anaphylaxis" states patients should seek prompt medical attention if any of the following occur: 1) worsening of symptoms; 2) trouble breathing or swallowing; 3) swelling of mouth or face; 4) chest pain; and 5) dizziness, weakness or fainting.

Table 1. Symptoms of anaphylaxis.

- Skin/mucosa: urticaria, pruritis, flushing, facial/mucosal angioedema
- Respiratory: wheezing, cough, stridor, dyspnea
- Cardiovascular: tachycardia, hypotension
- Gastrointestinal: nausea, vomiting, diarrhea, abdominal pain
- Oropharynx: throat swelling, oral pruritis

We also surveyed the subsequent EHR documentation to determine whether a repeat visit to an ED or other outpatient facility occurred within 48 hours of discharge. In patients with anaphylaxis who received both IM EPI and CS, the primary outcome measure was to determine 1) the rate of BPR, and 2) the comparative rates of BPR in 0–4 and 4–48 hours post receiving IM EPI. The secondary outcome measure was to determine the rate of ED return visit for BPR within 48 hours of ED discharge.

Statistical Considerations

Categorical data are described in terms of frequency (%) and compared using κ coefficients. We calculated a sample of 280 cases to allow for 80% power (alpha 0.05) to determine at least a 10% difference in BPR rates between intervals of <4 hours (15%) vs >4 hours (5%) after CS administration.[1,8] To determine inter-rater agreement in collating results, 30 cases (15% of total) were randomly selected and eight variables compared between reviewers; the kappa was 0.84, indicative of substantial agreement. Since there were fewer than five patients in one cell, we performed a Fisher exact test comparing rates of BPR during the 0–4 vs >4 hours post-treatment intervals. We calculated binomial probability 95% confidence interval (CI) for those who received IM EPI and

CS with no BPR occurrence, using the Clopper-Pearson exact method (CI 77–84%). The study was approved by the Icahn School of Medicine Investigational Review Board.

RESULTS

During the study period, there were 371 consecutive cases of anaphylaxis involving 280 patients; in 357 cases (94%) both IM EPI and CS were administered. Each record in the study cohort had a completed attending-level physician note reviewing history of present illness, review of symptoms, physical exam, and medical decision-making. The demographic profile of this cohort is given in Table 2. A total of 49 patients (14%) manifested BPR requiring at least one additional dose of IM EPI [14% required ≥2 additional doses]; 41 [84%] had received prehospital administration of IM EPI. All BPR events occurred during the initial four hours after initiating therapy, whereas no patient manifested BPR requiring an additional dose of IM EPI during the latter 4–48 hour interval after initiating therapy ($P = <0.001$). No patient was documented to return to the ED with recurrence or exacerbation of anaphylaxis symptoms within 48 hours after discharge.

Table 2. Patient characteristics: 357 cases of anaphylaxis treated with intramuscular epinephrine and corticosteroid.

Variable	N [%]
Patient age range	3 months–19 years
Patient age median	9.2 years
Patient sex	
• Male	181 [50.7%]
• Female	176 [49.3%]
ED length of stay (median)	4.7 hours
ED length of stay (range)	3.5–6.2 hours
Anaphylaxis trigger	
• Food exposure	328 [93%]
• Unknown	20 [5.0%]
• Environmental exposure	4 [1.0%]
• Drug-related	5 [1.0%]
Management received – all cases:	
• IM EPI	357 [100%]
• Prehospital IM EPI	193 [54%]
• CS	357 [100%]
• H1 and/or H2 receptor antagonist*	344 [96%]
Biphasic reaction cases^	
• Total	49 [14%]
• received >1 dose of IM EPI	49 [14%]
• received >2 doses of IM EPI	8+ [2%]
• received prehospital IM EPI	41 [84%]
• during the initial 4 hours after initiating therapy	49 [100%]#
• during the interval 4–48 hours after initiating therapy	0#
Inpatient hospitalization	11 [3%]
Deaths	0

*Receptor antagonist H1 = diphenhydramine; H2 = famotidine.
^Within 48 hours after initial presentation.
+All doses of IM EPI were given during the initial 0–4 hours after initiating ED therapy.
#*P*-value comparing rates is $P < 0.001$.
BPR, biphasic reaction; *CS*, corticosteroid; *ED*, emergency department; *IM EPI*, intramuscular epinephrine.

DISCUSSION

In our analysis we sought to review a large number of pediatric anaphylaxis cases treated with IM EPI and CS to determine the subsequent rate and timing of BPR. Our approach to management was nearly unanimous, as 96% of cases received IM EPI and CS. The 14% observed rate of BPR, and predominance of food allergen triggers, are consistent with prior pediatric reports.[9,10] The majority (84%) of BPR cases required only one additional dose of IM EPI to effect resolution.

Using our institutional approach, the 0% BPR rate achieved during the 4–48 hour interval after initiating therapy is lower than has been previously reported in the literature; several of those analyses found no significant difference in return rates between those who did vs those who did not receive CS.[11,12] The factor of time delay from entry into medical care to initial dose of IM EPI impacting BPR rate was minimized in our cohort, as 84% of patients developing this complication had received rapid deployment of an initial dose of IM EPI in the prehospital phase of management. Recent review articles on pediatric anaphylaxis recommend against CS treatment, due to lack of proven efficacy.[2,3] One[13] implicated CS treatment as increasing "the likelihood of a biphasic reaction in children by as much as 50%" (no study citation given). A foreign retrospective study surveying a large database comparing anaphylaxis treatment with and without CS found no significant difference in BPR rates yet did not specifically correlate onset of BPR with timing of CS administration.[14]

The exact pathogenesis of anaphylactic BPR is unclear; potential theories include a second wave of mast cell degranulation, delayed ongoing absorption of offending antigen (especially oral antigenic exposures), or the waning effect of therapy.[15] As an extension of treatment for other atopic conditions, CS therapy is expected to exert a beneficial effect in modulating the IgE-mediated process of anaphylaxis. This class of drugs has proven efficacy in ameliorating other allergic-mediated conditions such as urticaria and asthma. There is evidence that CS can inhibit mast cells, which are strongly implicated in the anaphylaxis cascade, by down-regulating pro-inflammatory cytokine

transcription, regulating multiple adaptor and signaling molecules, and rapidly decreasing cell histamine release.[4,5] These characteristics support the biological plausibility of CS affecting BPR prevention. Consistent with this, a prior study[12] of pediatric anaphylaxis showed early CS therapy was inversely associated with prolonged length of stay and subsequent IM EPI requirement among those hospitalized.

There are no published prospective randomized, placebo-controlled studies assessing CS effect in treating anaphylaxis. While such studies and their data would be an important step toward a more complete understanding of BPR in anaphylaxis, the design of such a study would be problematic. Obtaining informed consent to randomize treatment would be prohibitive for the potentially lethal medical condition of acute anaphylaxis, in which delay in therapeutic intervention measured in minutes can be crucial in determining outcome. Due to ethical considerations, such a study would mandate treatment of all patients with IM EPI and then compare a group treated with CS vs placebo. The intervals of analysis compared would be prior to vs after CS therapeutic onset, likely at the four-hour post-administration mark. Our methodology largely simulates this scheme; yet any analysis including IM EPI treatment of all patients still leaves unanswered the question of whether the initial IM EPI dose actually "resolves" anaphylaxis vs merely providing a temporizing suppression of the reaction—with CS exerting a further effect in BPR prevention.

Our findings may shed light on a potential CS therapeutic impact on rate of BPR recurrence. Since in all instances both IM EPI and CS were administered, we noted a significant difference in BPR rates when partitioning clinical course based on medication pharmacokinetics. The IM EPI effect is rapid in onset, lasting briefly (t½ of 2–3 minutes), whereas CS has clinical onset approximately >4 hours following administration, lasting beyond 24 hours.[16–18] It is likely that after four hours the IM EPI effect wanes, and any ongoing anti-allergy effect is likely due to CS. Within this context, we found the rate of BPR requiring repeat IM EPI administration was significantly lower 4–48 hours vs 0–4 hours after initiating therapy.

LIMITATIONS

As with any observational study, data gathering was limited by information present. We largely avoided this deficiency, in that nearly all our practitioners managed patients and thoroughly documented management in a stereotyped manner. We did not have sufficient data to analyze time from onset of anaphylaxis symptoms to receiving IM EPI and its potential impact on BPR rate.

CONCLUSION

Approximately 1 in 7 children with anaphylaxis experience a biphasic reaction after receiving intramuscular epinephrine. Children with anaphylaxis who exhibit symptomatic resolution 4–6 hours following initiation of therapy have a low risk for subsequently developing BPR. The majority of BPR cases require one additional dose of IM EPI to effect resolution. The rate of BPR in those receiving IM EPI and corticosteroids is significantly lower 4–48 hours vs 0–4 hours after initiating therapy.

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Hyperkalemia or Not? A Diagnostic Pitfall in the Emergency Department

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Introduction: Hyperkalemia, a potentially life-threatening electrolyte disturbance, is commonly encountered in the Emergency Department (ED). However, the frequency of factitious hyperkalemia, an artificially elevated potassium level in hyperkalemic ED patients, is unknown. This study aims to detect the rate of factitious hyperkalemia among patients with a potassium concentration of ≥5.0 mmol/l in an all-comer ED population.

Methods: This retrospective, monocentric chart review analyzed data of 2,440 ED patients who presented with a potassium concentration of ≥5.0 mmol/L in their initial whole blood or plasma sample, who also underwent a repeat potassium measurement on the same day. Two groups were established based on potassium levels in the initial and repeat blood tests: 1) True hyperkalemia, characterized by consistently elevated potassium levels in both the initial and repeat samples; and 2) Factitious hyperkalemia, defined by an elevated initial potassium level while the repeat blood test showed a normal potassium level. A subset of factitious hyperkalemia was spurious hyperkalemia. In spurious hyperkalemia, the initial blood sample showed an elevated potassium level with evidence of hemolysis, but a repeat test revealed a normal potassium level without evidence of hemolysis.

Results: Of the 2,440 patients, 1,576 (65%) had true hyperkalemia and 864 (35%) factitious hyperkalemia. Among the 864 patients with factitious hyperkalemia, 597 (69%) displayed hemolysis in their initial blood sample, indicating spurious hyperkalemia due to in-vitro hemolysis.

Conclusion: These data show that about one third of all hyperkalemic blood samples drawn in the ED were due to factitious hyperkalemia. The leading cause of factitious hyperkalemia was spurious hyperkalemia due to in-vitro hemolysis. [West J Emerg Med. 2025;26(1)176–179.]

INTRODUCTION

Hyperkalemia is a potentially life-threatening and commonly encountered electrolyte disorder in the emergency department (ED). Elevated potassium concentrations are associated with increased mortality and, hence, require rapid initiation of potassium-lowering therapy.[1] However, unnecessary treatment of hyperkalemia due to factitious hyperkalemia is not without risks.[2,3] Surprisingly, the frequency of factitious hyperkalemia in hyperkalemic ED patients has not been determined.

Therefore, our goal in this study was to determine the prevalence of factitious hyperkalemia among patients with a potassium concentration of ≥5.0 millimoles per liter (mmol/L) in an all-comer ED population (the primary outcome).

Population Health Research Capsule

What do we already know about this issue?
Factitious hyperkalemia, an artificially elevated potassium level, should be ruled-out before treatment of hyperkalemia is initiated, as unnecessary treatment is not without risks.

What was the research question?
What is the rate of factitious hyperkalemia among patients with hyperkalemia in an all-comer ED population?

What was the major finding of the study?
Among 2,440 patients, factitious hyperkalemia occurred in 35% of hyperkalemic blood samples drawn in the ED.

How does this improve population health?
Factitious hyperkalemia is a diagnostic pitfall that can potentially lead to unnecessary treatment.

METHODS

This retrospective, monocentric, chart-review study was approved by the ethics oversight committee (EKNZ identifier: 159/13). We evaluated 2,440 patients over a period of three years in whom a first whole blood or plasma sample showed a potassium concentration of ≥5.0 mmol/L at ED presentation and for whom a repeat (whole blood or plasma) lab test was ordered in the same patient (determined by a patient ID) on the same day by the treating physician. We adhered to 8 of 12 chart review criteria.[4] Our protocol omits performance monitoring, hypothesis blinding, and interobserver reliability (IRR) tests, as abstractors were involved in designing the study, and IRR tests did not align with the study aim. Blood sampling and analysis was performed in the same manner for the initial and repeat blood test.

Blood was collected using peripheral venous catheters (Vasofix Safety Cannula, B. Braun AG, Melsungen, Germany) with a dual-use S-Monovette system allowing either aspiration- or vacuum-based blood sampling (Sarstedt AG, Nümbrecht, Germany). Plasma potassium concentration was analyzed using a Cobas 8000 analyzer (Roche Diagnostics, Basel, Switzerland), and whole blood samples were analyzed as part of a blood gas analysis with an ABL 800 analyzer (Radiometer, Copenhagen, Denmark). Strong agreement was found between the potassium measurements of the Roche Cobas 8000 analyzers.[5] All scheduled calibrations for both devices were completed at 24-hour intervals in accordance with manufacturer requirements. The presence of hemolysis was either photometrically or visually assessed.

As there is no commonly accepted definition of factitious hyperkalemia, the terms pseudo-hyperkalemia, spurious hyperkalemia, and factitious hyperkalemia are often used interchangeably.[3,6–10] To categorize our hyperkalemia findings, we established two distinct groups (see Figure 1):

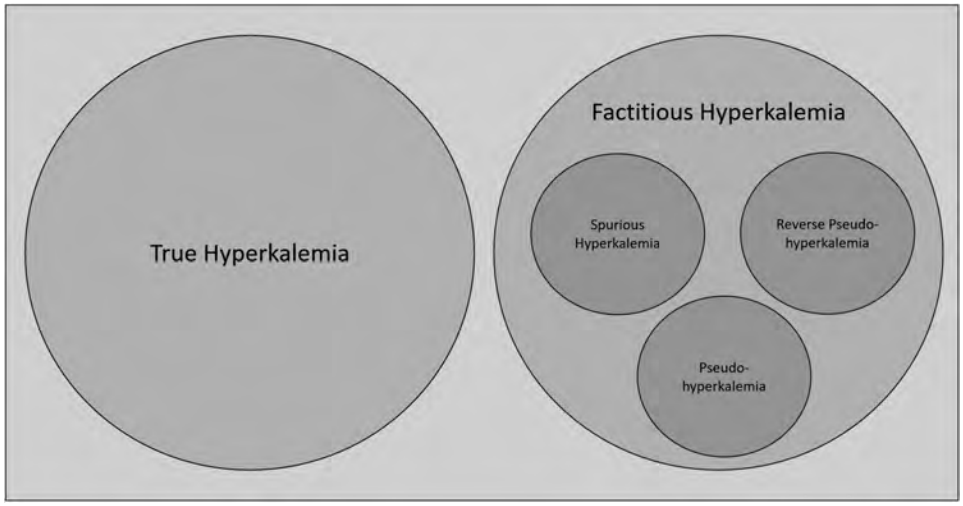

Figure 1. Venn diagram illustrating definitions of true hyperkalemia and factitious hyperkalemia. Factitious hyperkalemia is an umbrella term that encompasses various subcategories of falsely elevated potassium levels. These include reverse pseudohyperkalemia (in leukemic patients), pseudohyperkalemia (due to thrombocytosis or erythrocytosis), and spurious hyperkalemia (due to in-vitro hemolysis).

true hyperkalemia, characterized by consistently elevated blood potassium concentrations in both the initial and repeat blood test; and **factitious hyperkalemia**, which showed elevated blood potassium concentrations in the first sample while the repeat blood test showed a normal potassium level. Factitious hyperkalemia is an umbrella term for all subentities of falsely elevated potassium levels, as it does not differentiate between intrinsic (eg, hematologic disorders) and extrinsic causes (eg, blood sampling technique). Examples are reverse pseudohyperkalemia in leukemic patients or pseudohyperkalemia due to thrombocytosis or erythrocytosis. Another subset of factitious hyperkalemia is **spurious hyperkalemia**, in which an elevated potassium concentration with evidence of hemolysis was found in the first sample and a normal potassium in the repeat blood test. Spurious hyperkalemia is the result of hemolysis due to preanalytical errors during sampling or sample handling (ie, due to extrinsic causes).[6]

RESULTS

We included 2,440 patients with a potassium concentration of ≥5.0 mmol/L in the initial blood sample taken on the day of ED presentation. Patients with factitious hyperkalemia had a median age of 69 years, and 53% were female. Potassium levels of the factitious hyperkalemia group ranged from 5.0–29.9 mmol/L; median potassium concentration was 5.4 mmol/L. About one-third of the 864 hyperkalemia patients (35%) met the definition of factitious hyperkalemia, and 1,576 (65%) of the patients with hyperkalemia had true hyperkalemia (see Figure 2).

Of the 864 patients with factitious hyperkalemia, blood samples were rated as hemolytic in 597 cases (69%), indicating spurious hyperkalemia as the underlying etiology. In the remaining 267 of 864 cases (31%), the etiology of factitious hyperkalemia is unclear. Patients with true hyperkalemia had a median age of 75 years, and 41% were female. Potassium levels of the true hyperkalemia group ranged from 5.0–10.3 mmol/L; median potassium concentration was 5.4 mmol/L.

DISCUSSION

This study shows that factitious hyperkalemia can be observed in about one-third of hyperkalemic blood samples drawn under real-life conditions in the ED. Spurious hyperkalemia due to preanalytical errors during blood sampling or transport leading to in-vitro hemolysis appears to be the main cause of falsely elevated potassium levels in this study. However, in critically ill patients many factors can influence one sample measurement (eg, transient acidosis or hypoinsulinemia with hypotension). Thus, it is unclear whether a first hyperkalemic measurement, which resolved in a second measurement, is factitious, or simply transient and quickly resolved. On the other hand, it is conceivable that there is true hyperkalemia in the cases that we classified as factitious hyperkalemia as there is also the phenomenon of pseudonormokalemia (ie, the repeat blood test is falsely low).[11]

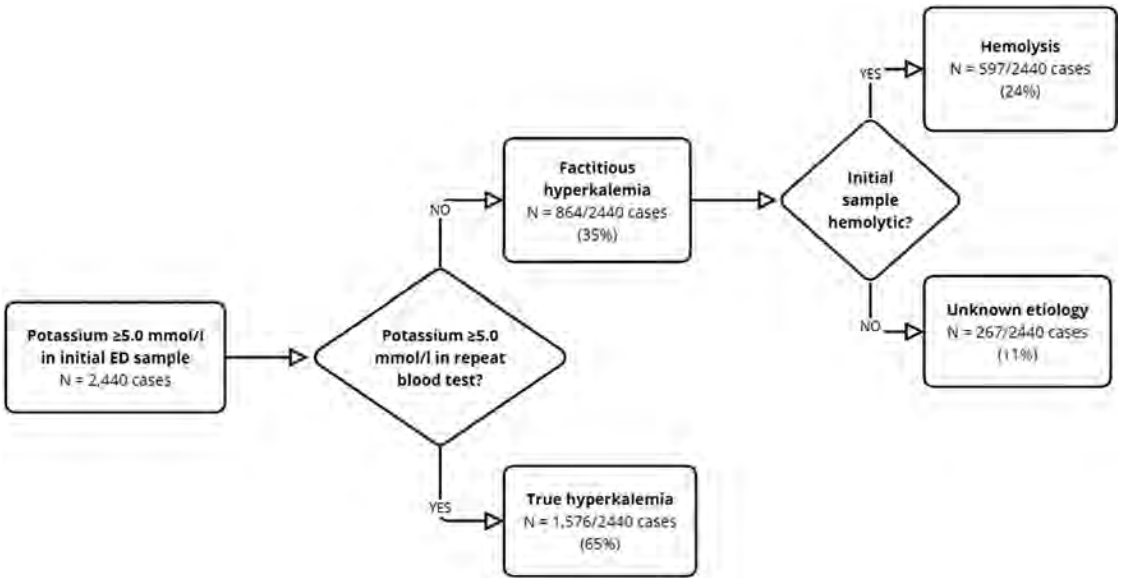

Figure 2. Proportions of patients that had true, factitious, and spurious hyperkalemia. Of 2,440 cases with a potassium of ≥5.0 millimoles per liter, 1,576 (65%) had persistent hyperkalemia in a same-day repeat blood test, (ie, they had true hyperkalemia); and 864 (35%) did not show hyperkalemia in a same-day repeat blood test; hence, these patients had factitious hyperkalemia. Of those 864 cases, 597 (69%) showed evidence of hemolysis in their initial blood test; thus, these patients had spurious hyperkalemia due to in-vitro hemolysis. In 267 of the 864 cases of factitious hyperkalemia (31%), no evidence of hemolysis was observed. The reason for the occurrence of factitious hyperkalemia in these cases remains unclear.
mmol/L, millimoles per liter.

In the process of analyzing the results of this study, we observed that the literature uses a variety of terms to describe factitious hyperkalemia.[3,6–10] In cases of factitious hyperkalemia the underlying cause is often not considered, which might cause confusion. Surprisingly, this has not yet been acknowledged in hyperkalemia management guidelines.[3,10,12,13] While our study shows that spurious hyperkalemia is a major contributor to factitious hyperkalemia in the ED, it also became apparent that the common assumption among clinicians that falsely elevated potassium levels are solely due to hemolysis resulting from inadequate blood-drawing techniques is false. There are numerous other significant underlying pathological processes that can lead to falsely elevated potassium levels (eg, thrombocytosis). While we cannot differentiate between all these underlying pathological processes in the ED, emergency physicians should be aware of the concepts of spurious, pseudo- and reverse pseudohyperkalemia, as potentially unnecessary treatment could be associated with risks.[2,3]

CONCLUSION

This data shows that one-third of all hyperkalemic blood samples drawn in the ED are due to factitious hyperkalemia. The leading cause of factitious hyperkalemia is spurious hyperkalemia due to in-vitro hemolysis.

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