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Understanding the Use of Composite Endpoints in Clinical Trials

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Clinicians, institutions, healthcare networks, and policymakers use outcomes reported in clinical trials as the basis for medical decision-making when managing individual patients or populations. Therefore, the choice of a valid primary endpoint is crucial for randomized controlled trials (RCT) to demonstrate efficacy of new therapies. Recent improvements in treatment, however, have led to a decline in the morbidity and mortality of several common diseases, resulting in a reduction in relevant outcomes that can be used as clinical trial endpoints. Composite endpoints have been used as a solution to maintain the feasibility of RCTs, particularly when facing low event rates, high cost, and long follow-up. However, the benefits of using composite endpoints must be weighed against the risks of misinterpretation by clinicians and policymakers, as incorrect interpretation may have a detrimental effect on patients and populations. This paper defines a composite endpoint, discusses the rationale for its use, and provides a practical approach to interpreting results to aid in medical decision-making. [West J Emerg Med. 2018;19(4)631–634.]

INTRODUCTION

Advances in medicine have led to decreased morbidity and mortality for many common medical conditions, with overall improvement in health of the population.[1-2] The smaller marginal benefit of new treatments has provided increasing challenges for medical research as smaller incremental benefits (effect sizes) of new therapies typically require studies with larger sample sizes and longer follow-up, both of which can be cost prohibitive.[3-5]

Researchers have been increasingly using composite endpoints in lieu of the customary single primary endpoint.[6,7] Although statistically treated like a single primary endpoint, composite endpoints provide unique challenges for patient care.[6-8] If used or interpreted incorrectly, they have the potential for detrimental impact on patient care on a large scale. This paper defines composite endpoints, discusses the rationale for their use, and provides a practical approach to understand whether they should be used in medical decision-making.

Composite Endpoint Defined

A composite endpoint consists of at least two or more distinct endpoints, called component endpoints.[6,7] Because of the need to observe a certain number of primary endpoints to achieve adequate statistical power for a study, investigators opt to use component endpoints that contribute to an overall composite event rate.[9]

Rationale for Using Composite Endpoints in Clinical Trials

Benefits

Combining two or more study outcomes into a single composite measure typically results in an increase in the incidence rates of the composite endpoint and improves the ability to detect differences in the primary endpoint. This pooling of different study outcomes will result in higher event rates and increased statistical precision that will subsequently lead to designing clinical trials that include fewer patients, are less costly, and can be completed in a more timely manner.[8,9] Other reported benefits include avoiding competing risks in outcome assessment and addressing rare instances where there is no obvious choice of a primary trial outcome.[10,11]

Challenges

Interpretation of composite endpoints remains difficult, as there are no generally accepted standardized approaches to interpretation, and evaluating a composite endpoint as if it were a single primary endpoint is an inadequate strategy. To date, there remains little guidance available on how these aggregated endpoints should be interpreted.[6]

One common challenge that arises in the process of interpretation is how to evaluate a composite outcome that is composed of component endpoints that may not be clinically meaningful. Combining component endpoints with large variability in importance (to patients or clinicians) raises substantial concerns when attempting to use a composite

endpoint as a basis for medical decision-making. Similar concerns arise when there is a large gradient in the frequency of the most and least important component outcomes, as well as in the variability of point estimates of the component outcomes.

Interpreting Composite Endpoints

The ultimate question that clinicians must answer when evaluating studies that use composite endpoints is whether or not the composite endpoint should be used as a basis for medical decision-making. The following section contains critical foundational questions that must be answered when considering the use composite endpoints.[7] To the extent that one can answer "yes" to the following questions, one can feel confident using the treatment effect on the composite endpoint as the basis for medical decision-making. Conversely, to the extent that one answers "no" to the following questions, one should use the individual component endpoints instead (Figure).

Evaluating the utility of a composite endpoint for medical decision-making
1. Are the component endpoints of similar importance to patients?
2. Did the more or less important endpoints occur with similar frequency?
3. Can one be confident that the component endpoints share similar relative risk reductions?
• Is the underlying biology of the component endpoints similar enough such that one would expect to see similar relative risk reductions?
• Are the point estimates of the relative risk reductions similar, and are the confidence intervals sufficiently narrow?

Figure. Questions to aid clinicians in evaluating the utility of a composite endpoint as a basis for medical decision-making (for therapies purported to decrease the risk of an undesirable outcome).

Are the Component Endpoints of Similar Importance to Patients?

If the component endpoints of a composite endpoint are of equal (or relatively similar) importance to patients, then it does not matter how a relative risk reduction is distributed among the components because if the composite crossed the threshold for statistical significance, one can be assured that an important component played a substantive role. The larger the gradient in importance between the most and least important component endpoints, the larger our skepticism about the usefulness of the composite endpoint.

An illustrative example of how an increase in the importance gradient leads to increased skepticism regarding using a composite endpoint can be seen in a study that evaluated the effect of systemic glucocorticoids on chronic obstructive pulmonary disease (COPD).[12] In this prospective, double-blind, randomized controlled trial, the authors evaluated the effectiveness of systemic glucocorticoids vs. placebo on the primary endpoint of treatment failure, which was a composite endpoint of death from any cause, need for intubation, readmission to the hospital for COPD, or intensification of drug therapy, for patients presenting with COPD exacerbations. The authors report that the rates of treatment failure were significantly higher in the placebo group at 30 days (33% vs. 23%, p=0.04) and 90 days (48% vs. 37%, p=0.04). The authors concluded that treatment with systemic glucocorticoids resulted in moderate improvement in clinical outcomes among patients hospitalized for exacerbations of COPD.

Combining an endpoint of paramount clinical importance such as death with a component endpoint of relatively trivial importance, such as intensification of steroid therapy or hospital readmission, can lead to challenges in interpreting the meaning of a composite endpoint. A higher rate of treatment failure in the placebo group on the composite outcome could conceivably lead one to believe that the placebo group had higher rates of the more important endpoint of death. However, there were no differences between the groups for the most important endpoint of death. Over the six-month follow up, 9.9% (11 of 111) of patients receiving placebo and 8.1% (13 of 160) of patients receiving glucocorticoids died (p=0.61). By combining the important endpoint of death with a more frequently occurring and relatively less important endpoint such as increase in steroid intensity, the authors were able to state that there was a statistically significant difference in the "composite" endpoint that included the important endpoint of death, although it was the relatively unimportant endpoint of increasing steroid intensity that was responsible for pushing the composite over the threshold for statistical significance. The large gradient in importance between the components in this study should prompt clinicians to conclude that the composite should not be used as a basis for medical decision-making and instead focus on the individual component endpoints.

Did the Component Endpoints Occur with Similar Frequency?

The larger the gradient in frequency between the most and least patient-important component endpoints, the more skeptical we should be about the usefulness of using the composite endpoint as a basis for medical decision-making. If the more important component endpoints occur with far less frequency than the less important ones, the composite endpoint becomes less informative.

In a prospective, randomized, multicenter trial reported in *The Lancet*, the authors evaluated the effectiveness of invasive vs. medical therapy in elderly patients (≥ 75 years) with chronic angina.[13] The primary endpoint was quality of life after six

months, as assessed by questionnaire and the presence of major adverse cardiac events (a composite endpoint of death, non-fatal myocardial infarction [MI], or hospital admission for acute coronary syndrome). The authors observed that angina severity decreased and quality of life measures increased in both groups, with improvements greater after revascularization. The authors also reported that major adverse cardiac events occurred more frequently in the medical group (49% vs. 19%, p<0.0001), and stated that patients aged 75 years or older with angina despite standard drug therapy benefit more from revascularization than from optimal medical therapy.

The difference in major adverse cardiac events of 30% between the medical and invasive group could conceivably lead a reader to believe that patients in the invasive group had lower rates of death, non-fatal MI, and hospital admission. However, the significant difference in the composite endpoint in this instance was solely due to an increased frequency of the least important outcome, hospital admissions, which accounted for 76% of events in the medical group, as compared to 36% of events in the invasive strategy group. This large gradient in frequency should prompt clinicians to focus on the individual component endpoints, and not the composite.

Can One Be Confident that the Component Endpoints Share Similar Relative Risk Reductions?

The confidence clinicians can have regarding the similarity in relative risk reductions among the component endpoints can be evaluated with two questions:

1. Is the underlying biology of the component endpoints similar enough such that one would expect to see similar relative risk reductions?

The rationale for using a composite endpoint is in part dependent on the confidence clinicians can have that the more and less important component outcomes share similar relative risk reductions. The stronger the biologic rationale for why an intervention should have a particular effect on the component endpoints, the more confident clinicians can become with the notion that the composite endpoint accurately portrays the net effect of treatment.

2. Are the point estimates of the relative risk reductions similar and confidence intervals (CI) sufficiently narrow?

Although a strong biologic rationale supporting similar treatment effects across component endpoints is reassuring, it is the actual observation of similar treatment effects among the component endpoints that leads to increased confidence in using the composite endpoint as a basis for medical decision-making. The larger the gradient in results between the more and less important component endpoints, the larger should be our concern about using a composite endpoint. This is particularly true for composite endpoints with components that include both beneficial and harmful effects.

The Losartan Intervention For Endpoint reduction (LIFE) trial was a prospective double-blinded, randomized study that evaluated the effectiveness of a losartan-based vs. atenolol-based antihypertensive treatment regimen on the composite outcome of death, MI, or stroke, for patients aged 55-80 years of age with essential hypertension and left ventricular hypertrophy.[14] The authors observed no significant difference in blood pressure reduction between the groups. They also reported a decreased risk in the primary composite endpoint in the losartan group (risk ratio [RR] [0.87], 95% CI [0.77 – 0.98]). Of the component endpoints, only the risk of stroke had a statistically significant reduction (RR [0.75], 95% CI [0.63 – 0.89]). The authors concluded that losartan prevents more cardiovascular morbidity and death than atenolol for a similar reduction in blood pressure, despite the lack of significant difference in death rates between the groups. The challenges for composite endpoint interpretation as well as the potential for widespread distribution of misleading study results is evidenced by the U.S. Food and Drug Administration restricting the regulatory labeling of the use of losartan for reduction of nonfatal stroke, as opposed to the original triple endpoint of death, MI, or stroke in the LIFE trial.[6,14,15]

SUMMARY

Composite endpoints in clinical trials are composed of primary endpoints that contain two or more distinct component endpoints. The purported benefits include increased statistical efficiency, decrease in sample-size requirements, shorter trial duration, and decreased cost. However, the purported benefits must be diligently weighed against the inherent challenges in interpretation. Furthermore, the larger the gradient in importance, frequency, or results between the component endpoints, the less informative the composite endpoint becomes, thereby decreasing its utility for medical-decision making.

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Emergency Department Time Course for Mild Traumatic Brain Injury Workup

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Introduction: Mild traumatic brain injury (mTBI) is a common cause for visits to the emergency department (ED). The actual time required for an ED workup of a patient with mTBI in the United States is not well known. National emergency medicine organizations have recommended reducing unnecessary testing, including head computed tomography (CT) for these patients.[10]

Methods: To examine this issue, we developed a care map that included each step of evaluation of mTBI (Glasgow Coma Scale Score 13-15) – from initial presentation to the ED to discharge. Time spent at each step was estimated by a panel of United States emergency physicians and nurses. We subsequently validated time estimates using retrospectively collected, real-time data at two EDs. Length of stay (LOS) time differences between admission and discharged patients were calculated for patients being evaluated for mTBI.

Results: Evaluation for mTBI was estimated at 401 minutes (6.6 hours) in EDs. Time related to head CT comprised about one-half of the total LOS. Real-time data from two sites corroborated the estimate of median time difference between ED admission and discharge, at 6.3 hours for mTBI.

Conclusion: Limiting use of head CT as part of the workup of mTBI to more serious cases may reduce time spent in the ED and potentially improve overall ED throughput. [West J Emerg Med. 2018;19(4):635-640.]

INTRODUCTION

According to the United States (U.S.) Centers for Disease Control and Prevention, the incidence of traumatic brain injury (TBI) has increased by nearly 60% from calendar-year (CY) 2001 to CY2010 (from 521 per 100,000 persons to 824 per 100,000 persons).[1] Visits to the emergency department (ED)

resulting in a diagnosis of TBI increased by 29.1% (95% confidence interval [CI], 18.9%–39.2%) in the time period 2006 to 2010, whereas the total number of ED visits increased by only 3.6% (95% CI [-0.7%–8.0%]) during the same period.[2] A recent analysis suggests that nearly five million patients present to U.S. EDs annually to be evaluated for head injury, and that approximately one-half of them are diagnosed with a TBI.[3] Further, most patients who present to the ED with suspected TBI have mild TBI (mTBI), estimated to be as high as 94.5%.[4,5]

In addition to obtaining a detailed patient history and thorough physical examination, computed tomography (CT) head imaging has frequently been part of the diagnostic workup, and has been recommended for most if not all patients with suspected mTBI.[4-6] CTs are now typically performed on >80% of patients who present to the ED with suspected TBI.[7] However, there has been growing concern about the radiation exposure and cost associated with CT. The decision to obtain a head CT also adds time to the ED visit (primarily waiting for the scan to be run and/or read), and requires additional resources, including use of the CT scanner and additional hospital staff. In a study by Rogg and colleagues, 8,312 ED patients who received a head CT reported a median time of 3 hours and 13 minutes (193 minutes) between the patient arrival and the CT preliminary report in high-volume EDs.[8] They concluded that head CT has a significant impact on patient wait times.

The present article explores the workflow and associated time of assessing a patient with a head injury. We evaluated the process by constructing a detailed, theoretical care map, retrospectively testing the care map against actual patient time data and comparing the results to those published in the literature. Using such a detailed care map from admission to discharge from the ED could help identify specific steps in care, which could significantly decrease patient wait times. The purpose of this study was to understand times associated with all of the steps in ED workup of a patient with mTBI, from the point of initial ED presentation to discharge. An understanding of each step in the workup and associated times is necessary to identify opportunities to shorten the total workup of these patients.

Population Health Research Capsule

What do we already know about this issue?
Traumatic brain injury (TBI) is a common cause for an emergency department (ED) visit. National emergency medicine organizations have recommended reducing unnecessary testing, including head computed tomography (CT) for these patients.

What was the research question?
What are the times associated with all the steps in ED workup of a patient with mild TBI, from the point of initial ED presentation to discharge?

What was the major finding of the study?
Evaluation for mild TBI in the ED was estimated at 401 minutes (6.6 hours) in EDs. Time related to head CT comprised about one-half of the total length of stay.

How does this improve population health?
Limiting use of head CT as part of the workup of mild TBI to more serious cases may reduce time spent in the ED and potentially improve overall ED throughput.

METHODS

We developed a theoretical care map describing the steps in the typical workup of a patient presenting to the ED following a mTBI. The care map was based on a facilitated consensus panel discussion between three experienced, academic, board-certified emergency physicians, each with at least 20 years of experience at academic, high-volume EDs, (JH, EM, RN,) during a four-hour meeting and two rounds of follow-up comments on the care map to gain consensus. The working draft was then presented for review to a larger expert panel of experienced emergency medicine nurses, nurse practitioners and physicians from around the U.S. (AP, DS, EM, JS, ML, MR, RN, SH). The care map was further revised based on feedback from the second group of reviewers, and subsequently finalized.

The care map of workup for a ED visit for suspected mTBI included 10 unique steps identified during a "typical" episode of care, beginning with initial presentation to the ED and ending with discharge (Figure). For each of these steps, estimates of time required to perform the step were identified and discussed with both consensus panels. The larger expert panel confirmed the steps in the care map. The figure summarizes the care map of 10 steps associated with ED visit for suspected TBI. The care map demonstrates a range of work/time flow differences. However, the map was only tested in sites with similar high volume, to compare with the Rogg published data, and also to validate the steps and timing contained in the care map.[8]

In the second part of the study, we tested the assumptions in the theoretical care map using retrospective data from EDs at two major U.S. teaching hospitals. Both were high-volume EDs, as defined above, one seeing 60,000 patients annually with four CT scanners and the second seeing 70,000 patients

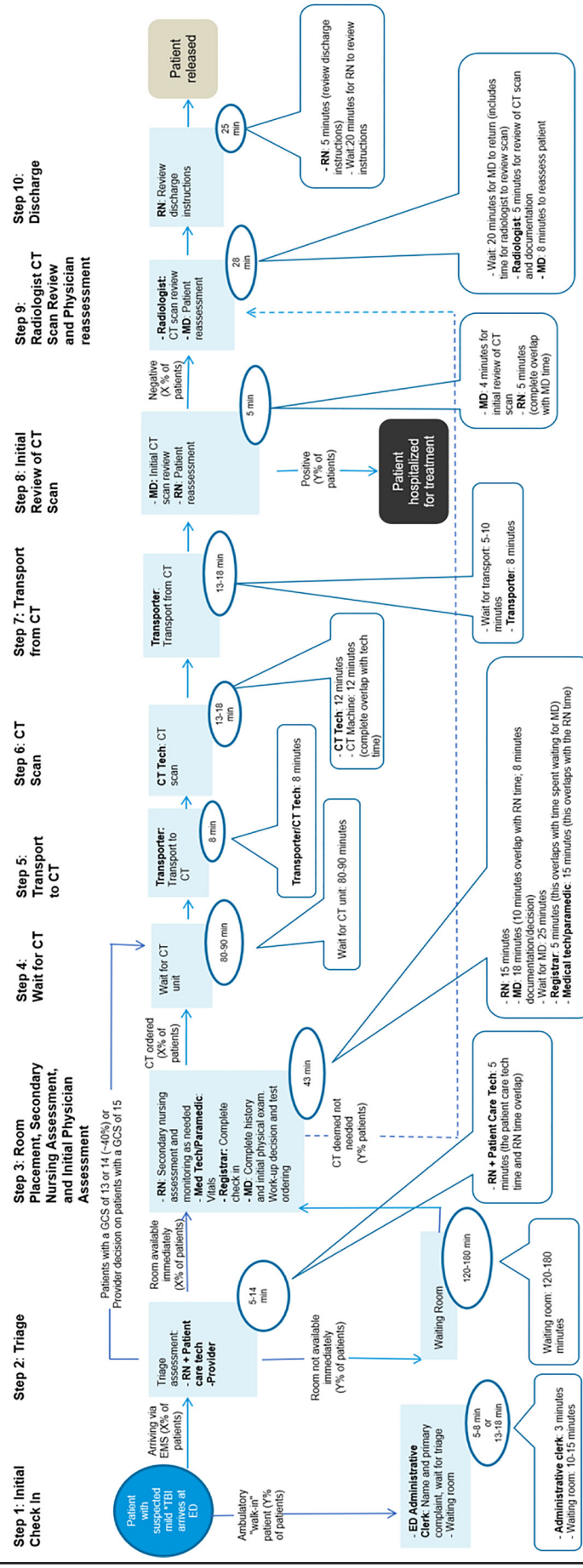

Figure. Care map of 10 steps associated with emergency department (ED) visit for suspected traumatic brain injury. *RN*, registered nurse; *CT*, computed tomography; *GCS*, glasgow coma scale; *TBI*, traumatic brain injury. *As defined by either New Orleans criteria or Canadian CT criteria.

annually with two CT scanners. We collected retrospective observational data on ED length of stay (LOS) defined as the time between registration and ED discharge. This data was extracted from the electronic data collection form from two of the 11 sites from a larger published clinical trial.[9] All patients were between the ages of 18-85 (mean 45.7, standard deviation [SD]=19.8), 50% male, with Glasgow Coma Score between13-15 (mean 14.9), and were evaluated within 72 hours of injury (mean 12.7 hours, SD=.47). The time of admission and discharge were obtained from the study electronic data capture form and confirmed from the electronic health record. From this data we calculated time interval between admission and discharge from the ED. Median LOS was calculated, as well as first quartile and third quartile, and these values were compared with the Rogg study data.[8] We conducted analyses using Microsoft Excel 2016 MSO (16.0.8431.2046) 32-bit (Microsoft Corporation, Redmond, Washington).

RESULTS

In the theoretical care map, total and component time of mTBI evaluation in U.S. EDs is summarized in Table 1. We estimated LOS as 401 minutes (~6.6 hours) in the EDs.

Step 2 of the care map outlines the triage of the patient, first by a registered nurse, and then by a provider. Many EDs, but not all, now use a provider in triage model to do brief patient assessments "up front" and initiate testing before the patient is placed in a room (Step 3). Time spent between waiting for transport to the CT unit (Step 4) and physician reassessment following radiologist review of the CT (Step 9) was estimated to be 151 minutes (~2.5 hours) at EDs. The difference is due to delays in transport, as well as longer times for radiology reads in high-volume sites. Regardless of hospital volume, the acquisition of the CT itself was estimated to take only 12 minutes (3.4% of LOS at hospitals).

Actual retrospective data from the two study hospitals showed a mean LOS of 7.9 hours ± 7.0 hours. The comparison between the present study (N=125) and the Rogg [8] study (N=8,312) LOS median, first quartile, and the third quartile are presented in Table 2. The Rogg study[8] included both CT+ and CT- subjects in its population but did not separate the population into CT+ and CT- subgroups. In the present study, we present the data for combined CT groups, as Rogg and colleagues, and in addition, we split the study population into CT+ and CT- patients to examine length of time for the two subtypes of patients. There was no significant difference in LOS between the CT+ and CT- patients (p=0.8) in the present study. Furthermore, it was of interest to note that there was no difference in the CT- and CT+ data.

DISCUSSION

The purpose of this study was to understand times associated with all of the steps in ED workup of a patient with mTBI, from the point of initial ED presentation to discharge. An understanding of each step in the workup and associated times is necessary to identify opportunities to shorten the total workup of these patients. We created a care map using input from eight healthcare professionals with expertise in emergency care. The care map developed comprised a total of 10 steps (Figure). The results from the

Table 1. Total estimated time associated with diagnosis of mild traumatic brain injury in United States emergency departments.

Step	Time
1. Initial check in	16 minutes
2. Triage	161 minutes
2a. RN triage assessment	6 minutes
2b. Provider triage assessment*	5 minutes
2c. Waiting room	150 minutes
3. Room placement, secondary nursing assessment, and initial physician assessment	48 minutes
4. Wait for CT	85 minutes
5. Transport to CT	8 minutes
6. CT scan	12 minutes
7. Transport from CT and radiologist CT review	13 minutes
8. Return to ED, CT review, and nursing reassessment	5 minutes
9. Physician reassessment	28 minutes
10. Discharge	25 minutes
Total	401 minutes (6.6 hours)

ED, emergency department; *CT*, computed tomography; *RN*, registered nurse.

Table 2. Length of stay comparison between the Rogg et al. study and the present study.

Length of stay (hours)	Rogg patients	Present study patients
Median	6.4	6.3
Quartile 1	4.6	3.8
Quartile 3	9	8.8

125 subjects, retrospective study LOS closely compare with the over 8,000-subject Rogg study[8] (6.3 hours, and 6.4 hours respectively).

Despite recent recommendations to the contrary,[11] CTs of the head continue to be frequently ordered as part of the workup of suspected mTBI. While CT imaging identifies problems that otherwise may be missed by physical examination (e.g., fractures, epidural and subdural bleeds, and subarachnoid hemorrhage), such scans are "positive" for only 6%-8% of patients with mTBI, and <1% of patients with mTBI are found to require neurologic intervention.[11,12] Inclusion of CT adds substantially to the total workup of mTBI. Moreover, CT is costly to the patient, does not establish or confirm diagnosis of concussion and increases – albeit nominally – exposure to radiation and subsequent potential risk of cancer. Furthermore, given its limitations a negative CT does not exclude significant TBI with associated symptoms. The American College of Emergency Physicians "Choosing Wisely" guidelines[10] for emergency medicine were designed to avoid unnecessary testing. The first recommendation (of 10) was to "Avoid computed tomography (CT) scans of the head in emergency department patients with minor head injury who are at low risk based on validated decision rules."[10] In addition to reducing patient exposure to radiation, results of our study suggest that avoiding unnecessary CTs could substantially reduce time spent to render care. Specifically, elimination of the head CT and all related steps (i.e., steps 4-9), would result in an estimated time savings of 151 minutes, as a substantial proportion of the time required to assess suspected mTBI was attributable to steps following the decision to order a CT. The removal of these steps may require additional physician time to discuss benefits of avoiding a CT. While this represents a "best-case" estimate in that it assumes that no patient would undergo a CT, it should be noted that a recent report found that 82% of ED patients with suspected TBI underwent CT, producing about 3.9 million head scans annually; 91% of these scans (3.5 million) were negative.[3] Moreover, <1% of patients with mTBI require neurological intervention.[10,11] There is a need for an alternative, objective triage tool or decision rule that could potentially aid in the safe reduction of the number of CTs ordered. Moreover, when working up a patient with mTBI a normal CT does not rule out the presence of a functional brain injury or concussion.

The U.S. government, and consequently hospitals, have become increasingly concerned about long wait times in the ED and patient satisfaction. Median time (in minutes) from ED arrival to departure is a quality-of-care metric developed by the U.S. Centers for Medicare and Medicaid Services used by the government to determine accreditation, external oversight, external and internal quality improvement, pay-for-reporting, and public reporting.[12] Reducing the time from presentation to diagnosis by limiting CT or other recognized inefficiencies from the care map could contribute to increased levels of patient satisfaction.

LIMITATIONS

The present study has some limitations. First, the care map was not based on time-and-motion studies of actual EDs, but rather on the input of a panel of experienced emergency medicine providers. Second, while assumptions are required to develop care maps, the ones made herein were designed to describe the course of care for the typical patient who presents to the ED with suspected mTBI. Our care map estimated times associated with workup to the point of a decision for admission or discharge. We did not study the further times or steps that patients admitted following workup might experience. Accordingly, the degree to which findings from this study are generalizable to the entire relevant patient population is conjectural.

Third, we did not attempt to study the total charges associated with the workup of mTBI. Future work could examine the costs to insurers as well as patients associated with use of the ED, professional fees from emergency physicians as well as the professional and technical fees associated with a head CT. Finally, the potential impact of more selective utilization of head CT and subsequent quicker disposition of patients with mTBI on overall ED throughput was not studied. New point-of-care technologies, now available for diagnosing mTBI, might enhance practitioner confidence for more selective use of head CT as well.[9]

CONCLUSION

We found that approximately one-half of the time associated with the current typical ED evaluation work-up of suspected mTBI is the result of the decision to order and the time and resources necessary to complete and obtain an interpretation of a head CT. Given the large number of visits for suspected mTBI, any strategies that result in more selective utilization of head CTs may reduce the time and cost required to render care.

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Geospatial Clustering of Opioid-Related Emergency Medical Services Runs for Public Deployment of Naloxone

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Introduction: The epidemic of opioid use disorder and opioid overdose carries extensive morbidity and mortality and necessitates a multi-pronged, community-level response. Bystander administration of the opioid overdose antidote naloxone is effective, but it is not universally available and requires consistent effort on the part of citizens to proactively carry naloxone. An alternate approach would be to position naloxone kits where they are most needed in a community, in a manner analogous to automated external defibrillators. We hypothesized that opioid overdoses would show geospatial clustering within a community, leading to potential target sites for such publicly deployed naloxone (PDN).

Methods: We performed a retrospective chart review of 700 emergency medical service (EMS) runs that involved opioid overdose or naloxone administration in Cambridge, Massachusetts, between October 16, 2016 and May 10, 2017. We used geospatial analysis to examine for clustering in general, and to identify specific clusters amenable to PDN sites.

Results: Opioid-related emergency medical services (EMS) runs in Cambridge, Massachusetts (MA), exhibit significant geospatial clustering, and we identified three clusters of opioid-related EMS runs in Cambridge, MA, with distinct characteristics. Models of PDN sites at these clusters show that approximately 40% of all opioid-related EMS runs in Cambridge, MA, would be accessible within 200 meters of PDN sites placed at cluster centroids.

Conclusion: Identifying clusters of opioid-related EMS runs within a community may help to improve community coverage of naloxone, and strongly suggests that PDN could be a useful adjunct to bystander-administered naloxone in stemming the tide of opioid-related death. [West J Emerg Med. 2018;19(4)641–648.]

INTRODUCTION

Opioid-associated overdose and death continues at epidemic levels throughout the United States (U.S.) with mortality from opioid use the leading cause of accidental death in the U.S.[1, 2] In Massachusetts (MA) there were 1,990 confirmed opioid-related deaths in 2016, an all-time high and a 19% year-to-year increase over 2015.[3] Naloxone, a pure competitive antagonist at the opioid receptor, is capable of temporarily reversing the effects of an opioid overdose, and distribution of naloxone to people at risk of opioid overdose as well as their families and friends is a cornerstone of the response to the opioid epidemic.[4, 5] Bystander naloxone,

administered by the non-medically trained lay public, has been shown to reverse opioid overdoses and save lives; however, it requires an individual carrying naloxone at the same place and time as an overdose occurs.[2, 6] Efforts to improve community prevalence of naloxone have focused on increasing prescribing and improving availability in pharmacies, and naloxone is now available in many areas either as an over-the-counter substance or under a standing order.[7] However, barriers to obtaining and carrying bystander naloxone still exist, and bystander naloxone is not currently available everywhere it is needed.[8-10]

Unlike bystander-carried naloxone, the public deployment of automated external defibrillators (AEDs) in pre-determined, easy-to-access locations for use by bystanders in cases of witnessed arrest requires no single individual in particular to obtain or carry the life-saving device and shifts the burden of providing potentially life-saving equipment from individuals to the community.[11, 12] Traditionally deployed in settings of high traffic and mass gatherings such as airports, casinos, or sports stadiums, distribution of AEDs has recently been guided by geospatial analyses of cardiac arrest data and pedestrian traffic with encouraging results.[13, 14] Publicly deploying naloxone in AED-like kits may improve naloxone availability to overdose victims and overcome barriers associated with current bystander-carry methods. However, like AEDs and cardiac arrests, determining where to place potential PDN kits requires understanding where opioid overdoses occur. Recent work by our team and others has shown spatial clustering of opioid-related emergency department visits, opioid-related deaths, and self-reported bystander naloxone use, suggesting that opioid overdoses may also show spatial clustering amenable to PDN placement.[15-17]

We performed a geospatial analysis of emergency medical services (EMS) runs involving suspected or confirmed opioid overdose in the community of Cambridge, MA. We hypothesized that opioid overdoses do not occur randomly but instead show spatial clustering, and that identifying these clusters would both support the concept of publicly deployed naloxone and help identify locations where naloxone could be stationed for maximum potential effect.

Population Health Research Capsule

What do we already know about this issue?
Acute opioid overdose can be reversed by bystanders using naloxone, but only if they have access to it. Deploying naloxone kits in set locations might improve public access and facilitate overdose reversal.

What was the research question?
Do opioid overdose-related emergency medical services (EMS) runs in Cambridge, Massachusetts, show distinct geospatial clusters where naloxone might be deployed?

What was the major finding of the study?
Among 700 EMS runs, we found significant geospatial clustering with approximately 40% occurring within 200 meters of one of three distinct hot spots.

How does this improve population health?
Identifying clusters of opioid-related EMS runs within a community may help to improve community coverage of naloxone by suggesting specific locations for publicly deployed naloxone kits.

METHODS

Study Design and Selection of Participants

This was a retrospective analysis of EMS runs that occurred in Cambridge, MA, between October 16, 2016 and May 10, 2017. Cambridge, MA, is a community of approximately 110,000 citizens spread across approximately 17 Km^2; EMS calls in Cambridge, MA, are served by a public-private partnership using the public fire service and a single, private EMS company, ProEMS.[18, 19] As part of their standard operating procedures, EMS providers record pertinent information in an electronic medical record maintained by the EMS service. All runs for which overdose is part of the dispatch information or provider impression, or in which naloxone was administered by bystanders, first responders or EMS, are submitted to the Cambridge Department of Public Health. All cases, including the EMS patient care record and narrative were reviewed by an independent epidemiologist blinded to our study hypothesis. We included in this analysis any case for which the Cambridge Department of Public Health determined a suspected or probable opioid overdose. Data were manually reviewed for duplicate entries. We excluded any runs originating outside of Cambridge, MA. All data manipulation and statistical analysis was performed using the R programming language.[20] This study was approved by the institutional review board at Partners Healthcare Boston, MA.

Geocoding EMS Runs

Geocoding is the process of determining the exact spatial location of an address: During this process, a human-readable address such as 795 Massachusetts Ave, Cambridge, MA 02139 (Cambridge City Hall) is transformed to spatial coordinates (e.g., X: -71.106026, Y: 42.36681), which are amenable to mapping and statistical analysis. We performed first-pass geocoding of addresses of EMS runs using

the U.S. Census Geocoder and address-batch geography lookups matched to U.S. Census 2010 data vintage, which provided coordinates in the North American Datum 1983 (NAD83).[21] Addresses not successfully geocoded by the U.S. census were geocoded using Google Maps, which provided coordinates in the World Geodetic System (WGS84).[22] NAD83 and WGS84 systems are equivalent to within approximately two meters over the small areas involved in this study, so the two systems were treated interchangeably for all geospatial analyses reported here.[23-25] Cambridge, MA, city boundaries were defined by the Geographic Information System of the City of Cambridge, MA.[26] Projections between latitude/longitude (degrees) and Cartesian coordinates (meters [m]) were performed using "sp" package in R.[27] Maps of EMS runs in Cambridge, MA, were produced using either the "spatstat" package in R, or QGIS software with base maps provided by OpenStreetMaps.[28-30]

Geospatial Analysis

Analysis of global spatial clustering of EMS runs, asking the question – do EMS runs cluster at all in Cambridge, MA? – was examined through calculations of Ripley's K-function [K(r)]. We performed calculations of Ripley's K function, as well as Monte Carlo estimates (MCE) of expected envelopes of K(r), using the "spatstat" package in R with Ripley's isotropic corrections at window borders.[28] Briefly, K(r) tests for clustering in a pattern of spatial points by examining observed vs. expected distributions of points around an index point within circles of various areas; in the setting of complete spatial randomness, the density of points should be uniform, so the expected number of points scales with the area of the test circle and should produce an exponential plot of K(r) vs. the circle radius. Compared to the global analysis of clustering provided by the Ripley's K function, local analysis of clustering addressing the question of where exactly within Cambridge, MA, clusters might occur was performed using density-based clustering. We used an unsupervised, spatial density-based clustering algorithm – the density-based spatial clustering of applications with noise (DBSCAN) method via the "dbscan" package in R, after projecting coordinate data to the European Petroleum Survey Group (EPSG) Projection 26986.[31, 32] Epsilon neighborhood parameters for the DBSCAN algorithm (EPS) was estimated at 200 using visual inspection of k-nearest-neighbor (KNN) plots (Supplemental Figure 1) with minimum KNN cluster sizes set to three members as described in the DBSCAN vignette.[31] To maximize the potential utility of identified clusters, we only considered clusters of opioid-related EMS runs with at least 69 runs (10% of the total number of successfully geocoded runs in Cambridge, MA). We calculated distributions of distances between cluster points and cluster centroids in the EPSG 26986 projection using the "raster" package in R.[33]

RESULTS

Characteristics of EMS Runs

Between October 16, 2016, and May 10, 2017, we identified 700 opioid-related EMS runs in the ProEMS database, spread among 359 unique addresses in Cambridge, MA. Of these addresses, 353 (98.3%) were successfully geocoded to 349 unique physical locations; the majority (327, 92.6%) were geocoded using the U.S. census, and an additional 26 addresses (7.4%) were geocoded using Google Maps. The discrepancy between address and physical locations reflects the fact that multiple distinct addresses can occur at the same coordinates, such as with a multi-unit apartment building. For the remainder of our analyses, we used a location-based, as opposed to an address-based, approach. Collectively, these 349 locations accounted for 693 (99.0%) of the initially identified 700 runs. Figure 1 shows a map of the locations of EMS runs in Cambridge, MA, during the study period. Of note during mapping, three locations (each with one run) were found to lie outside the official spatial boundary of Cambridge, MA, and were removed from further analyses, resulting in a final dataset of 690 geocoded runs. Of these 690 runs, we recorded information on patient gender for 683 runs (99.0%), and patient date of birth for 677 runs (98.1%); patients ranged from less than one year of age to 107 years old at the date of EMS service, with a median age of 36 years (interquartile range ([QR] 29-49 years), and the majority were male (422, 61.8%).

Geospatial Clustering

To test the hypothesis that opioid-related EMS runs in Cambridge, MA, show spatial clustering, we estimated Ripley's K-function for the set of 690 EMS runs that were geocoded within Cambridge, MA. Figure 2 shows an estimate of the K(r) function for the observed EMS runs, as well as a theoretically expected envelope generated by a MCE with 999 simulations of completely random spatial distributions of EMS runs within Cambridge, MA. As the observed estimate of K(r) deviates substantially from the MCE-generated expected envelope at multiple radii, there is statistically significant evidence of EMS runs clustering with an MCE approximate p-value of $p \sim 0.001$.

While computing K(r) shows evidence that opioid-related EMS runs do cluster in general across the study area, understanding where to optimally place PDN sites would require more granular knowledge on locations of individual clusters within the study area. To begin to look for these clusters, we first searched for evidence of clusters of opioid-related EMS runs occurring at an individual location. Of the 346 unique locations in Cambridge, MA, 242 locations (69.9%) had a single run each; 103 locations (29.8%) had between two and 16 runs each, collectively accounting for 372 runs (53.9%); finally, a single outlier

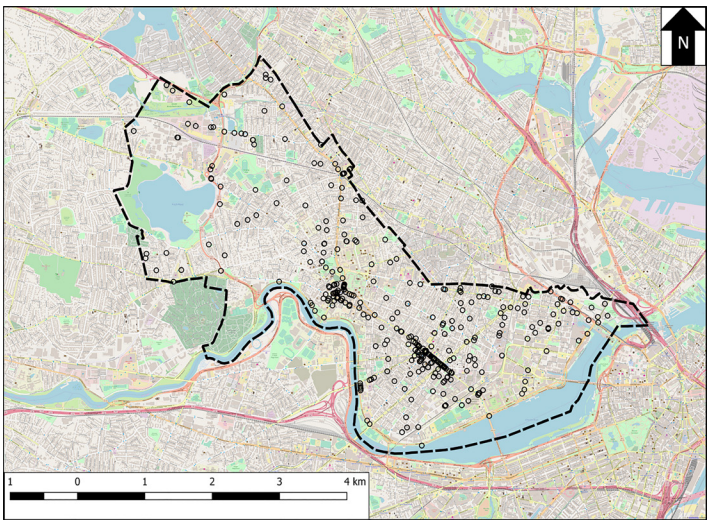

Figure 1. Map of locations of opioid-related emergency medical services (EMS) runs in Cambridge, Massachusetts (MA). Open circles represent locations at which at least one EMS run occurred during the study period. The dashed line shows the border of the city of Cambridge, MA. A scale bar is provided in the bottom left, and the arrow labeled "N" at the top right points due north. Background map data, obtained from OpenStreetMap contributors, is available at www.openstreetmap.org.

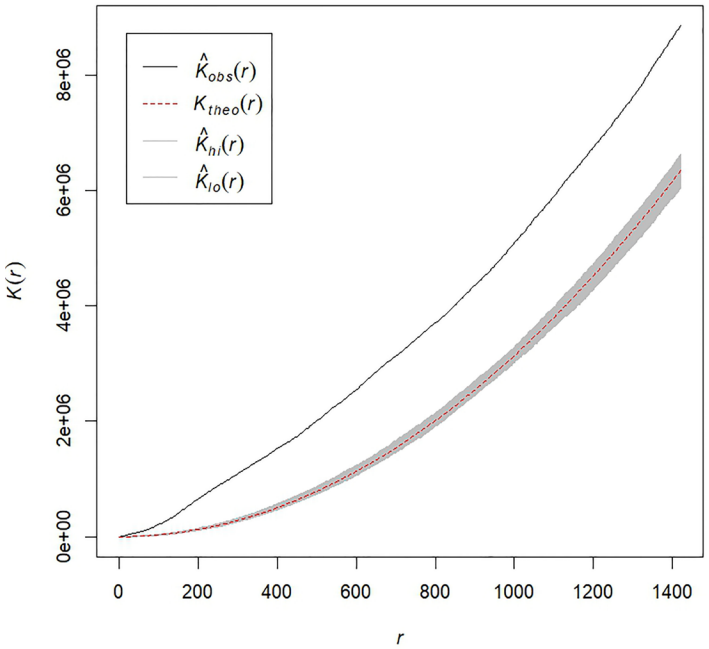

Figure 2. Estimates of Ripley's K-function (K) for opioid-related runs. Monte Carlo estimates (MCE) of observed vs. expected values of Ripley's K-function as a function of distance (r). The solid black line shows the estimated observed K(r), while the dashed red line shows the theoretical K(r) in the setting of complete spatial randomness for the same number of observations. The gray-shaded area shows estimates of potential variability in K(r) assuming complete spatial randomness, generated by MCE with n=999 simulations. *Obs*, observed; *Theo*, theoretical; *Hi*, Maximum MCE of theoretical distribution of K(r); *Lo*, minimum MCE of theoretical distribution of K(r).

location had 76 EMS runs, individually accounting for 11.0% of all runs during the study period. This outlier location is a community-based service organization that provides recovery services and emergency shelter to homeless individuals, including those struggling with drug and alcohol addiction.[34] Compared to runs originating at other addresses, EMS runs originating at this emergency shelter involved patients who were older, with a median age of 43 years (IQR 36.5-58.5 years) for patients coming from the emergency shelter compared to 35 years (IQR 28-48 years) for patients coming from elsewhere in Cambridge, MA. No significant differences were observed in patient gender between patients coming from the service organization or from elsewhere in Cambridge, MA.

After identifying this single-location cluster, we next considered clusters of EMS runs that spanned multiple, distinct locations, using an unsupervised, density-based clustering approach. Figure 3 shows the three distinct clusters of opioid-related EMS runs identified, named clusters "A," "B," and "C." Collectively, 362 EMS runs (52.5%) were located in one of the three clusters. Cluster A includes 86 EMS runs (12.5%) from 42 separate locations covering a roughly circular area of approximately 116,948m^2 (0.05miles^2) centered on the Harvard Square area, a busy, mixed commercial-residential area containing a public transportation hub and parts of Harvard University. Cluster B was the largest cluster, involving 191 EMS runs (27.7%) from 81 separate locations spread over a linear / ellipsoid area covering approximately 319,630m^2 (0.12miles^2) along Massachusetts Avenue at the Central Square area, another large, mixed commercial-residential area containing a public transport hub. Finally, Cluster C included 85 EMS runs (12.3%) from only eight separate locations, one of which is the single-location cluster previously identified, which accounted for 76 (89.4%) of the EMS runs in Cluster C. The table summarizes geospatial and run-related details about these three clusters.

Modeling PDN Sites

For clusters A and B, which involved EMS runs spread widely across multiple locations, we modeled the potential impact of sites located at cluster centroids. For the purposes of these models, we assumed the PDN sites to be accessible within 200 meters (m) in any direction of the cluster centroid. This number was chosen to match the epsilon neighborhood parameter of the density-based scan statistic, but is an assumption of the distance a bystander would be willing to travel to access a PDN site. Figure 4 shows maps

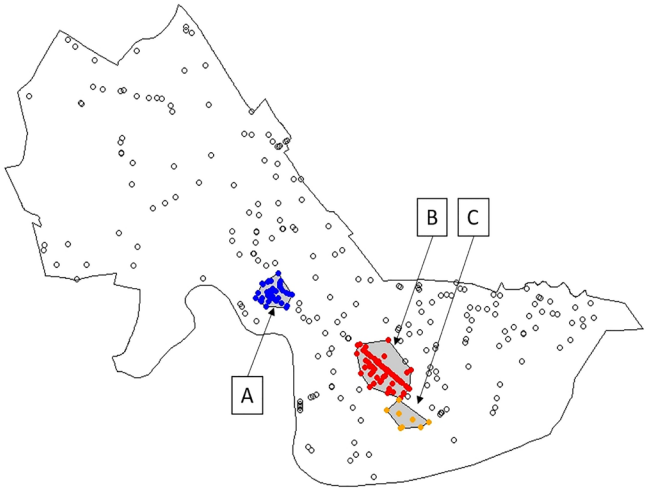

Figure 3. Density-based clustering of opioid-related emergency medical services (EMS) runs. Map of locations of opioid-related EMS runs with superimposed cluster analysis. Filled and unfilled circles both identify locations at which at least one EMS run occurred during the study period. Unfilled circles show locations not in clusters, while filled circles show locations in clusters and are colored by cluster membership. The areas encompassed by identified clusters are shaded in gray. The outer black line shows the boundary of Cambridge, Massachusetts, while the inner black lines surrounding clusters show the convex hull polygons enclosing each cluster. Labels "A," "B," and "C" identify and name the clusters.

of Clusters A and B with shaded circles representing the area within which the PDN was modeled to be accessible. For the purposes of visualization, a spatial jitter (random, small, spatial "nudge") was applied to EMS runs in these clusters to better show call volumes at different locations in each cluster by allowing runs occurring at the same location to be displayed simultaneously on the map. With these assumptions, PDN sites at cluster centroids could potentially have modified 75 EMS runs (87.2%) from Cluster A, and 116 EMS runs (60.7%) from Cluster B. Cluster C involves 85 runs, but 76 of these runs come from a single location – assuming a PDN site was placed inside the service organization at that single location, and that all 76 EMS runs from this individual site might be modifiable by a PDN site at that location, deploying PDN across all three clusters could potentially have modified 267 EMS runs, 38.7% of the total runs during the study period.

DISCUSSION

We found that EMS runs involving opioid overdose exhibit geospatial clustering in Cambridge, MA, and identified three distinct geospatial clusters as potential targets for publicly deploying naloxone. To our knowledge, this is the first work to examine spatial clustering of opioid overdoses at the level of spatial granularity required to pinpoint potential sites of naloxone deployment. Our findings show two distinct types of spatial clusters, which may require different methods of naloxone deployment: clusters "A" and "B" are both centered at highly trafficked public areas in Cambridge, MA, while cluster "C" represents a spike of opioid-overdoses occurring at a single location.

The optimum strategy for delivering naloxone to Cluster C would likely be locating naloxone kits at or inside the identified emergency shelter. By comparison, there might be multiple strategies for PDN sites within Clusters A and B, the simplest of which would be to position PDN sites at cluster centroids we modeled here. Positioning PDN sites at the cluster centroid is an inherently naïve solution that does not account for geographic realities such as vehicle and pedestrian access to various locations within a cluster, public visibility, and accessibility at off hours. Further work would be needed to understand how to optimize PDN placement within a cluster accounting for

Table. Characteristics of clusters of opioid-related emergency medical services runs.

Cluster	Runs	Locations	Area	M-Dist	N-200	P-200	M-Age	P-Female
A	86	42	116948.3	97.2	75	87.2	38	34.9
B	191	81	319630.7	171.7	116	60.7	37	31.4
C	85	8	94332.4	17.7	80	94.1	40	35.3

Runs: total number of emergency medical services (EMS) runs included in cluster.
Locations: unique spatial locations included in cluster.
Centroid: coordinates of cluster centroids, listed as Latitude / Longitude with WGS84 coordinate reference.
Area: physical size of cluster in square meters.
M-Dist: median distance in meters between all points in a cluster and the centroid of that cluster.
N-200 and P-200: number and percentage of EMS runs in a cluster falling within 200 meters of the cluster centroid.
M-Age: median age in years of patients receiving EMS care within a cluster.
P-Female: percent of patients receiving EMS care within a cluster that was identified as female.

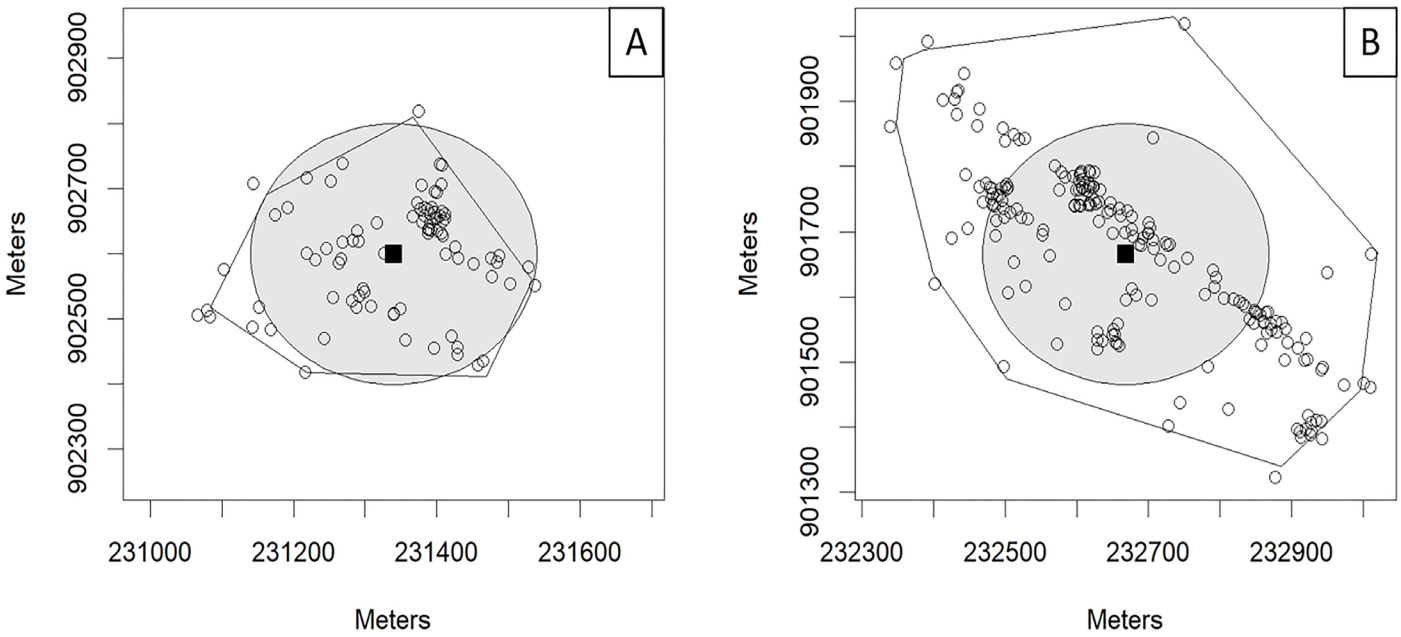

Figure 4. Publicly deployed naloxone coverage areas in opioid-related emergency medical services (EMS) run clusters. Sub-maps of locations of opioid-related EMS runs in Cambridge, Massachusetts, centered on Cluster A (left) or Cluster B (right). Open circles represent locations in each cluster where at least one EMS run occurred during the study period. (A random spatial jitter has been applied to reduce numbers of degenerate points and better show approximate numbers of EMS runs at each location.) Locations of EMS calls that were not part of the relevant cluster are not shown. Solid lines surrounding clusters show the convex hull polygons describing the boundary of each cluster; because of the random spatial jitter, run locations may artificially appear outside of these polygons. Solid squares show the location of the centroid of each cluster, and shaded gray circles show circles with radii of 200 meters centered on cluster centroids.

these geographic realities, and different clusters likely have different optimal solutions. Still, using the simple models of naloxone deployment at cluster centroids, our results show that approximately 40% of the opioid-overdoses in this dataset would have occurred within 200m of a potential PDN site, suggesting that deploying naloxone at these sites would have a large impact on improving the availability of naloxone where it is needed most.

Beyond simply providing targeting information for stationing naloxone kits, understanding local clustering patterns in opioid-related EMS runs could provide crucial information for a broader, multidisciplinary approach to a community's response to the opioid epidemic. Knowledge of cluster location and EMS transport patterns could be used to identify potential community partners, for example, large academic centers such as a large university located in cluster A, a second large university located close to Clusters B and C, coalitions of business owners such as those in Clusters A and B, or specific hospitals that handle large portions of EMS transport from particular clusters. Knowledge of cluster locations could also inform other efforts to respond to the opioid epidemic including potentially where to deploy ambulances or where to focus efforts on training first responders and the lay public on bystander naloxone delivery.

While these clusters represent effective potential PDN sites, future work combining these maps with spatial information about public naloxone use, deaths from opioids, or overdoses involving synthetic opioids such as fentanyl or car-fentanyl, could further optimize PDN placement within Cambridge, MA. Similarly, it might be useful to consider other sites of public access to emergency equipment that already exist and compare clusters of opioid-related EMS runs to the locations of AEDs already deployed in Cambridge, MA. Future work is also needed to consider the details of how PDN sites physically would be constructed, how the naloxone would be stored, and how they could be made most easily accessible to the public. In general, geospatial analysis of a particular subset of EMS runs, such as opioid-related runs, could be a useful tool for focusing community engagement, education, and intervention.

LIMITATIONS

This analysis of geospatial clustering of opioid-related EMS runs is limited to the underlying data captured by Cambridge's EMS services, and therefore might not include all opioid overdoses in Cambridge, MA. While the total number

of opioid overdoses occurring in Cambridge, MA, during the study period is therefore likely greater than the 700 EMS runs we consider here, it is not possible to determine where non-recorded overdoses occur geospatially. While inclusion of EMS runs into our data was determined by a trained epidemiologist independent to our study who examined all EMS data, we did not have access to outcome data including toxicological testing and hospital records. Thus, it was not possible to confirm overdose in each case with certainty. Additionally, the raw data for each run were not available so it was not possible to independently verify the epidemiologist's assessment. However, these cases do likely represent the patients who would receive naloxone in a PDN program. Collectively, these facts might introduce error into our clustering, which is inherently only as good as the data it is built on. A minor limitation is the inability to independently verify the age of the one patient transported by EMS with a reported age of 107; it is not possible from available data to determine if this patient actually was 107 years old or had a default date of birth of 01/01/1910 entered.

Within each cluster, the percentage of EMS runs that we label as "potentially modifiable" is dependent on our assumption of 200m as a travel distance to a PDN site. As discussed above, optimal placement of PDN sites requires further study, and bystanders might be willing to travel more or less than this distance depending on factors such as the built environment, weather, and time of day. Additionally, the analysis we performed here is limited to a single city served by a single EMS service, and more work would be needed to extend the modeling solution developed here to other cities including cities served by multiple EMS services each with partial data. Specifically, larger cities or cities with unique geographic features such as rivers or geographic boundaries that partition the city would require more robust spatial analysis. Each city considering implementation of PDN sites would need to analyze city-specific overdose data to optimize PDN positioning.

Finally, it is not yet known if placing PDN sites would improve outcomes for cases of opioid overdose or would actually offer a quicker delivery of naloxone over EMS administration when studied in real life, and significant future work would be needed to investigate if this is the case. We believe that this analysis offers the theoretical and geospatial grounding for performing an "*in vivo*" PDN study and determining its utility as a response to the opioid epidemic.

CONCLUSION

Opioid overdoses show spatial clustering in this geospatial analysis of EMS runs in Cambridge, MA, with three distinct clusters of opioid overdoses identified. In general, public deployment of naloxone in areas of high opioid overdose could be a useful and important adjunct to other methods of naloxone delivery including bystander naloxone and first-responder naloxone. Identifying clusters of opioid-related EMS runs within a community is a key first step.

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Systemwide Clinical Ultrasound Program Development: An Expert Consensus Model

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Clinical ultrasound (CUS) is integral to the practice of an increasing number of medical specialties. Guidelines are needed to ensure effective CUS utilization across health systems. Such guidelines should address all aspects of CUS within a hospital or health system. These include leadership, training, competency, credentialing, quality assurance and improvement, documentation, archiving, workflow, equipment, and infrastructure issues relating to communication and information technology. To meet this need, a group of CUS subject matter experts, who have been involved in institution- and/or systemwide clinical ultrasound (SWCUS) program development convened. The purpose of this paper was to create a model for SWCUS development and implementation.[West J Emerg Med. 2018;19(4)649–653].

INTRODUCTION

Clinical ultrasound (CUS) is integral to the practice of an increasing number of medical specialties. CUS significantly augments the accuracy and timeliness of many aspects of patient care, including diagnosis, monitoring, and procedural guidance.[1-19] Health systems have identified a need to establish a systemwide clinical ultrasound (SWCUS) program. As a result, many emergency physicians are being tasked with leading these programs and initiatives at their health systems.

Guidelines are needed to ensure effective CUS utilization across health systems and to support consistent and high-quality CUS utilization across the range of clinical settings in which it is used. Such guidelines should address all aspects of CUS within a hospital or health system. These include leadership, training, competency, credentialing, quality assurance and improvement, documentation, archiving, workflow, equipment, and infrastructure issues relating to communication and information technology. To our knowledge, no literature addresses this specific topic. The purpose of this paper was to create a model for SWCUS development and implementation.

METHODS

This paper is an expert consensus opinion and descriptive model. No research was performed. We queried Medline/PubMed using the keywords: System-Wide Clinical Ultrasound Director, System-Wide Clinical Ultrasound Initiative, Point-of-Care Ultrasound Director and Point-of-Care Ultrasound Initiative. No direct and relevant articles were found. Because of the lack of peer-reviewed data pertaining to this concept, we created a consensus writing group comprised of emergency medicine subject matter experts. All related references were vetted and reviewed by two authors (RS, JM). Disagreements were discussed. A group of SWCUS subject matter experts from the American College of Emergency Physicians Ultrasound Section (ACEP US), Society of Clinical Ultrasound Fellowships (SCUF) and Academy of Emergency Ultrasound (AEUS) of the Society for Academic Emergency Medicine, who have been directly involved in institution and/or SWCUS program development, was convened. We used in-person meetings, teleconferences, online sharing software, and email communications to create a model for a SWCUS program. Because this was not a research study, the initiative was exempt from the institutional review board.

Systemwide CUS Director and Committee

The mission of a SWCUS program is to collaborate with departments using CUS to improve patient care and standardize CUS across the health system. The organizational purview of a SWCUS program includes but is not limited to the following: initial training, continuing education, credentialing, documentation, archiving, reimbursement, workflow solutions, equipment purchasing, and quality assurance and improvement. Such responsibilities are likely to increase as CUS utilization spreads within specialty-practice domains and increases among individual providers. An effective SWCUS program requires a director, with experience in interdisciplinary and interdepartmental team building, leadership, and technical expertise in CUS. In most settings, it is anticipated that the director will be the head of a SWCUS committee. The SWCUS committee should include CUS leaders from all departments and divisions across the health system that either use CUS or are involved in any of the administrative aspects of the program. This may also include team members from information technology, information security systems, revenue capture, clinical engineering, and infection control. To be effective, support is also needed from the executive leaders within the health system, such as hospital chief executive, medical, and information officers, participating clinical and ancillary department chairs, as well as the executive medical staff board and system credentialing committee, or equivalent.

In most cases, the SWCUS director will be appointed by, and report to, the chief medical officer and the executive medical staff board. The ability to effectively discharge the responsibilities summarized in the Table requires at minimum 0.5 full-time equivalent. This varies based upon the health system size, CUS utilization,and other responsibilities. As it expands, a SWCUS program is likely to require other resources (apart from the capital and infrastructure costs of performing clinical ultrasonography) such as those for clerical and administrative staff, and office space.

Table. Responsibilities of the director of a systemwide clinical ultrasound CUS program.

Oversight of CUS committee, and execution and implementation of its actions.
Oversight of training, continuing education, and credentialing across disciplines
Quality review and improvement across CUS disciplines
Documentation, archiving, reimbursement, and workflow solutions
Equipment purchase and other capital and infrastructure expenditures

Competency and Training

CUS competency assessment is a necessity for all participating medical specialties [20-23] and is increasingly being introduced at the medical school level.[24-27] SWCUS leaders are able to coordinate knowledge and skills training for numerous departments, thereby reducing redundant efforts and overall teaching hours by any individual faculty or department.

As CUS is adopted by new medical specialties and its applications within medical specialties are extended, new

ultrasound educational programs will need development. This role will naturally fall to the SWCUS director and team. SWCUS leadership will be able to collaborate with departments and divisions newly adopting ultrasound practices to ensure that their standards and workflow reflect institutional guidelines. Institutionally-developed training resources such as curricula and lectures can be redeployed to minimize the workload of new educational initiatives. Other medical professionals including nurses, advanced practice providers, intravenous technicians, anesthesia personnel, and prehospital teams may also need CUS training. CUS leadership can help to coordinate such education synergistically with other programs.

Credentialing

Individual departments using CUS and the credentialing committees are typically responsible for ensuring compliance with national and local standards and with specialty-specific CUS training and credentialing policies. SWCUS leadership should be of assistance in coordinating credentialing policies that are consistent across the institution. Creation of an institutional credentialing policy can assist departments lacking formal, specialty-specific CUS guidelines and provide practice-based pathways for physicians seeking CUS but lacking previous training. All clinicians seeking credentialing in CUS should demonstrate at a minimum, the following knowledge:

- Basic ultrasound physics
- Operation of basic machine controls (e.g., depth, zoom, gain, focus, image capture)
- Image optimization
- Relevant normal and abnormal sonographic anatomy and physiology
- Biosafety
- Specialty-specific scope of CUS applications and limitations

The SWCUS director should be an active member of committees within the health system that oversee CUS credentialing to ensure a clinician applying for CUS privileging meets the institutional requirements for CUS.

Quality Assurance and Improvement

In accordance with existing specialty-specific guidelines, individual department CUS leadership should be responsible for timely, quality assurance review of CUS examinations and providing feedback to their clinicians.[2,29] SWCUS leadership should be responsible for ensuring that effective quality planning, quality assurance and continuous quality improvement processes are used across all departments. This includes regular review of department- and division-level training, credentialing, competency assessment, documentation, and oversight review of adverse outcomes potentially related to CUS. The SWCUS leadership should participate with the institutional oversight committee in any adverse outcome analysis or root cause analysis related to CUS.

Documentation, Archiving Workflow Solutions, and Reimbursement

SWCUS leadership should work with individual departments to ensure proper documentation and image archiving. Medical record documentation of CUS should comply with institutional, local, regional, and national standards.[4] SWCUS leadership should ensure that CUS images and interpretations performed as part of patient care are readily available to other clinicians, either through the health system's picture archiving and communications system (PACS) or a vendor neutral archive (VNA) consistent with other institutional practices and standards.

Extensive CUS reimbursement guidelines have been published.[2,30-34] The SWCUS director should ensure that CUS reimbursement practices are consistent throughout the institution and integrated with the reimbursement practices of traditional imaging specialists. SWCUS leaders will coordinate clinical departments, hospital information technology, and billing departments to implement CUS workflow solutions that promote efficiency and quality care, and meet standards of meaningful use. At the minimum, an integrated SWCUS workflow solution should include the following:

- Ability to generate a CUS report (either at the point of care or through accessing a server)
- Wireless (preferred) transfer of CUS images to a server or cloud for quality review and archival
- Wireless transfer of CUS images to a hospital PACS with image interpretation report in the electronic medical record
- Ability to de-identify images and videos that are used for teaching and education
- Capacity for storage of educational/practice ultrasound examinations in a location that is separate and different from the CUS evaluations that are part of medical decision-making
- Ability to flag CUS examinations for future query (e.g., teaching, research, follow-up)
- Ability to generate billing reports that can be accessed by billing departments, thus facilitating accurate and consistent billing of these examinations

Equipment Purchasing and Maintenance

CUS equipment needs vary among specialties and practice settings. In addition, there is continual technical and ergonomic improvement in ultrasound equipment. Purchasing decisions should be made by SWCUS leadership in collaboration with the clinicians using ultrasonography in their practice.

Important factors to consider include image quality, transducer options, advanced software packages, user interface, educational support, durability, warranty, expected costs, machine size, medical record and workflow

solution integration.[35-36] Individual departments may have unique equipment needs based on the type and volume of CUS examinations performed. It is ideal to have the SWCUS leadership coordinate real-time equipment demonstrations from key vendors. In addition, with the advent of pocket-size ultrasound machines on tablets or phone-size devices, it is incumbent on the health system to provide guidance for purchase, security, image transmission, and maintenance.

Standardization of equipment across a healthcare system has advantages and disadvantages. Advantages include clinician familiarity, simplified integration with the electronic medical record, uniform workflow solutions, and the possibility of bulk pricing for purchases, upgrades and repairs. Disadvantages include the significantly increased costs of replacing equipment on a system-wide basis if it becomes apparent that more competitive alternatives exist, and the lack of specialty-specific capabilities of some ultrasound equipment.

Several strategies exist to reduce equipment costs, while allowing application and specialty-specific needs within the system. As noted, "bulk" purchasing may afford significant cost savings because many manufacturers provide discounts based on number of systems purchased. SWCUS leadership might also facilitate purchasing by improving revenues for CUS services, by increasing the efficiency and decreasing the redundancy of CUS services throughout the institution, and by applying for non-departmental discretionary institutional funds. Leadership and knowledge of various hardware, software and ultrasound applications will be needed.

FUTURE DIRECTIONS AND BARRIERS

With the increasing use of CUS across many medical specialties, it is important for hospitals and hospital systems to ensure standardized, accurate, safe and responsible utilization of this important diagnostic and procedural modality. This expert, consensus-based document outlines the key components of a SWCUS program needed for a robust and successful program. The authors acknowledge the potential for changes in understanding as the field progresses. Barriers to establishing a SWCUS program include lack of executive leadership support, poor interdepartmental cooperation, inadequate time allocation and insufficient financial support. As SWCUS programs arise and evolve at many health systems, their impact will need to be measured. Future research should quantify the impact of a SWCUS program on health system quality of care, patient safety and cost savings. Downstream benefits of a SWCUS program such as improvements in clinical competency, workflow integration and interdepartmental team building should also be investigated.

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Paramedic Out-of-hospital Cardiac Arrest Case Volume Is a Predictor of Return of Spontaneous Circulation

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Introduction: Many factors contribute to the survival of out-of-hospital cardiac arrest (OHCA). One such factor is the quality of resuscitation efforts, which in turn may be a function of OHCA case volume. However, few studies have investigated the OHCA case volume-survival relationship. Consequently, we sought to develop a model describing the likelihood of return of spontaneous circulation (ROSC) as a function of paramedic cumulative OHCA experience.

Methods: We conducted a statewide retrospective study of cardiac arrest using the North Carolina Prehospital Care Reporting System. Adult patients suffering a witnessed, non-traumatic cardiac arrest between January 2012 and June 2014 were included. Using logistic regression, we calculated an adjusted odds ratio (OR) for the influence of the preceding five-year paramedic OHCA case volume on ROSC while controlling for the potentially confounding variables identified a priori as patient age, gender, and non-Caucasian race; shockable presenting rhythm; layperson/first responder cardiopulmonary resuscitation (CPR); and emergency medical services (EMS) response time.

Results: Of the 6,405 patients meeting inclusion criteria, 3,155 (49.3%) experienced ROSC. ROSC was more likely among patients treated by paramedics with ≥ 15 OHCA experiences during the preceding five years (OR [1.21], p<0.01). ROSC was also more likely among patients with shockable initial rhythms (OR [2.35], p<0.01) and who received layperson/first responder CPR (OR [1.77], p<0.01). Increasing patient age (OR [0.996], p=0.02), male gender (OR [0.742], p<0.01), and increasing EMS response time (OR [0.954], p<0.01) were associated with a decreased likelihood of ROSC. Non-Caucasian race was not an independent predictor of ROSC.

Conclusion: We found that a paramedic five-year OHCA case volume of ≥ 15 is significantly associated with ROSC. Further study is needed to determine the specific actions of these more experienced paramedics who are responsible for the increased likelihood of ROSC, as well as the influence of case volume on the longer-term outcome measures of hospital discharge and neurological function. [West J Emerg Med. 2018;19(4)654-659.]

INTRODUCTION

Sudden cardiac death accounts for more than half of all coronary heart disease deaths in the United States (U.S.), with approximately 326,200 cases of out-of-hospital cardiac arrest (OHCA) patients assessed by emergency medical services (EMS) each year.[1] The importance of bystander cardiopulmonary resuscitation (CPR), early defibrillation, and quality resuscitation and post-resuscitation care on favorable outcomes are well documented. However, other factors such as the quality and timing of paramedic interventions may also influence outcomes. Unfortunately, resuscitation skills are known to decline over time,[2] which may lower survival

rates. Such skill decay may be the result of limited exposure to OHCA case volume, which has been observed to average less than two cases per year per paramedic in some areas.[3] Only one study has previously quantified the OHCA case volume-survival relationship among paramedics;[4] however, it is unclear if the findings of this international study can be extrapolated to EMS systems in the U.S.

Due to the lack of previous investigations among U.S. EMS systems, the influence of OHCA case volume on patient outcomes remains poorly quantified. Therefore, using a statewide dataset we sought to develop a model describing the likelihood of return of spontaneous circulation (ROSC) as a function of OHCA case volume. We hypothesized that the likelihood of ROSC increased with increasing paramedic OHCA case volume.

Population Health Research Capsule

What do we already know about this issue?
Many factors contribute to the survival of out-of-hospital cardiac arrest (OHCA). One such factor is the quality of resuscitation efforts, which in turn may be a function of OHCA case volume.

What was the research question?
To quantify the OHCA case volume-survival relationship.

What was the major finding of the study?
Paramedic five-year OHCA case volume of ≥ 15 is significantly associated with return of spontaneous circulation.

How does this improve population health?
Strategies to increase paramedic cardiac arrest case volume or exposure to high fidelity simulation have the potential to prevent resuscitation skill decay and improve OHCA survival.

METHODS

Data Sources

With institutional review board approval from Western Carolina University, we conducted a retrospective observational study of the influence of cardiac-arrest case volume on ROSC using the North Carolina Prehospital Care Reporting System (PreMIS) database. PreMIS is the data collection and management system that collects statewide data from over 400 North Carolina EMS agencies. Data are submitted to PreMIS for all EMS responses in North Carolina, and the data points for collection are a subset of the National Emergency Medical Services Information System (NEMSIS) dataset.[5]

Outcome Measures

The primary outcome measure was prehospital ROSC. We did not make any distinction between transient or persistent ROSC.

Study Setting

North Carolina is the nation's ninth most populous state with approximately 10 million people dispersed across a land mass of 48,617 square miles.[6] Demographically, the state is comprised of urban, suburban, and rural populations, with 33.9% of the population living in rural areas.[7] Cardiovascular disease is the second leading cause of death in the state, resulting in 18,467 deaths in 2015.[8]

Sample

We queried the PreMIS database to identify individuals who suffered a cardiac arrest in North Carolina between January 1, 2012, and June 30, 2014. These records were then filtered to meet our inclusion and exclusion criteria. Inclusion criteria consisted of all adult patients (≥18 years) suffering a bystander- or EMS-witnessed, non-traumatic cardiac arrest. The PreMIS database was then queried by the primary paramedic attending to each patient in the sample to determine his/her number of cardiac arrest cases treated in the previous five years. In determining the historical OHCA case volume, no distinction was made as to whether the paramedic was the primary attending paramedic, or "code leader," or assumed a secondary ("skills") role on the resuscitation team. We believed that any experience in OHCA resuscitation, whether in a primary or secondary role, would contribute positively to the cumulative resuscitation experience.

Statistical Analysis

We analyzed abstracted data using IBM SPSS Statistics version 24 (IBM Corporation, Somers, NY) with $p \leq 0.05$ indicating statistical significance. Continuous variables and time intervals are presented as means (standard deviation), and categorical variables are presented using frequency distributions and percentages. We compared continuous variables using Student's t-test or the Mann-Whitney test. Categorical data were analyzed using the chi square test, continuity correction, or Fisher's exact test as appropriate. We calculated an adjusted odds ratio (OR) for the influence of OHCA case volume using logistic regression to control for potentially confounding variables identified a priori as patient age, gender, and non-Caucasian race; shockable presenting rhythm; layperson/first responder CPR; and EMS response time.

Table 1. Demographics of patients enrolled in a study of the effect of paramedic out-of-hospital cardiac arrest (OHCA) case volume on return of spontaneous circulation (ROSC).

Characteristic	Result
Paramedic OHCA experience over previous 5 years (mean, SD)	23.6 (±20.3)
Male (%)	61.7
Non-Caucasian (%)	30.8
Age (mean, SD)	66.5 (±15.2)
Shockable rhythm (%)	30.0
Layperson/first responder CPR (%)	44.0
EMS response time in minutes (mean, SD)	8.3 (±4.8)
ROSC (%)	49.3

SD, standard deviation; *CPR,* cardiopulmonary resuscitation; *EMS*, emergency medical services.

Table 2. Univariate comparison of patients enrolled in a study to determine the effect of paramedic OHCA case volume on ROSC comparing patients with and without ROSC.

Variable	ROSC	No ROSC	P value
Paramedics with prior OHCA case volume ≥ 15 (%)	24.5	22.7	<0.01
Male gender (%)	60.1	63.2	0.01
Non-Caucasian (%)	31.7	29.8	0.09
Age in years (mean, ± SD)	65.7	67.4	<0.01
Shockable rhythm (%)	38.9	21.2	<0.01
Layperson/first responder CPR (%)	51.8	36.3	<0.01
EMS response time in minutes (mean, ± SD)	7.7	8.9	<0.01

OHCA, out-of-hospital cardiac arrest; *ROSC*, return of spontaneous circulation; *SD*, standard deviation; *CPR*, cardiopulmonary resuscitation; *EMS*, emergency medical services.

RESULTS

During the study period, 8,790 patients met inclusionary criteria. Of these, 2,385 were excluded due to incomplete data elements. Of the 6,405 patients included in the analysis, the mean age was 66.5 (±15.2) years and males accounted for 61.7% of the sample. A shockable rhythm was the first presenting rhythm upon EMS arrival in 30.0% of cases. The mean EMS response time, measured as call receipt to scene arrival, was 8.3 (±4.8) minutes, and layperson/first responder CPR was performed prior to EMS arrival in 44.0% of cases. In total, 3,155 patients (49.3%) experienced ROSC. The lead paramedics attending the patients in the database had participated in an average of 23.6 (±20.3) OHCA cases in the previous five years, either as the "code leader" or in a secondary role. Additional details of the sample are provided in Table 1.

The results of the univariate analysis of ROSC are presented in Table 2. Notably, compared to patients without ROSC, a greater proportion of patients with ROSC received layperson/first responder CPR (60.0% vs. 51.4%, $p = 0.03$) and presented with a shockable rhythm (38.9 vs. 21.2%, $p < 0.01$), but were less likely to be male (60.1% vs. 63.2%, $p < 0.01$). Patients with ROSC also had shorter EMS response times (7.7 vs. 8.9 minutes, $p < 0.01$) and were treated by paramedics with greater five-year cumulative OHCA experience (24.5 vs. 22.7, $p<0.01$).

We used logistic regression to control for potentially confounding variables. Based on clinical reasoning, the following variables were entered into the model: paramedic OHCA experience ≥15 in the previous five years; patient age, gender, and non-Caucasian race; shockable presenting rhythm; layperson/first responder CPR; and EMS response time. OHCA case volume was defined as a binary variable of participation in ≥ 15 previous resuscitation attempts. This level of case volume was selected because the probability of ROSC by OHCA case volume appeared to plateau around 15 previous arrests (Figure).

ROSC was more likely when the patient was treated by a lead paramedic who had attended 15 or more cardiac arrests in the previous year (OR [1.21], $p<0.01$), and less likely with increasing age (OR [0.99], $p <0.02$) and EMS response time (OR [0.95], $p<0.01$). Compared to patients with non-shockable rhythms, patients with shockable rhythms were more likely to achieve ROSC (OR [2.35], $p<0.01$). ROSC was more likely among patients receiving layperson/first responder CPR (OR [1.77], $p<0.01$) and less likely among males (OR [0.74], $p<0.01$). Non-Caucasian race was not an independent predictor of ROSC. Details on the logistic regression results for ROSC are provided in Table 3.

With the exception of scene arrival to administration of the first vasopressor time interval, there were no differences in the time required to perform on-scene skills between paramedics with and without 15 or more cumulative OHCA experiences (Table 4).

DISCUSSION

This study is the first to examine the relationship between paramedic OHCA case volume and ROSC in a U.S. EMS system. We found that patients treated by paramedics with 15 or more OHCA exposures in the previous five years were 21% more likely to attain ROSC. Few previous studies have investigated this relationship among paramedics, and none have done so in a U.S. EMS system.

Dyson et al. measured the association between paramedic OHCA exposure and patient survival in Victoria, Australia.[4] In their study they found that OHCA exposure during the preceding three years had a positive impact on patient survival. The odds of survival increased for every additional increase in

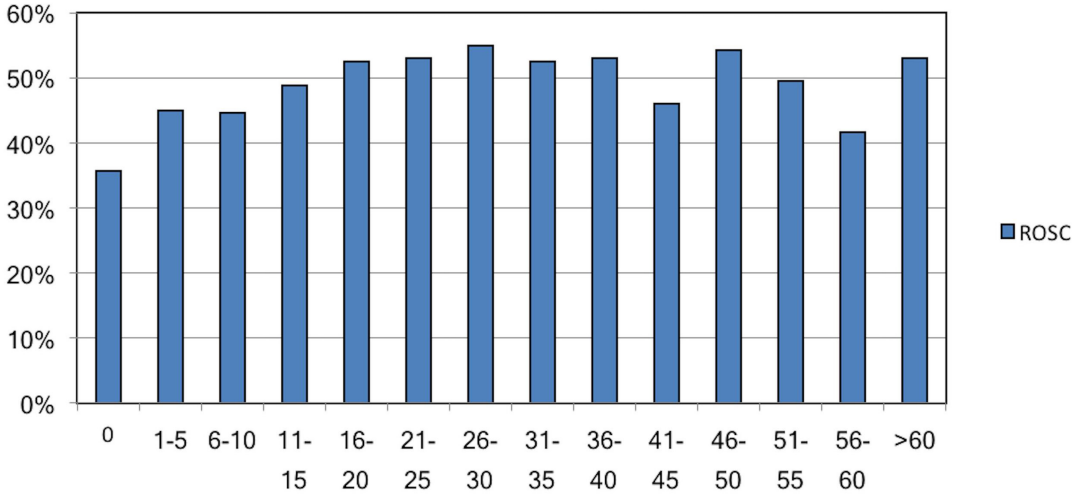

Figure. Percentage return of spontaneous circulation (ROSC) by paramedic cumulative out-of-hospital cardiac arrest (OHCA) cumulative case volume. Proportion of patients attaining ROSC by paramedic five-year OHCA case volume.

the median OCHA exposure. Compared with patients treated by paramedics with a median of ≤ 6 arrests during the preceding three years, the odds of survival were higher for patients treated by paramedics with 7-11 (OR [1.26]), 12-17 (OR [1.29]), and >17 (OR [1.50]) OHCA exposures. Interestingly, they did not find any relationship between paramedic career experience and survival, suggesting that career longevity alone does not convey any benefit in terms of patient outcomes following OHCA.

Another salient finding by Dyson et al. was that patient survival decreased when six months or more had lapsed since the previous OHCA exposure.[4] They noted that this time frame is similar to the post-training decay rate of advanced life support skills after training, reported by Yang et al.[2,4]

The only previous investigation involving a U.S. EMS system was conducted in King County, Washington, by Gold and Eisenberg.[9] Although they did not specifically evaluate the impact of OHCA exposures on survival, they did examine the influence of the number of years of paramedic career experience of the primary (code leader) and secondary (skills) paramedic on patient survival.[9] They found no association between years of paramedic experience and survival for the primary paramedic (OR [1.01], 95% confidence interval [CI] [0.99-1.03]), but they did find a positive relationship between experience and survival for the secondary paramedic (OR [1.02], 95% CI [1.00-1.04]). They speculated that treatment of cardiac arrests tends to be protocol-driven events and on-scene decision-making, and ultimately survival, is not sensitive to paramedic career experience. In contrast, they surmised that the "skills paramedic" did become more proficient at rendering treatments as career experience increased and this resulted in improved outcomes. However, they did not report skills success rates or time to treatments, so it is unclear if these measures were actually influenced by career experience. In our dataset, we did not find any improvement in on-scene performance between lead paramedics with and without 15 or more OHCA experiences other than a shorter time to administer the first dose of vasopressors for the more experienced paramedics (Table 4). Unfortunately, we did not have data to compare on-scene performance of the secondary (skills) paramedics with respect to cumulative OHCA experience.

Suspecting a link between endotracheal intubation (ETI) experience and OHCA survival, Wang et al. compared outcomes among paramedics with low (1-10 tracheal intubations in the preceding six years), medium (11-25 tracheal intubations), high (26-50 tracheal intubations), and very high (greater than 50 tracheal intubations).[10] After adjusting for factors known to influence patient outcome and using low cumulative experience as the reference category, they found a significant survival benefit among paramedics with very high ETI exposure (OR [1.48], 95% CI [1.15-1.89]).[10] This finding lends credence to the hypothesis of Gold and Eisenberg that OHCA survival is influenced by increased levels of proficiency of the "skills paramedic" rather than the team leader whose decision-making role is somewhat dictated by protocol.[9] In our study we focused only on OHCA exposure and did not evaluate cumulative skills experience.

If our findings and those of Dyson et al. are accurate, then a case volume-survival relationship exists between paramedics' OHCA experience and patient survival.[4] In general terms, this relationship is not unique to EMS and OHCA as clinical case volume has been linked to patient outcomes in other settings and patient conditions.[11-13] The greater issue, then, is devising strategies to ensure that paramedics have adequate case volumes to obtain and maintain proficiency in OHCA management. In the study by Dyson et al. on average, paramedics were exposed to two OHCA per year and 10% of their workforce had no OHCA

Table 3. Adjusted odds ratios for selected predictors of return of spontaneous circulation (ROSC) among patients enrolled in a study of the effect paramedic out-of-hospital cardiac arrest (OHCA) case volume on return of spontaneous circulation.

	ROSC		
Variable	Adjusted odds ratio	P value	95% CI
Prior OHCA case volume ≥ 15	1.217	<0.01	1.109-1.355
Male gender	0.742	<0.01	0.667-0.827
Non-Caucasian	1.073	0.22	0.959-1.201
Age	0.996	0.02	0.993-0.999
Shockable rhythm	2.354	<0.01	2.096-2.644
Layperson/first responder CPR	1.773	<0.01	1.597-1.969
EMS response time in minutes	0.954	<0.01	0.943-0.964

CPR, cardiopulmonary resuscitation; *EMS*, emergency medical services.

Table 4. Comparison of scene events by paramedic 5-year out-of-hospital cardiac arrest (OHCA) case volume experience.

Scene events	<15 Cumulative OHCA resuscitations	≥15 Cumulative OHCA resuscitations	P value
Scene arrival to first defibrillation (minutes)[1]	7.25	6.80	0.36
Scene arrival to first advanced airway (minutes)	10.05	10.21	0.51
Scene arrival to first vasopressor administration (minutes)	10.04	9.33	<0.01
Scene arrival to first ROSC (minutes)	22.26	21.35	0.16

[1]For patients presenting with a shockable rhythm upon EMS arrival.
ROSC, return of spontaneous circulation.

exposure during their seven-year study.[4] In our study, patients were treated by paramedics who averaged 24 OHCA during the preceding five years, yet 41% of the patients were treated by paramedics who had fewer than the 15-case threshold that was associated with increased odds of ROSC. Combined, these studies suggest that other forms of skills maintenance are needed.

To address the problem of infrequent exposure to specific patient populations and skills opportunities, some EMS systems have instituted strategies whereby paramedics specialize in certain patients or procedures, such as cardiac arrest.[14] These paramedics are then dispatched to all relevant calls in an effort to coalesce experience among a smaller group of clinicians. Such strategies mimic the rapid response team approach used in hospitals, which has been demonstrated to reduce mortality.[15-17] The disadvantage to this strategy is that turnover may eventually exhaust this cadre of highly experienced clinicians that must then be replaced with clinicians who have had relatively few cumulative exposures. Thus, this may only be a short-term strategy that ultimately results in minimal experience among the bulk of clinicians. Moreover, we were unable to identify any published reports on the effectiveness of this strategy.

Another approach to maintaining skills proficiency is through high-fidelity simulation. This strategy has been used successfully to increase survival rates in the hospital setting.[18,19] However, its use in EMS training programs varies,[20] and there are no published reports correlating simulation training among paramedics with improved OHCA outcomes. Nonetheless, in low call-volume settings this may be the best option to maintain resuscitation skills.

LIMITATIONS

Our study is subject to the usual limitations of a retrospective design, including the accuracy of data collection and the potential for measured and unmeasured confounders that may account for the observed outcomes. In addition, our study focused exclusively on the influence of the "code leader." Consequently, we did not evaluate the influence of the "skills paramedic" on skills success rates or ROSC. Although we found a relationship between OHCA case volume and ROSC, we do not know the reason for these differences. Additional study is needed to investigate the specific resuscitation traits of the more experienced paramedics that might explain their increased likelihood of attaining ROSC. Moreover, additional studies are needed to correlate these findings with longer-term outcomes such as hospital discharge and neurological function.

CONCLUSION

Within the limits of our study design, we found that a paramedic five-year OHCA case volume of ≥ 15 is significantly associated with ROSC. Further study is needed to determine the specific actions of the more experienced paramedics that are responsible for the increased likelihood of ROSC, as well as the influence of case volume on the longer-term outcome measures of hospital discharge and neurological function.

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A Randomized Comparison of In-hospital Rescuer Positions for Endotracheal Intubation in a Difficult Airway

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Introduction: Emergency endotracheal intubation (ETI) is a common and critical procedure performed in both prehospital and in-hospital settings. Studies of prehospital providers have demonstrated that rescuer position influences ETI outcomes. However, studies of in-hospital rescuer position for ETI are limited. While we adhere to strict standards for the administration of ETI, we posited that perhaps requiring in-hospital rescuers to stand for ETI is an obstacle to effectiveness. Our objective was to compare in-hospital emergency medicine (EM) trainees' performance on ETI delivered from both the seated and standing positions.

Methods: EM residents performed ETI on a difficult airway mannequin from both a seated and standing position. They were randomized to the position from which they performed ETI first. All ETIs were recorded and then scored using a modified version of the Airway Management Proficiency Checklist. Residents also rated the laryngeal view and the difficulty of the procedure. We analyzed comparisons between ETI positions with paired t-tests.

Results: Forty-two of our 49 residents (85.7%) participated. Fifteen (35.7%) were female, and all three levels of training were represented. The average number of prior ETI experiences among our subjects was 44 (standard deviation=34). All scores related to ETI performance were statistically equivalent across the two positions (performance score, number of attempts, time to intubation success, and ratings of difficulty and laryngeal view). We also observed no differences across levels of training.

Conclusion: The position of the in-hospital provider, whether seated or standing, had no effect on the provider's ETI performance. Since environmental circumstances sometimes necessitate alternative positioning for effective ETI administration, our findings suggest that there may be value in training residents to perform ETI from both positions. [West J Emerg Med. 2018;19(4)660-667.]

INTRODUCTION

Airway management in general, and endotracheal intubation (ETI) more specifically, is an essential skill for both prehospital and in-hospital providers. The procedure is performed an estimated 265,000 times annually in United States (U.S.) emergency departments (ED).[1] Accordingly, ETI is a core competency that Accreditation Council of Graduate Medical Education-accredited emergency

medicine (EM) training programs are required to teach and assess.[2] Currently, EM residency programs throughout the nation train their residents to perform ETI from a standing position. However, in the setting of the ED an emergency physician (EP) may be compelled to intubate at low bed heights to accommodate the simultaneous performance of high-quality chest compressions on a cardiac arrest patient.[3] Furthermore, in the realm of emergency care, difficult environmental circumstances (such as mass casualty or disaster events) or difficult patient conditions may require rescuers to adapt their position for ETI.[4] While conditions may dictate alternatives to standing for ETI, we have little evidence that EM residents can easily adapt from the standing position in which they are trained.

Studies of out-of-hospital providers (paramedics) have demonstrated that rescuer positions do not influence airway management results in the prehospital setting, especially those involving patients lying on the ground.[5-7] One such study found no clinically relevant differences between paramedic positions for delivering ETI from the ground, which included prone, sitting, kneeling, and straddling-the-patient positions.[5] The other study demonstrated that paramedics required fewer attempts when performing ETI from a left lateral decubitus position (relative to a patient lying supine on the ground), when compared to performing ETI from the kneeling position.[6]

In-hospital providers such as EPs are traditionally trained to perform ETI from the standing position. Since little is known about the topic of positioning for ETI involving in-hospital providers, we sought to determine whether performing ETI from the seated position might contribute to improved ETI performance. This question became more compelling when we considered that the performance of ETI from a seated position has the potential for easy implementation in the ED setting. Thus, the purpose of this study was to compare the ETI performance of EM trainees from both seated and standing positions. More specifically, we sought to determine how the traditional standing position with stretcher at mid-chest compared to the seated position with regard to ETI difficulty and laryngeal-inlet visualization. A finding of favorable or comparable performance metrics from the seated position would have important implications for training, particularly in situations where ETI is challenging.

Population Health Research Capsule

What do we already know about this issue?
In-hospital providers typically stand at the head of the stretcher with the patient's head at mid-chest level when performing endotracheal intubation (ETI).

What was the research question?
Does performing ETI from a seated position compare favorably to performing ETI from the traditional standing position?

What was the major finding of the study?
EM residents performed equally well in both positions. Furthermore, there were no differences in time, view, or difficulty.

How does this improve population health?
When challenges to effective ETI involve environmental circumstances, assuming a seated position may prove to be an effective alternative.

METHODS

Population

This was a prospective, randomized, experimental cross-over design. The target population was EM residents from one EM residency program in the Midwestern U.S. Residents were approached during conference and asked to volunteer to participate in this study. We used stratified random sampling to assign resident volunteers to one of two groups. Stratification ensured that both groups had equal numbers of residents from each program year of training: first (postgraduate year [PGY]-1); second (PGY-2); and third (PGY-3). This study was reviewed and approved by our institutional review board.

Materials

The experimental setup was comprised of two parts: a difficult airway model and an audiovisual recording system. The difficult airway model was designed and used for another study, but is briefly described here.[8] The model was composed of a simulation mannequin (the Deluxe Difficult Airway Trainer, Laerdal Medical Corporation, Wappingers Falls, NY) strapped to a rigid backboard and placed on a stretcher. The difficulty of this simulator was enhanced with two additional features: 1) a rigid cervical collar (Laerdal Stifneck) to limit neck flexion and jaw movement; and 2) the inflation of the tongue to 60 mm Hg static pressure.[8] The mannequin was modified to include a pressure gauge allowing for the accurate measurement of tongue inflation pressure throughout the performance assessment. Supplies required for intubation of the mannequin were provided, including a laryngoscope, an endotracheal tube (ETT), a stylet, and a bag-valve mask.

The audiovisual recording system was comprised of two moveable, bullet type-recording cameras and one additional view

from a video laryngoscope. The three camera views increased the likelihood that essential video images of the resident's ETI performance were captured in a systematic fashion. The two bullet cameras were mounted perpendicular to, but above, the mannequin to allow for visualization of the resident and the mannequin in both a horizontal and vertical plane. The horizontal-view camera captured the resident's body position and the force applied to the mannequin during intubation. The vertical-view camera monitored the resident's hand positioning during procedures such as ventilation and lateral movement during intubation. The third camera view was from C-MAC direct laryngoscope device (video laryngoscope), which captured the view of the resident's manipulation of the ETT. While the C-MAC can be used to help the provider visualize the path of the ETT, we did not allow residents to use the visualization screen during these exercises. Sound was captured by a separate microphone placed in the simulation environment. All three video feeds and the audio feed were processed through a digital video recorder that produced a synchronized recording of all three views on one screen in real time.

Measurement Instrument

The Airway Management Proficiency Checklist (AMPC) is a 40-item instrument designed for measuring comprehensive airway management performance in prehospital providers (paramedics).[9] The instrument is comprised of three subscales including intubation, ventilation, and back-up airway. We adapted the instrument for assessing in-hospital providers in the ED setting by using only items from the intubation subscale and then selecting from those only the items relevant to in-hospital providers. This reduced the AMPC to 12 items, which represented the most important tasks required by in-hospital providers for successful intubation.

Performance Assessment

One group was assigned to perform an ETI on the difficult airway mannequin from the seated position first. For this encounter, the height of the stretcher was set at 61 cm (two feet) from the ground, which appeared comfortable for a typical provider. The second group was assigned to perform an ETI on the difficult airway mannequin from the traditional standing position first. For the standing encounter, the stretcher was set at mid-chest height of the provider. After completion of the first encounter, residents switched to the alternative encounter so that each resident performed an ETI from both the seated and standing position.

Following informed consent, the EM residents entered an in situ simulation environment resembling an ED treatment bay. They were provided with a brief but detailed patient scenario and were then asked to perform an ETI on the difficult airway mannequin, in either the seated or standing situation. All ETI encounters were recorded and stored for future evaluation by two EM faculty who have had significant airway- management expertise. After each encounter, residents were asked to rate the difficulty of the ETI encounter using a 10-point visual analogue scale (VAS) in which "0" was considered extremely easy, and "10" was considered extremely difficult.[10] Additionally, residents were asked to rate their view of the glottis using the Cormack-Lehane classification system.[11]

Scoring

Evaluators used the modified AMPC to assess the recorded performances of resident ETIs. To check inter-rater reliability, 22 of the 42 subjects (52%) were assessed by both evaluators. Evaluators scored each performance task using a dichotomous scale in which a "0" indicated that the task was either not correctly performed or not performed at all; or a "1" indicated that the task was correctly performed. Summary scores were generated for each performance assessment, seated and standing, by summing the number of "1s" and converting the sum to a percentage out of 12 (total number of items). For the 22 subjects assessed by both evaluators, we used an average of the two evaluators' summary scores. When a resident required more than one ETI attempt, the evaluators were instructed to score only the successful attempt. The amount of time to successful ETI, defined as the time it took (in seconds) for the resident to place the ETT in the mouth and successfully pass the ETT through the vocal cords, was obtained from the digital recordings. For residents with multiple attempts, time was calculated cumulatively by summing their time across attempts.

Data Analysis

We used paired (or dependent) t-tests to compare the seated and standing conditions for each of the following variables: the performance scores of residents; time to successfully passing the tube; resident ratings of difficulty; and the Cormack-Lehane classification of the view of the glottis. We used a Bonferroni adjustment for multiple comparisons, setting the critical value for alpha to .05/5=.01.[12] We also used box and whisker plots to compare the residents by level of training on their ETI performance and their time to success in both the standing and seated positions. We assessed inter-rater reliability between the two evaluators on each of the performance items using percentage of agreement and Krippendorff's alpha.[13]

RESULTS

Forty-two of 49 EM residents (85.7%) from our program volunteered to participate in the study. Of the 42 participants, 15 (36%) were women. Slightly more PGY-1s (18 of 42, or 43%) participated than PGY-2s (11 of 42, or 26%) or PGY-3s (13 of 42, or 31%) (Table 1).

Residents across different levels of training reported similar numbers of ETI encounters over the previous 12 months in both simulation (mannequin ETIs) and with live patients. However, as one would expect, PGY-3 residents

Table 1. Numbers and percentages of emergency medicine residents by level of training, gender and participation in the sit-stand endotracheal intubation study.

	Participant		
Level	Female	Male	Both
1	8 (16)	10 (20)	18 (100)
2	2 (4)	9 (18)	11 (69)
3	5 (10)	8 (16)	13 (87)
Total	15 (31)	27 (55)	42 (86)

reported significantly more live-patient ETI encounters over their career then did their peers (Figure 1).

The evaluators' agreement was relatively good for most items (11 of 12) during their assessment of the resident's standing ETI performance. The exception was "Maintains control over ETT placement." The evaluators' average percentage agreement for the standing assessment was 87.5%. The evaluators' agreement for assessment of the seated performance was relatively good for nine of 12 items. The exceptions included "Flips up epiglottis to expose larynx;" "Passes tube through cords with limited or no impingement;" and "Maintains control over ETT placement." The average percentage agreement for the seated position was 83.7% (Table 2). The three items in which evaluator agreement was less than "good" share the common characteristic of involving a high inference, qualitative judgment (exposure, impingement, or control).

Table 3 shows the descriptive and inferential statistics for the study's measurements. Residents scored an average of three percentage points higher on the seated ETI performance assessment than they did on the standing performance assessment. The difference was not significant, and the associated effect size was small. Furthermore, we observed no other differences between the two ETI positions with regard to the number of attempts, the time to ETI success, and ratings of difficulty and view of the glottis.

Seven of the 42 residents (16.7%) required more than one attempt at ETI; five for the standing position, and two for the seated. Five of the seven residents successfully passed the ETT in the second attempt. The other two required more than two attempts, both in the standing position.

We observed that residents exhibited variability in their performance scores depending on their level of training, regardless of ETI position. PGY-1 scores were widely variable (as can be seen from the length of the box and whiskers in Figure 2) compared to PGY-2 scores, which were a little less variable, and then PGY-3 scores, which

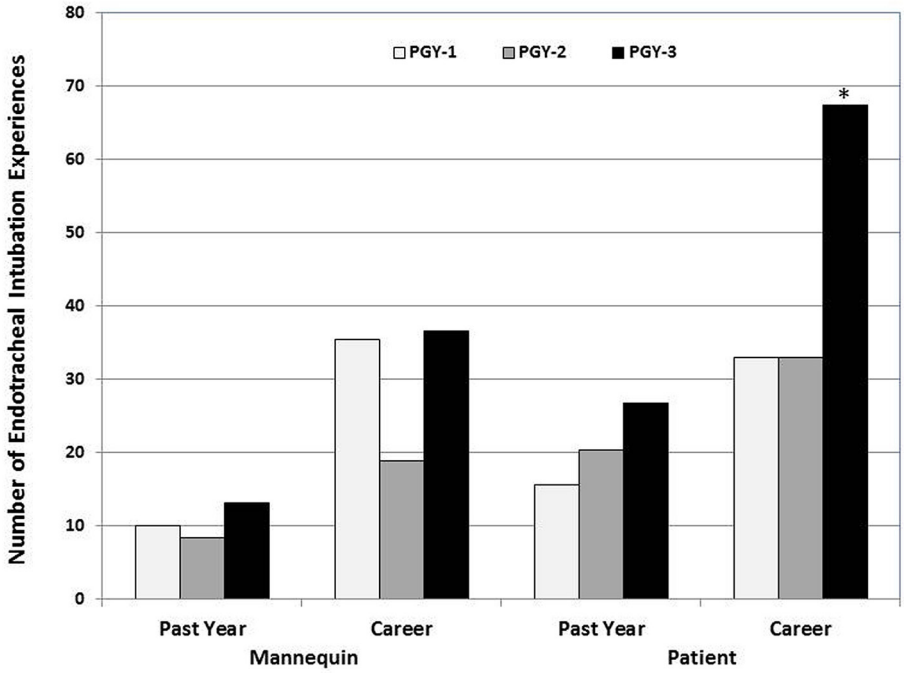

Figure 1. Residents' experience with endotracheal intubation in the preceding year and over their careers in both simulated and actual patient care environments, by training level.
PGY, postgraduate year.
*PGY 3s had significantly more patient intubations over their career than did PGY 1a or 2s. ($F=5.6$, $df=2$, $P \leq .01$).

Table 2. Inter-rater reliability for version of the Airway Management Proficiency Checklist modified for in-hospital endotracheal intubation.

	Standing position		Seated position	
Performance task	% Agreement	K-Alpha	% Agreement	K-Alpha
Uses straight-to-cuff stylet curvature technique	100.0	NA	100.0	NA
Positions head properly	100.0	NA	100.0	NA
Grasps laryngoscope with left hand	95.5	.00	95.5	.00
Elevates mandible up and out w/ laryngoscope	95.5	.00	95.5	.00
Flips up epiglottis to expose larynx	72.7	.47	68.2	.34
Inserts laryngoscope to appropriate depth	86.4	.73	81.8	.64
Moves blade tip smoothly without shaking or jerking	95.5	.83	81.8	-.08
Maintains view until ETT is at correct depth	95.5	.65	81.8	-.08
Passes ETT through cords with limited or no impingement	81.8	.25	68.2	-.16
Passes tube through cords in < 20 seconds	72.7	.46	68.2	.42
Maintains control over ET tube placement	54.5	-.02	63.6	-.19
Successfully intubates within 1 attempt	100.0	1.00	100.0	1.00

K-alpha, Krippendorff's alpha; *ETT*, endotracheal tube; *ET*, endotracheal.
Notes: NA= When there is no variability in the rater's scores (Both judges rated everyone the same) the K-Alpha cannot be computed due to invariant values, and the percentage agreement should be used instead. A K-Alpha=0 when both judges' scores agree on all but 1 subject.[13]

Table 3. Comparison of 42 residents' performances of endotracheal intubation from two positions

	Standing position		Seated position		T-test			
	Mean	SD	Mean	SD	t	df	p	es
Performance score (Pct)	78.2	14.8	81.2	13.5	1.2	41	.24	.213
N attempts	1.21	0.72	1.05	0.22	-1.4	41	.16	.323
Time in seconds	32.7	31.5	24.1	20.1	-1.6	41	.12	.331
Difficulty rating	4.17	2.68	4.16	2.36	-.03	41	.98	.004
Cormack-Lehane view rating	1.90	0.66	1.86	0.65	-.42	41	.68	.074

ETI, endotracheal intubation; *SD*, standard deviation; *t*, dependent t-test; *df*, degrees of freedom; *p*, probability value; *es*, effect size; *Pct*, percentage.
Notes: Bonferroni adjustment is alpha = .01. We computed the Cohen's d effect size for correlated designs as recommended by Dunlop et al. (1996). All Cohen's d effect sizes were interpreted as small or trivial.[14]

were much less variable. The box and whisker plot of the performance scores also shows that PGY-1s and 3s showed slightly better but not significantly better median performance in the seated position (Figure 2). Residents also demonstrated more variability in the time it took to successfully pass the tube from the standing position than from the seated position (Figure 3).

DISCUSSION

In this study we evaluated whether the standing or seated position of EM residents impacted ETI performance or time to successful intubation. We expected that residents would perform better and pass the endotracheal tube more quickly from the standing position, since this is how nearly all residents are trained to perform ETI. We also expected that resident performance would improve as they progressed through their training.

We found that residents performed equally well in both the standing and seated positions. We also observed no differences in ratings of difficulty or laryngeal view between these positions. These findings are noteworthy since they suggest that there may be benefits to delivering ETI from a seated position. The change of position is easy to implement in many in-hospital settings, which makes these findings interesting for ED care. Further, since EPs, especially those involved in EMS and disaster/emergency preparedness, may find themselves needing to perform airway management in the field, learning to perform ETI from alternative positions may be important.

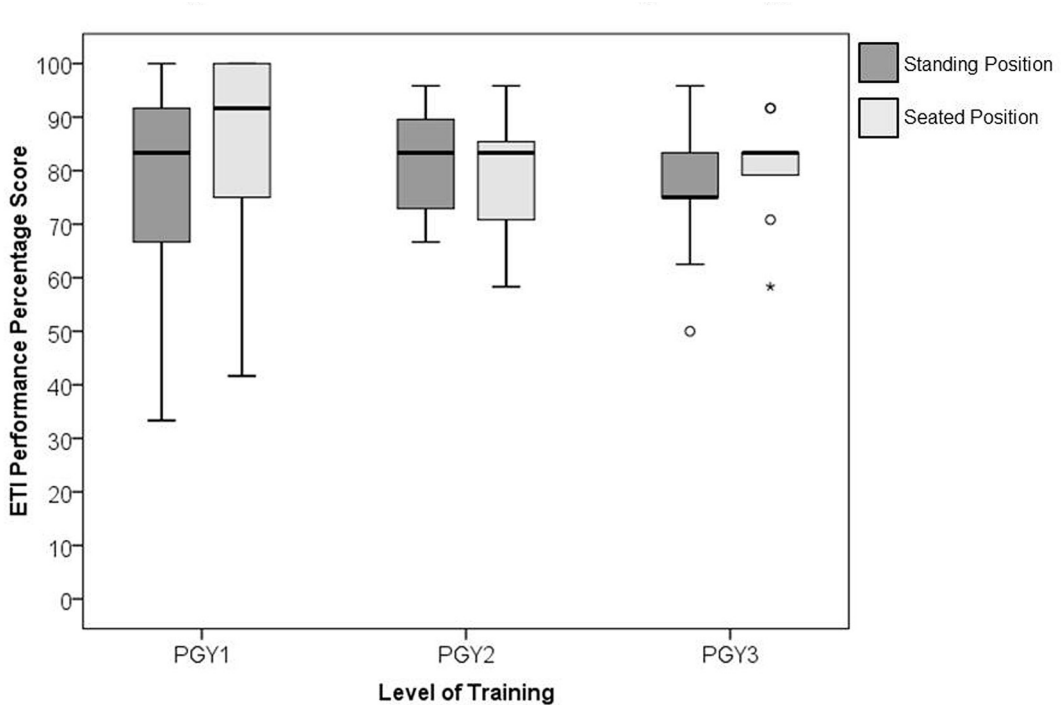

Figure 2. Box and whisker plots representing endotracheal intubation-performance scores by level of training for emergency medicine residents, in both the standing and sitting positions.
PGY, postgraduate year.

Another interesting observation was that when EM trainees were sitting, numerous residents chose to use their elbow as an anchor on the head of the bed just lateral to the patient's head. This is a distinctly different approach to what residents are taught when performing ETI from a standing position and may indeed provide an advantage when performing ETI from a seated position.

Several studies have examined ETI positioning for in-hospital providers. One of the original studies demonstrated that minimum vs. maximum bed height (68.9 versus 101.3 cm) had no impact on time to intubation, success rate, or C-L view.[3] Another study of in-hospital providers compared airway management performance across three different bed heights: at the knees, at mid-thigh height, and at the waist (anterior iliac spine height).[15] These authors also found no difference across the three heights in terms of intubation time or outcome success; nor did they find differences in providers' self-ratings of comfort, difficulty of the intubation, or the visual field. In both of these studies, the primary limitation was that they only measured outcomes and not the actual performance of the in-hospital providers during the ETI simulations.

We attempted to enhance these findings by incorporating actual performance measures into the study and found that performance was not affected by position. Finally, one large clinical evaluation of provider positioning for ETI involved a prehospital emergency medical unit in a suburb of Paris. In this study of 45 prehospital providers including EPs, residents, anesthesiologist and specialized nurses, there were no differences found in difficulty of tracheal intubation when comparing providers in the standing (referent) and kneeling positions (odds ratio [OR] [1.1]). However, this study did demonstrate an increased odds of difficulty in the lateral decubitus (OR [2.0]) and ventral decubitus positions (OR [2.0]).[4]

We chose the C-MAC device for this study because it could be used for both direct laryngoscopy and to provide a video record of the ETI performance for assessment.[16] Participants were not permitted to see the video output from the C-MAC device. While video laryngoscopy is increasingly used for primary and secondary airway attempts, direct laryngoscopy remains a fundamental approach taught in virtually all programs providing instruction in airway management. Perhaps future research should investigate the effects of "types of laryngoscopy" combined with provider positioning on ETI outcomes. Knowing this, investigating the combined effects of various types of laryngoscopy and positioning on ETI may be worthwhile for future research.

LIMITATIONS

Our observations were limited to one EM residency program in one institution. For more generalizable findings, this study will need to be replicated using a broader spectrum of in-hospital providers, i.e., EPs at more advanced levels of practice,

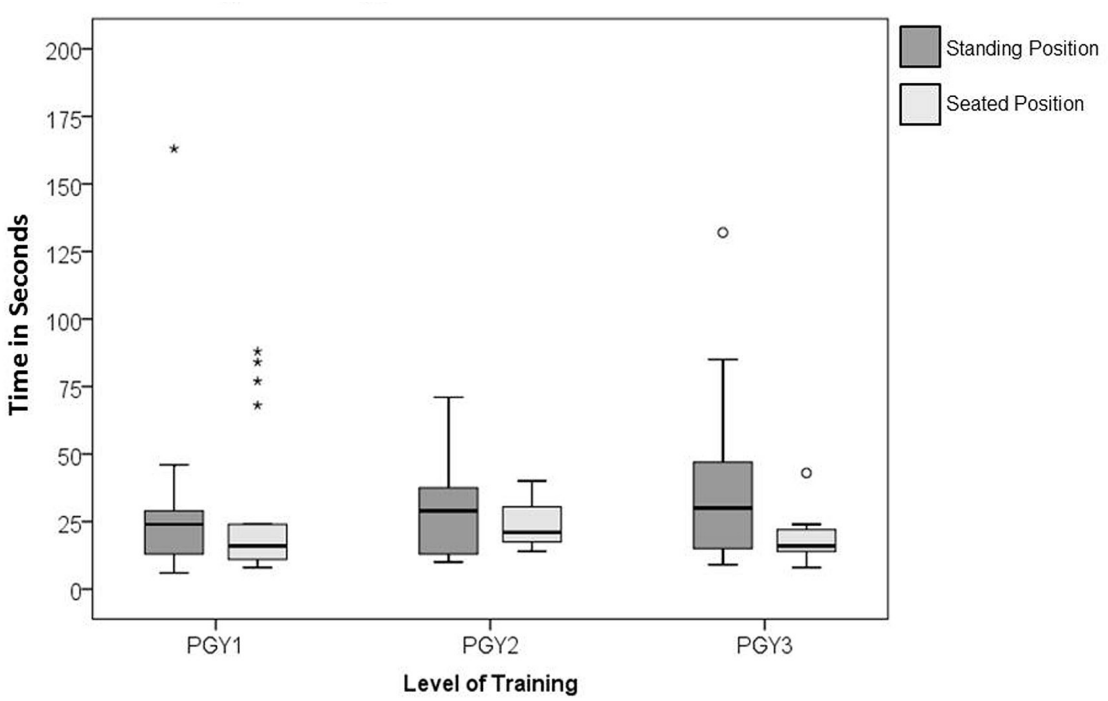

Figure 3. Box and whisker plots representing the distribution of time to intubation (in seconds) by level of training for emergency medicine residents, in both the standing and sitting positions.
PGY, postgraduate year.

and practitioners from other disciplines and institutions. We also failed to establish acceptable inter-rater reliability for at least three of the 12 items used to assess ETI performance. While we do not think that this affected our overall findings, it points to the need for either improved evaluator calibration/training or revision of these performance items to remove the high-inference qualifiers. Finally, we recognize that performance in simulated settings does not equal performance in the actual clinical setting, suggesting that further study in an actual clinical setting would be needed to confirm our findings.

CONCLUSIONS

EM residents demonstrated equivalent ETI performance on a difficult airway model from both a standing and seated position. This was somewhat of a surprising finding, since residents in our program are trained to perform ETI from a standing position. We also found that while performance of PGY-1 residents was more variable, they scored at about the same level as their more experienced peers. All other comparisons, including time to placement of the ETT, laryngeal visualization, and number of attempts, were found to be comparable. Since environmental circumstances sometimes necessitate adaptation to a position other than standing for administering ETI, this study demonstrates that there may be value in training residents to perform ETI from both positions.

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Simple Changes to Emergency Department Workflow Improve Analgesia in Mechanically Ventilated Patients

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Introduction: In 2013 the Society for Critical Care Medicine (SCCM) published guidelines for the management of pain and agitation in the intensive care unit (ICU). These guidelines recommend using an analgesia-first strategy in mechanically ventilated patients as well as reducing the use of benzodiazepines. Benzodiazepines increase delirium in ICU patients thereby increasing ICU length of stay. We sought to determine whether a simple educational intervention for emergency department (ED) staff, as well as two simple changes in workflow, would improve adherence to the SCCM guidelines.

Methods: This was a cohort study that took place from 2014-2016. All patients who were intubated in the ED by an emergency physician (EP) during this time were eligible for inclusion in this study. In January 2015, we began an educational campaign with the ED staff consisting of a series of presentations and online trainings. The impetus for our educational campaign was to have best practices in place for our new emergency medicine residency program starting in July 2016. We made two minor changes in our ED workflow to support this educational objective. First, fentanyl infusions were stocked in the ED. Second, we instituted a medication order set for mechanically ventilated patients. This order set nudged EPs to choose medications consistent with the SCCM guidelines. We then evaluated the use of opioids and benzodiazepines in mechanically ventilated patients from 2014 through 2016 using Fisher's exact test. All analyses were conducted in the overall sample (n=509) as well as in subgroups after excluding patients with seizures/status epilepticus as their primary admission diagnosis (n=461).

Results: In 2014 prior to the interventions, 41% of mechanically ventilated patients received an opioid, either as an intravenous (IV) push or IV infusion. In 2015 immediately after the intervention, 71% of patients received an opioid and 64% received an opioid in 2016. The use of benzodiazepine infusions decreased from 22% in 2014 to 7% in 2015 to 1% in 2016.

Conclusion: A brief educational intervention along with two simple changes in ED workflow can improve compliance with the SCCM guidelines for the management of pain and agitation in mechanically ventilated patients. [West J Emerg Med. 2018;19(4)668–674.]

INTRODUCTION

Background

In 2013 the Society for Critical Care Medicine (SCCM) published its Clinical Practice Guidelines for the Management of Pain, Agitation, and Delirium in Adult Patients in the Intensive Care Unit (ICU).[1] These guidelines disseminated best practices in the care of both critically ill and mechanically ventilated patients. The SCCM Guidelines recommend that "intravenous

(IV) opioids be considered as the first-line drug class of choice to treat non-neuropathic pain in critically ill patients." For sedation, the SCCM guidelines suggest that "sedation strategies using nonbenzodiazepine sedatives may be preferred over sedation with benzodiazepines (either midazolam or lorazepam) to improve clinical outcomes in mechanically ventilated adult ICU patients. Benzodiazepines have been showed to increase ICU delirium thereby increasing ventilator days and ICU length of stay (LOS).[2] ICU delirium is well known to increase ICU and hospital LOS as well as six-month mortality.[3]

Mechanically ventilated patients are subjected to many painful procedures such as urinary catheters, central venous access lines, and frequent blood draws. Simply having an endotracheal tube in place is painful. By treating pain first, the SCCM guidelines aim to increase patient comfort while simultaneously reducing the occurrence of delirium in the ICU. Prior studies that have looked at the emergency department (ED) treatment of post-intubation patients found suboptimal use of analgesic and anxiolytic medications. For example, Bonomo in 2007 found that 33% of mechanically ventilated patients in the ED received no anxiolytics, 53% received no analgesia, and 20% received neither analgesia nor anxiolytics.[4] Additionally, a large study using the National Ambulatory Medical Care Survey found that less than 50% of mechanically ventilated patients received a sedative or opioid medication.[5]

In 2015 the Accreditation Council for Graduate Medical Education Residency Review Committee approved a new emergency medicine (EM) residency at our institution. In preparation for the new residency, we undertook an assessment of our current clinical practices, seeking to have best practices in place for the new residency program. Therefore, we sought to determine whether a brief educational intervention coupled with two simple changes in ED workflow would improve adherence to the SCCM guidelines. More specifically, we wanted to increase the use of opioids and decrease the use of benzodiazepines in mechanically ventilated patients in the ED.

Population Health Research Capsule

What do we already know about this issue?
Analgesia provided to mechanically ventilated patients in the emergency department (ED) is often inadequate and does not follow published recommendations.

What was the research question?
Can simple changes in ED workflow improve the use of analgesia in mechanically ventilated patients?

What was the major finding of the study?
Simple changes to the electronic medical record and stocking fentanyl infusions in the ED increase use of analgesia in intubated patients.

How does this improve population health?
Simple workflow changes that encourage following published guidelines can change physician behavior and potentially lead to improved patient outcomes.

METHODS

Design

This was a cohort study that took place from 2014-2016 at Crozer Chester Medical Center (CCMC), a community-based 300-bed tertiary care center, Level II trauma center, and regional burn center. CCMC has multiple graduate medical programs and initiated an EM residency program in July 2016. The CCMC ED treats approximately 53,000 patients per year with an admission rate of approximately 36%.

Patients

All patients who were intubated in the ED by emergency physicians (EPs) between January 1, 2014, and December 31, 2016, were eligible for inclusion. We identified all intubated patients through retrospective review of our electronic medical record (EMR) (Optum ED PulseCheck®, Optum Clinical Solutions, Inc. Eden Prairie, Minnesota). Trauma patients were excluded from our study because, in our facility, these patients were intubated by anesthesia with subsequent medication management by the trauma team. Other exclusions included children less than the age of 18, intubated patients who died in the ED, patients who were intubated solely for a procedure and then extubated (such as endoscopy), or patients who were transferred out of the hospital system. We excluded the latter patients because the receiving facilities often requested a specific sedation and analgesia package for transport. Finally, we excluded any patients who were intubated by the authors of this study as they were aware of its hypothesis.

For all patients who met inclusion criteria, data was extracted via chart review and entered into a Microsoft Excel (Redmond, Washington) database in a blinded fashion for review and analysis. We considered the time period February 1, 2014, through December 31, 2014 our "pre-intervention" period. We used January 2015 as a "wash out" period in which ED staff and physicians were acclimated to the new analgesia-first strategy. We gathered our outcomes data from February 1, 2015, until December 31, 2016.

Interventions

In January 2015 the authors began an educational campaign to improve sedation and analgesia practices for

mechanically ventilated patients. First, to educate the EPs we gave brief presentations at two consecutive faculty meetings. We reviewed the SCCM guidelines, discussed our current sedation and analgesia practices, and made recommendations as to the appropriate medications for mechanically ventilated patients. We also sent periodic educational emails to the faculty. To educate the nursing staff, we provided a similar, brief, 20-minute educational online presentation using Brainshark© (Waltham, Massachusetts). In addition, we met with the nurses at their daily shift huddles to discuss the new initiative.

To support our new initiative, we made two changes in our ED workflow. First, fentanyl infusions were stocked in the ED medication-dispensing machines. This change allowed nurses to access fentanyl infusions at the time of intubation rather than waiting on infusions to be prepared in and delivered from the central pharmacy (which had been the standard practice). Secondly, we instituted a best-practices order set for mechanically ventilated patients. As shown in Figure 1, EPs could choose from pre-populated medication choices that included fentanyl and propofol. EPs could still order benzodiazepines but had to use a search function in the EMR.

Outcomes

Our primary outcome was the percentage of mechanically ventilated patients who received an opioid. Secondary outcomes included the percentage of mechanically ventilated patients who received any benzodiazepine and the percentage of patients who received no sedation. We also performed a subgroup analysis excluding patients with a primary diagnosis of seizure/status epilepticus as benzodiazepines may be the most appropriate medications for these patients.

Statistical Analysis

We used descriptive statistics to characterize the use of opioids and benzodiazepines in this sample. Continuous variables were described with means, standard deviations, and ranges, and categorical variables were described with frequencies and percentages. Changes in the use of opioids and benzodiazepines in patients from 2014 vs. 2015, 2014 vs. 2016, and 2015 vs. 2016 were evaluated using Fisher's exact test. We conducted analyses in the overall sample (n=509), as well as in a subgroup excluding patients with seizures or status epilepticus as their primary admission diagnosis (n=461). Statistical significance was taken at the 0.05 level. No adjustments were made to account for multiplicity. This study was approved by the investigational review board of CCMC.

RESULTS

Overall Sample

We included in the study 509 patients who were mechanically ventilated (Figure 2). Of the 509 total patients, we obtained data from 233 patients in 2014, 150 in 2015, and 126 in 2016. Patient demographics for the overall sample are summarized in Table 1.

The use of opioids and benzodiazepines in the overall sample from 2014-2016 is summarized in Table 2. In 2014, prior to the workflow changes, 41% of mechanically ventilated patients received an opioid, either as an intravenous push (IVP) or as an IV infusion (n=95). In 2015, immediately after the intervention, and in 2016, the later study period, 71% (n=106) and 64% (n=81) of mechanically ventilated patients received an opioid (both $p<0.0001$). We found significant differences in the percent of patients receiving an opioid IV infusion in 2014 vs. 2015 and 2014 vs. 2016 (both $p<0.0001$). Specifically, only 29% (n=67)

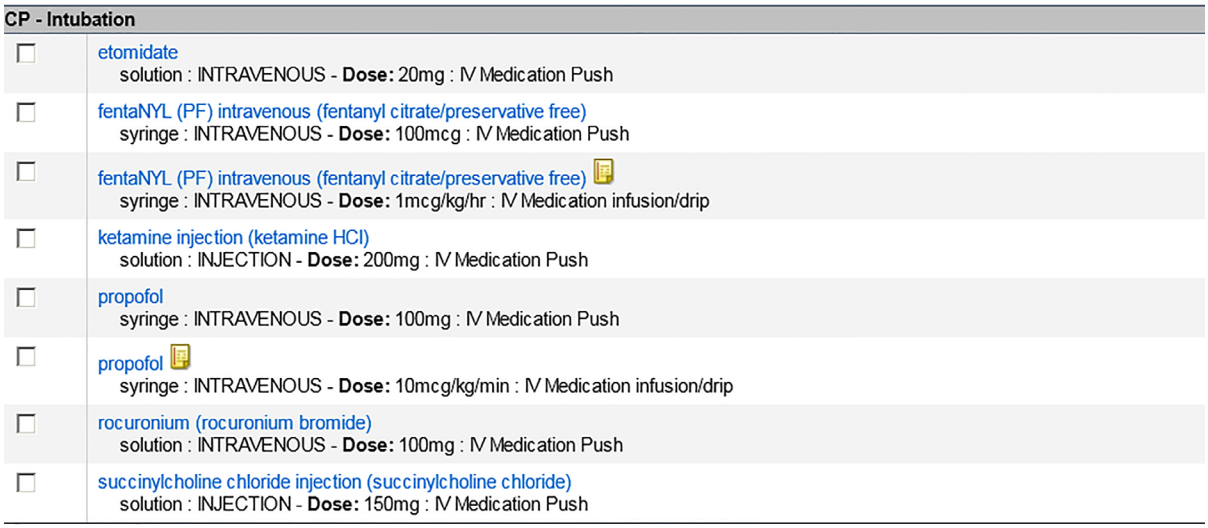

Figure 1. Intubation medication order set (Picis Clinical Solutions© Wakefield, Massachusetts).

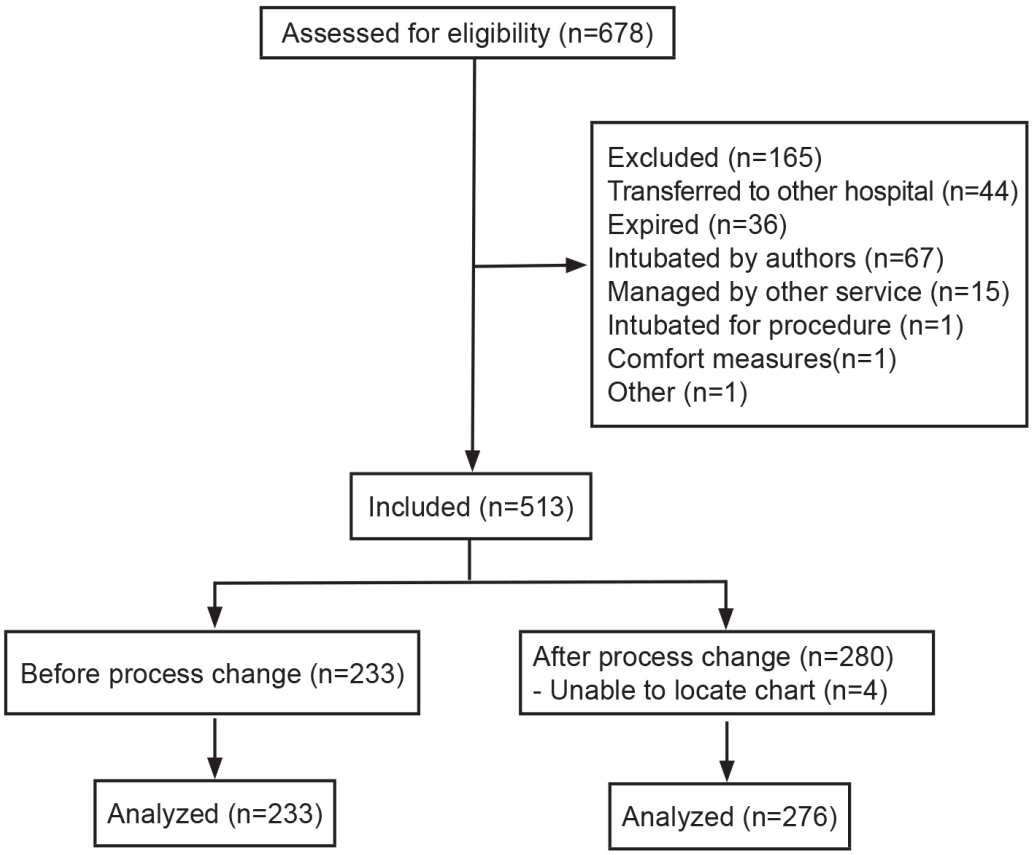

Figure 2. CONSORT (Consolidated Standards of Reporting Trials) flow diagram.

Table 1. Demographics for all mechanically ventilated patients from 2014-2016 (n=509).

	2014 n=233	2015 n=150	2016 n=126
Female [n (%)]	110 (47%)	57 (38%)	63 (50%)
Age (years)			
Mean (SD)	54.1 (18.7)	55.3 (18.3)	54.5 (19.5)
Range	18-92	18-94	18-94
Reasons for intubation			
Cardiac	21	13	13
Change in mental status	19	6	5
GI bleed	7	2	3
Other	17	7	24
Overdose	37	37	15
Respiratory	82	51	34
Seizure/status epilepticus	22	15	13
Sepsis	18	11	12
Stroke	10	8	7

SD, standard deviation; *GI*, gastrointestinal.

of mechanically ventilated patients received an opioid IV infusion in 2014 compared to 61% (n=92) in 2015 and 61% (n=77) in 2016.

The use of benzodiazepine infusions significantly differed in 2014 vs. 2015 and 2014 vs. 2016 (both $p<0.0001$). Specifically, the use of benzodiazepine infusions was 22% (n=52) in 2014, 7% (n=10) in 2015, and 1% (n=1) in 2016. Additionally, significant differences were found in the percent of patients receiving any benzodiazepine, either as an IVP or infusion, in 2014 vs. 2015, and 2014 vs. 2016 (both $p<0.0001$). Sixty-two percent (n=144) of mechanically ventilated patients received a benzodiazepine in 2014, compared to 34% (n=50) in 2015 and 29% (n=37) in 2016. There were no significant differences in the percent of patients receiving propofol or no sedation/analgesia in 2014 vs. 2015 and 2014 vs. 2016.

Subgroup Analysis

We also conducted Fisher's exact tests in a subgroup that excluded patients with seizures or status epilepticus as their primary admission diagnosis. A total of 461 patients were used in this subgroup analysis, with 211 patients in

Table 2. Use of opioids and benzodiazepines in all mechanically ventilated patients from 2014-2016 (n=509).

	2014 n=233	2015 n=150	P value	2014 n=233	2016 n=126	P value
Received opioid IVP [n (%)]	76 (33%)	62 (41%)	0.1028	76 (33%)	51 (40%)	0.1651
Received opioid IV infusion [n (%)]	67 (29%)	92 (61%)	<0.0001	67 (29%)	77 (61%)	<0.0001
Received any Opioid [n (%)]	95 (41%)	106 (71%)	<0.0001	95 (41%)	81 (64%)	<0.0001
Received benzodiazepine IVP [n (%)]	137 (59%)	48 (32%)	<0.0001	137 (59%)	37 (29%)	<0.0001
Received benzodiazepine infusion [n (%)]	52 (22%)	10 (7%)	<0.0001	52 (22%)	1 (1%)	<0.0001
Received any benzodiazepine [n (%)]	144 (62%)	50 (34%)	<0.0001	144 (62%)	37 (29%)	<0.0001
Received propofol [n (%)]	79 (34%)	48 (32%)	0.5100	79 (34%)	47 (37%)	0.7100
Received propofol only [n (%)]	10 (4%)	5 (3%)	0.6300	10 (4%)	10 (8%)	0.0200
No sedation [n (%)]	45 (19%)	23 (15%)	0.2000	45 (19%)	23 (18%)	0.7700

IVP, intravenous push, *IV,* intravenous.

Table 3. Use of opioids and benzodiazepines in non-seizure patients from 2014-2016 (n=461).

	2014 n=211	2015 n=135	P value	2014 n=211	2016 n=115	P value
Received opioid IVP [n (%)]	69 (33%)	56 (41%)	0.0873	69 (33%)	48 (42%)	0.0873
Received opioid IV infusion [n (%)]	61 (29%)	84 (42)	<0.0001	61 (29%)	72 (63%)	<0.0001
Received any opioid [n (%)]	87 (41%)	96 (71%)	<0.0001	87 (41%)	75 (65%)	<0.0001
Received benzodiazepine IVP [n (%)]	120 (57%)	41 (30%)	<0.0001	120 (57%)	30 (26%)	<0.0001
Received benzodiazepine infusion [n (%)]	34 (16%)	9 (7%)	<0.0001	34 (16%)	1 (1%)	<0.0001
Received any benzodiazepine [n (%)]	127 (60%)	43 (33%)	<0.0001	127 (60%)	30 (26%)	<0.0001
Received propofol [n (%)]	68 (32%)	36 (27%)	0.2400	68 (32%)	31 (36%)	0.3600
Received propofol only [n (%)]	10 (5%)	4 (3%)	0.2800	10 (5%)	9 (8%)	0.1400
No sedation [n (%)]	42 (20%)	23(17%)	0.3800	42 (20%)	23 (20%)	0.1000

IVP, intravenous push, *IV,* intravenous.

2014, 135 in 2015, and 115 in 2016. Similar results were seen in this subgroup of patients. Table 3 summarizes the use of opioids and benzodiazepines in this subgroup from 2014-2016. In 2014, 41% (n=87) of mechanically ventilated patients received an opioid, either as an IVP or an IV infusion, compared to 71% (n=96) in 2015, and 65% (n=75) in 2016 (both p<0.0001). Significant differences were found in the percent of patients receiving an opioid infusion in 2014 vs. 2015 and 2014 vs. 2016 (both p<0.0001). Specifically, 29% (n=61) of patients received an opioid infusion in 2014, compared to 42% (n=84) in 2015, and 63% (n=72) in 2016.

The use of benzodiazepine infusions significantly differed in 2014 vs. 2015, and in 2014 vs. 2016 (both p<0.0001). Specifically, the use of benzodiazepine infusions was 16% (n=34) in 2014, 7% (n=9) in 2015, and 1% (n=1) in 2016. Additionally, there were significant reductions in the percent of patients receiving any benzodiazepine in 2014 vs. 2015 and 2014 vs. 2016 (both p<0.0001). Sixty-seven percent (n=127) of patients received a benzodiazepine in 2014, compared to 33% (n=43) in 2015, and 26% (n=30) in 2016. No significant differences were found in the percent of patients receiving propofol or no sedation/analgesia in 2014 vs. 2015 and 2014 vs. 2016.

DISCUSSION

Although the SCCM guidelines are largely directed toward ICU care, we believe these recommendations should be adopted for mechanically ventilated patients in the ED to provide a unified care strategy.[1] As a result of our interventions, we were able to significantly increase the use of opioids in mechanically ventilated patients while simultaneously decreasing the use of benzodiazepines. We were able to effect this change in medication ordering while

maintaining the overall percentage of patients who received analgesia and/or sedation following mechanical ventilation at 82-83%, significantly above reported rates.[4,5] As follow up to this research, we are currently evaluating whether the increased use of an analgesia-first strategy in the ED reduces ventilator LOS in mechanically ventilated patients.

In the current study, we failed to observe a change in the total number of patients who did not receive analgesia or sedation following intubation over the three-year study period. We suspect this is due to a subset of patients who require no sedation or analgesia while on the ventilator. For example, the patient with a devastating intracranial hemorrhage may not require sedation or analgesia. Similarly, a patient with a depressed mental status from an opioid, benzodiazepine, or polysubstance ingestion may not require sedation or analgesia in the initial hours after initiation of mechanical ventilation.

With the advent of the EMR, clinical support tools have been embedded into the system as a way to improve resource utilization. In 2005 Samore et al. tested the use of an electronic decision aid for primary care providers to prescribe antibiotics for acute respiratory tract infections.[6] The authors were able to reduce antibiotic prescriptions by 8.8% in the intervention group that used the decision aid compared to the control group.

Additional research involving the integration of clinical support tools in the ED EMR has focused on decreasing inappropriate imaging. Gupta et al. showed that a decision support tool for mild traumatic head injury improved compliance with published guidelines by 27%.[14] An embedded support tool for the ordering of computed tomography (CT) pulmonary angiograms decreased ordering from 2.6% to 2.1%, while increasing the positive yield of the studies from 5.8% to 9.8%.[8]

Most recently, Heitz et al. conducted a trial of EMR-embedded clinical support tools to reduce inappropriate imaging for head trauma, cervical spine injuries, and pulmonary embolism. This study of 235,858 ED visits found that the embedded support tools reduced the ordering of brain CTs by 10%, cervical spine CTs by 6% and pulmonary embolism studies by a non-significant 2%. Interestingly, although the most-frequent users of CT decreased their use, some of the least-frequent users increased their use of CT.

Our study is one of the first to look at EMR-embedded clinical support for prescribing practices in the ED. Rather than a series of checkboxes or pop-up menus, which are typically used in EMR-embedded clinical support tools, we used a principle called "nudging" to push the emergency physician (EP) toward choosing opioids and non-benzodiazepine medications for sedation.[10] This study supports the idea that simple changes in the EMR workflow can nudge EPs toward certain medication order choices. We hope that future research will continue to examine how redesign of ED workflow, specifically the EMR, can aid EPs in selecting the best medication choices for their patients.

LIMITATIONS

As the data was gathered retrospectively, we have the standard limitations of a chart review. For example, if an intubation procedure was not properly recorded in the EMR, that patient would not have been included in the study for analysis. We also only evaluated a subset of mechanically ventilated patients in our ED as we did not include in our study trauma patients, transfers out of the system, or children. In addition, only medications ordered through the EMR were included. It is always possible that medications were given after a verbal order and not later recorded in the EMR.

CONCLUSION

In summary, a brief educational intervention and two simple changes in ED workflow – stocking fentanyl infusions in the ED and redesigning the medication ordering screen – can improve compliance with the SCCM guidelines for the management of pain and sedation in mechanically ventilated patients. This study also supports the idea that the EMR can function as a clinical support tool to nudge physicians to improve medication ordering practices.

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Using the Natural Experiment Study Design to Evaluate the Effect of a Change in Doctor's Roster on Patient Flow in an Emergency Department

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Introduction: The effect of changes in doctors' rosters is rarely subjected to scientific evaluation. We describe how a natural experiment (NE) study design can be used to evaluate if a managerial decision about doctors' rosters has an effect on patient flow in an emergency department (ED). We hypothesized that an extra doctor each morning from 6 a.m. (i.e., a modified "casino shift") might improve the productivity of a hospital's ED.

Methods: This was an NE observational study using data on patient flow in the ED of Zealand University Hospital, Denmark, between April 1, 2016, and April 1, 2017. We compared days on which the 6 a.m. emergency physician called in sick (case days) with data from the same weekday a week later where staffing was as scheduled (control days).

Results: Patient caseload did not did differ significantly on days with and without the extra doctor from 6 a.m. (measured by number of admissions, triage scores and mean patient age). Door-to-doctor time was 70 minutes (mean, standard deviation [SD], 49) on days without the extra doctor and 56 minutes (mean, SD 41) on days with the early-morning doctor present ($p > 0.05$). ED length of stay was 250 minutes (mean, SD 119) on days without the extra doctor and 209 minutes (mean, SD 109) on days with the early-morning doctor present ($p > 0.05$).

Conclusion: In our setting, an extra doctor in the ED from 6 a.m. did not change patient flow. These results suggest that the workflow in the ED should be viewed as a connected supply chain. The study also demonstrates that a natural experiment study design can be used to evaluate ED managerial decisions. [West J Emerg Med. 2018;19(4)675–677.]

INTRODUCTION

It is rare that managerial decisions in healthcare about staff rosters, for example, are evaluated using the same scientific approach as would otherwise be required in healthcare interventions[1] This is surprising given the influence that the rosters can have on the wellbeing of the staff and possibly even the patient flow. Staff fatigue on night shifts is a common problem in emergency departments (ED),[2] and during shifts resident productivity falls.[3,4]

A so-called "casino shift" where handover takes place during the early hours of the morning (e.g., at 4 a.m.) has been suggested as a way of reducing physician fatigue compared to a shift where the handover takes place at the beginning of normal office hours.[5,6] At the Department of Emergency Medicine at Zealand University Hospital, Denmark, we introduced a modified "casino shift" in the spring of 2016. We hypothesized that an extra doctor each morning from 6 a.m. might improve productivity in the ED.

To investigate this hypothesis we used a natural experiment (NE) study design. The NE approach is a type of observational study used for evaluation of situations where a controlled experiment is difficult, if not impossible, to conduct. A situation can be analyzed as an NE if outside factors introduce an element of randomness.[7]

METHODS

The "early morning shift" in our ED was introduced to comply with new labor agreements for junior doctors. The new agreements require that doctors rest an average of 2-3 hours if a shift exceeds 13 hours. This "early morning shift" starts at 6 a.m. on weekdays. The doctor on the "early morning shift" will join the evening/night team of four residents (three in their first year and one in second year or beyond with a consultant on call); the evening/night team is on call from 4 p.m.-8 a.m. Doctors who arrive at 6 a.m. will typically relieve the most experienced doctor on call. The early morning shift was introduced in our ED on April 1, 2016.

If the early-morning doctor calls in sick the vacant shift will not be filled, leaving the on-call evening/night team to handle all patients. Using these "sick-days" as the random element in our study set-up, we compared data from days where the 6 a.m. doctor called in sick (case days) with data from the same weekday a week later (where staffing was as scheduled [control days]). If a control day fell on a public holiday or on another day with a 6 a.m. doctor who called in sick, the weekday in the preceding week was used as control.

In compliance with the regulations on the use of administrative data in the Danish Health Act,[8] we retrieved data on patient flow in our ED from the electronic flow management system (IMATIS^{R} Fundamentum Platform) from April 1, 2016, to April 1, 2017. Workflow data was included if the patient arrived at the ED between 5 a.m. and 8 a.m. The triage system used a scale from 1 – 5 to signal urgency, with category 1 being the most urgent. We defined door-to-doctor time as the interval between a patient's arrival and the first registration in the allocated doctor's flow management system; thus, the triage process was not included, even though all patients are seen by a doctor at the triage station shortly after arrival. Admission to the observational unit was considered as "departure from the ED" even though it remains part of the ED's area of responsibility. Some patient categories are routinely treated by doctors/teams from other departments of the hospital with little involvement of our emergency physicians. These categories (major trauma; out-of-hospital cardiac arrest; patients with ear/nose/throat-related problems) were not included in the material and neither were patients with minor injuries who were not admitted.

Statistical analysis used t-test and chi-square test with a significance level of 0.05. We analyzed the following data: time of arrival; departure from the ED; triage score; patient age; door-to-doctor time; and next destination for the patient (admission to or discharge from hospital).

RESULTS

During the 52 weeks of our study there were 16 case-days with a total of 37 patient visits. On the 16 controls days, there were a total of 26 visits ($p>0.05$). Data on triage were not available for four patients (control days) and time from door to doctor was not available for one patient (control day). On case-days, 48% (n=18) of patients had a length of stay (LOS) of more than four hours, while this was the case in 38 % (n=10) on control days ($p>0.05$). Days with and without the 6 a.m. doctor did not differ significantly for patient caseload (measured as number of admissions, triage score, or patient age). Door-to-doctor time was 70 minutes (mean, standard deviation [SD], 49) on case-days and 56 minutes (mean, SD 41) on control-days ($p > 0.05$). ED LOS was 250 minutes (mean, SD 119) on days without the extra doctor and 209 minutes (mean, SD 109) on days with the early-morning doctor present ($p > 0.05$).

DISCUSSION

Our study shows that a doctors' roster incorporating a modified "casino shift" reduces neither the door-to-doctor time nor LOS for patients admitted between 5 a.m. and 8 a.m. in our ED. The results illustrate that the concept of NEs can be used to evaluate managerial decisions in the ED without setting up a costly and time-consuming traditional, randomized controlled experiment. Although the NE research design is well known in fields such as economics, it is not used much in healthcare research. Rockers et al. argue that the NE may have "unrealized potential for … causal evaluation of health policies and programs globally."[9] Thus, this design could be considered a complementary approach to gaining insights into the effectiveness of healthcare initiatives.

That rationale for introducing a casino-style, early-morning shift was to relieve resident fatigue, rather than to increase productivity. However, since resident productivity falls during shifts[3,4] it would be a likely "side effect" of a casino shift that productivity on a department level didn't fall. So why doesn't adding an extra, rested doctor from 6 a.m. on weekdays in the ED have any significant effect on patient flow? The described "dip" in productivity at the end of shifts described by others[4] might not be applicable to doctors working in Danish hospitals under Danish labor agreements, partly because the labor agreements mandate that on-call doctors should have opportunities to rest. This might explain why there was no decrease in door-to-doctor time when a vigorous colleague arrived to help out at 6 a.m.

Another explanation could be that other factors than just the number of doctors at work determine the rate of workflow in the ED. This explanation is supported by

the fact that LOS in the ED was unchanged between the groups. It is well described in the literature that the rate of patient flow in the ED is determined by multiple factors, not just number of staff.[10] Other factors could limit the rate of patient flow and the rate with which doctors can see and treat patients in the ED, for example, the sequence of clinical working processes or availability of radiology services and lab tests. Thus, the results we present here point toward the idea that the workflow in the ED should be viewed as a connected supply chain and that no single intervention will improve workflow unless rate-limiting processes are identified first.

Although this study could not document any effect on LOS and door-to-doctor time, there may be other, secondary impacts of the early-morning shift that were not evaluated in this study, e.g., impacts later in the day. Indeed, the labor agreement and the shift reflect attempts to reduce fatigue, rather than increase productivity. More importantly, using LOS and door-to-doctor time as metrics does not indicate whether there was an effect on the quality of care.

LIMITATIONS

Our study has the inherent limitations of an observational study. In addition, the relatively few number of days with sick staff resulted in a small sample size. A small sample size made it difficult to eliminate other confounding variables. However, a power calculation (using the current incidence of sick days and a standard deviation of 110 minutes) shows that it would require management data from seven years of ED operations to evaluate whether the change in roster increased patient flow. Even if this were done, the absolute risk reduction for a LOS > 4 hours would be 10% (48 minus 38), with a number needed to treat of 10 patients. Thus, in our setting, this equals three to four mornings with a casino shift to reduce door-to-doctor time with 14 minutes. Evaluation of a minor change in a roster by using a study period of seven years to prove a very small effect for a small group of patients would hardly be justifiable. Another limitation is that the results in this study might not be generalizable to other settings where the caseload, staffing or labor agreements differ significantly from our ED.

CONCLUSION

In our departmental setting, a modified "casino shift" did not change patient flow; however, the results of our study illustrate that the concept of natural experiments can be used to evaluate managerial decisions in the ED.

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Opioid Administration and Prescribing in Older Adults in U.S. Emergency Departments (2005-2015)

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Introduction: We assess trends in opioid administration and prescribing from 2005-2015 in older adults in United States (U.S.) emergency departments (ED).

Methods: We analyzed data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) survey from 2005 to 2015. ED visits for painful conditions were selected and stratified by age (18-64, 65-74, 75-84, ≥ 85 years). We analyzed trends in opioid administration in the ED and prescribing at discharge to encounters ≥ 65 and assessed predictors of use using survey-weighted chi-square tests and logistic regression. Trends in the use of five commonly prescribed opioids were also explored.

Results: Opioid administration in the ED and prescribing at discharge for encounters with patients ≥ 65 years fell overall, but not significantly. By contrast, opioid administration in the ED and prescribing at discharge significantly declined for adult encounters 18-64 by 20% and 32%, respectively. A similar proportion of adult encounters ≥ 65 were administered opioids in the ED as 18-64, but adult encounters ≥ 85 had the lowest rates of administration. A smaller proportion of adult encounters ≥ 65 years with painful conditions were prescribed opioids at discharge compared to <65. However, this age-related disparity in prescribing narrowed over the study period. There were shifts in the specific types of opioids administered and prescribed in adult encounters ≥ 65 years over the study period, with the most notable being a 76% increase in hydromorphone administration comparing 2005-06 to 2014-15.

Conclusion: From 2005-15, 1 in 4 to 1 in 10 ED patients with painful conditions were administered or prescribed an opioid in U.S. EDs. Opioids prescribing increased from 2005-11 and then declined from 2012-15, more so among visits in the 18-64 age group compared to ≥ 65 years. Opioid administrating demonstrated a gradual rise and decline in all adult age groups. Age consistently appears to be an important consideration, where opioid prescribing declines with advancing age. Given the nationwide opioid crisis, ED providers should remain vigilant in limiting opioids, particularly in older adults who are at higher risk for adverse effects. [West J Emerg Med. 2018;19(4)678-688.]

INTRODUCTION

Debate continues about the use of opioids in older adults. This conversation is complicated by the significant knowledge gaps regarding the safety and efficacy of opioids, factors that predict positive or negative treatment outcomes, approaches to minimize adverse effects of opioids in older adults, and concerns of addiction and misuse.[1] However, pain is a common symptom experienced by older adults: studies have shown that approximately 50% of community-dwelling older adults experience daily pain, which has a negative impact on physical and mental health-related quality of life.[2,3] Poorly controlled pain in the outpatient setting increases the number of falls, decreases mobility, and raises the risk of coronary artery disease and mortality in older adults.[4,5] In an inpatient setting, poorly controlled pain has been shown to lead to longer hospital stays, missed physical therapy sessions, decreased ambulation, and delirium.[6,7] Managing pain in older adults is a challenge, given the need to balance the effectiveness of the medication, adverse drug effects, and the potential for drug-drug and drug-disease interactions. Opioid pain relievers control pain, yet they carry risks including constipation, dry mouth, nausea, vomiting, dizziness, somnolence and pruritus.[8] These risks are magnified in older adults.[9]

Some recent studies have shown that older adults are less likely than younger patients to receive analgesia in the emergency department (ED) for acutely painful conditions and have advocated for increased opioid administration in this population when presenting with painful conditions. One single-center, retrospective observational study revealed that older adults presenting with moderate to severe pain were significantly less likely than younger adults to receive an opioid in the ED.[10] Another single-center study revealed that patients ≥ 80 years presenting with an acute fracture in the ED were less likely to be prescribed an opioid upon discharge than patients < 80 years (55% vs. 75%).[11] A national study revealed that adults ≥ 75 years of age were 14.6% less likely to receive an opioid analgesic for painful conditions in the ED than adults 35-54 years.[12]

These results need to be weighed against current research that has shown large increases in opioid prescribing over the past 15 years to the adult population and adverse health outcomes that may be related to increased opioid prescribing. From 2001 to 2010 the percentage of ED visits in which an opioid was prescribed increased from 20.8% to 31.0%, based on national-level data. This study further noted a 6.6% increase in opioid utilization to adults ≥ 65 during the studied time frame.[13] The number of opioid prescriptions per 100 people in the United States (U.S.) increased by 35% between 2000 and 2009.[14] This has been paralleled by increasing rates of opioid addiction, overdoses, and deaths.[15]

Older adults are increasingly visiting U.S. EDs.[16] When ED visits involve acute or chronic pain, ED providers must balance medication risks and benefits when making decisions on pain-control strategies. No studies have examined recent trends specifically in older adults. In this study, we used a nationally representative sample of U.S. ED visits to assess trends in opioid administration in the ED and prescribing at discharge for acutely painful conditions from 2005–2015 among older adults. We focused on the use of specific analgesics, reasons for visit, demographic and hospital factors, as well as pain severity.

Population Health Research Capsule

What do we already know about this issue?
Opioid use has been increasing in the past 15 years for all age groups, and while opioids can control pain in older adults, there is a risk of adverse effects, abuse and addiction in this special population.

What was the research question?
What are the trends in opioid administration in the emergency department (ED) and prescribing at discharge to adults ≥ 65 from 2005-2015?

What was the major finding of the study?
While opioid administration in the ED and prescribing at discharge significantly declined for adults 18-64 from 2005-2015, there was no significant decline for adults ≥ 65. Older adults were also consistently prescribed fewer opioids than their younger counterparts.

How does this improve population health?
There are clear disparities by age group for opioid use. ED providers need to balance the concerns of increasing rates of opioid abuse and misuse in older adult, with the need for adequate pain control in this population.

METHODS

Study Design

We conducted this study using data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) from 2005 to 2015. NHAMCS is a multi-stage probabilistic sample collected by the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention (CDC) using an annual survey of hospital-based EDs. Using NHAMCS, it is possible to generate national-level estimates of characteristics of ED visits, including patient-level

characteristics, such as demographics, reasons for visit, diagnoses, services provided, and patient disposition, as well as hospital-level information, including the geographic region and teaching status. Because NHAMCS is a de-identified, publicly available data source, this study was exempted from institutional board review.

Methods and Measurements

We analyzed NHAMCS data from 2005 to 2015. Beginning in 2005, NHAMCS indicates whether a medication was administered in the ED or prescribed at discharge, which is why we used 2005 as the initial time point in analysis. To ensure analyses were consistent with NCHS recommendations that raw sample sizes for subgroup analyses meet or exceed 30 cases, we combined data into two-year blocks for most analyses. Thus, comparisons in this study were between 2005-06 and 2014-15, except where otherwise noted.

Our sample was restricted to patients who presented with a painful reason for visit; all such reasons for visit are included in Appendix A. Subgroup analyses were stratified by age group (18-64, 65-74, 75-84, ≥ 85), sex, race, disposition, geographic region, utilization of hospital resources (imaging, procedures, and blood work) and pain type (chest pain, abdominal pain, back pain, musculoskeletal pain, dental pain, and other pain). Hospital characteristics analyzed included the teaching status of hospital. We also analyzed self-reported pain scores, with pain scores of 8 or higher categorized as severe pain and scores of 7 or lower categorized as non-severe pain.

We also examined medications used during ED visits. Medications were classified generally as opioids; specific drugs are available in Appendix B. We analyzed the use of specific, commonly used opioids, including codeine, hydrocodone, hydromorphone, morphine and oxycodone.

Data Analysis

To examine trends in medication utilization, we tabulated survey-weighted proportions of visits in which patients received opioids, stratified by subgroup. Differences in proportions by year were tested using survey-weighted chi-square analyses. To compare proportions in the grouped years at the ends of the study period, we used survey-weighted linear combinations of estimates. To investigate factors associated with opioid utilization in patients aged 65 years or older, we constructed a survey-weighted logistic regression model. The regression model was constructed using opioids as the dependent variable. We entered all relevant clinical and demographic variables as independent variables. The odds of receiving opioids were adjusted for age group, sex, race, disposition, region, and type of pain. All analyses were conducted using Stata, version 14 (College Station, TX). P-values of < 0.05 were considered significant.

RESULTS

Trends in Opioid Administration in the ED

The NHAMCS database included 21.0 million ED visits for painful conditions in patients ≥18 years old who were administered opioids in 2005-06 and 21.7 million visits in 2014-15. Comparing the beginning of the study period in 2005-06 to the end 2014-15, we found no significant change in opioid administration in the ED in adult encounters 65-74, 75-84 or ≥85 years of age, while noting a significant decline in patients 18-64 (Table 1). In 2005-06, rates of opioid administration were similar for visits with patients <85 years (range 22.9-23.4%) with considerably lower rates in 85+ visits (18.7%); however, by 2014-15 rates were lower in the 18-64 group (18.6%) and were slightly lower in visits by patients aged 65-84, and had remained stable for the 85+ group. When assessed by year in graphical form, opioid administration from 2005-15 demonstrated a rise in use in all age groups from 2005-11 with the steepest rise in visits with patients 85+. This was followed by a decline in all age groups (Figure 1A).

In subgroup analyses of encounters with patients ≥ 65, we found that opioid administration in encounters declined in females from 2005-06 to 2014-15 (absolute decrease of 5.4%, p-value = 0.007), during encounters with headaches (absolute decrease of 10.9%, p-value 0.013) and musculoskeletal pain (absolute decrease of 6.8%, p-value 0.009). There was no change in administration for the other subgroups or by specific types of pain (Table 2).

Trends in Opioid Prescribing From the ED

The NHAMCS database included 15.0 million ED visits for painful conditions in encounters for patients ≥18 years old who were prescribed opioids at discharge from the ED in 2005-06 and 13.3 million visits in 2014-15. Comparing 2005-06 to 2014-15, we found no significant change in opioid prescribing to adults 65-74 and 75-84 years of age from the ED. There was a significant decline in opioid prescribing to patients aged 18-64 (absolute decrease of 5.8%, p-value 0.001) (Table 1). When we graphed opioid prescribing over time, we noted a rise from 2005-11, followed by a sharp decline in opioid administration for 18-64 year olds, and less so for other age groups (Figure 1B). There was no change in prescribing based on demographic factors or types of pain from 2005-06 to 2014-15 (Table 2).

Trends in Specific Opioid Administration and Prescribing

From 2005-06 to 2014-15, hydromorphone had a large increase in administration to adults ≥ 65 with an overall relative increase of 75.6% (Table 3). There were insufficient data to determine changes in administration of oxycodone, hydrocodone, or codeine. There were also insufficient data to determine changes in prescribing of hydromorphone, morphine, oxycodone, hydrocodone and codeine.

Table 1. Percentage of patients presenting to United States emergency departments with a painful condition and administered or prescribed opioids, stratified by age, from the National Hospital Ambulatory Medical Care Survey: 2005-2015.

Age	Estimated number of visits 2005-06	2005-06	95% CI	Estimated number of visits 2014-15	2014-15	95% CI	Relative change	Absolute change	95% CI	P value
Opioids administered in the ED										
18-64	17,113,649	23.3%	(21.9-24.6)	17,191,523	18.6%	(16.7-20.4)	-20.2%	-4.7%	(-6.9-2.4)	0.001*
65-74	2,367,473	22.9%	(20.7-25.0)	2,865,244	20.0%	(17.3-22.6)	-12.7%	-2.9%	(-6.4-0.6)	0.109
75-84	1,051,919	23.4%	(20.3-26.4)	1,119,566	20.3%	(16.6-24.0)	-13.2%	-3.1%	(-7.7-1.7)	0.205
85+	423,000	18.7%	(14.6-22.8)	568,705	18.5%	(13.9-23.2)	-1.1%	-0.2%	(-6.4-6.1)	0.957
Opioids prescribed at discharge										
18-64	13,389,541	18.2%	(17.0-19.4)	11,453,917	12.4%	(11.0-13.8)	-31.9%	-5.8%	(-7.8-3.9)	0.001*
65-74	1,073,687	10.4%	(8.8-12.0)	1,203,855	8.4%	(6.1-10.7)	-19.2%	-2.0%	(-4.7-0.8)	0.161
75-84	422,774	9.4%	(7.4-11.4)	500,111	9.1%	(6.2-12.0)	-3.2%	-0.3%	(-3.9-3.3)	0.869
85+	135,660	-	-	159,490	-	-	-	-	-	-

(-) = Insufficient data, (*) = Significant finding.
CI, confidence interval; *ED*, emergency department.

Demographic Factors that Predict Opioid Administration and Prescribing

For both administered and prescribed opioids in older adults, there were significant demographic and visit specific factors that influenced usage (Table 4). Younger age, White race, female gender, hospital location in the Midwest, South or West, admission of patient, a high pain score, diagnostic imaging, ED procedures, blood work, and presentation for abdominal pain, back pain and musculoskeletal pain were all associated with opioid administration in the ED. Patients presenting with chest pain and dental pain were less likely to receive an opioid in the ED. Younger age, hospital location in the South or West, a high pain score, use of computed tomography/magnetic resonance imaging, and presentation for back pain and musculoskeletal pain were associated with higher prescribing of opioids at discharge from the ED. Patients who had blood work done in the ED or presented with chest pain were less likely to receive an opioid prescription.

DISCUSSION

In this nationally representative sample, we demonstrate the rise and fall of opioid administration and prescribing over the decade 2005-15. There were disparities in prescribing by age, where younger patients appear to have greater declines in both opioid prescribing and administration than older patients, particularly after 2011 when evidence of the opioid crisis was emerging in the popular media and in public health circles. However, rates of prescribing appear to be more impacted by older age than administration of opioids in the ED. This may be the case because in the ED, patients – in particular older adults – can be observed closely for adverse reactions. By contrast, people receiving discharged prescriptions cannot be directly observed for adverse effects, which tend to be greater in older adults. Our study also extends prior work that demonstrated a rise in opioid use and administration from 2001-2010.[13] That study, however, analyzed combined opioid administration and prescribing, as prior to 2005 these were not separate variables in the NHAMCS database. Another study that looked at the National Ambulatory Medical Care Survey (NAMCS), found that opioid prescribing to adults ≥65 in outpatient clinics, more than doubled from 1999-2010.[17] Another similar study using the NAMCS database found a nine-fold increase in prescriptions from 1995 to 2010.[18]

The reasons for our findings are likely multi-factorial and related to increased awareness of the opioid epidemic and to the implementation of mitigation strategies. The increasing use of prescription drug monitoring programs in the past decade has been associated with decreased opioid prescribing.[19,20,21] In the past 10 years the CDC and the American College of Emergency Physicians, as well as several states (New York, Ohio and Washington), have developed prescribing guidelines for opioids.[22,23] These factors along with a national recognition of concerns for over-prescribing and divergence of opioids may be contributing to the decline in opioid prescribing in the general adult population and the stable usage in older adult populations, rather than an increasing trend.

Prior studies have demonstrated disparities in prescribing and administering to older adults in the ED. These studies had suggested that older adults with acute pain received less analgesia and, specifically, fewer opioids than younger patients in the ED and upon discharge.[24,25] Our study indicates that while this may be an issue when prescribing opioids upon

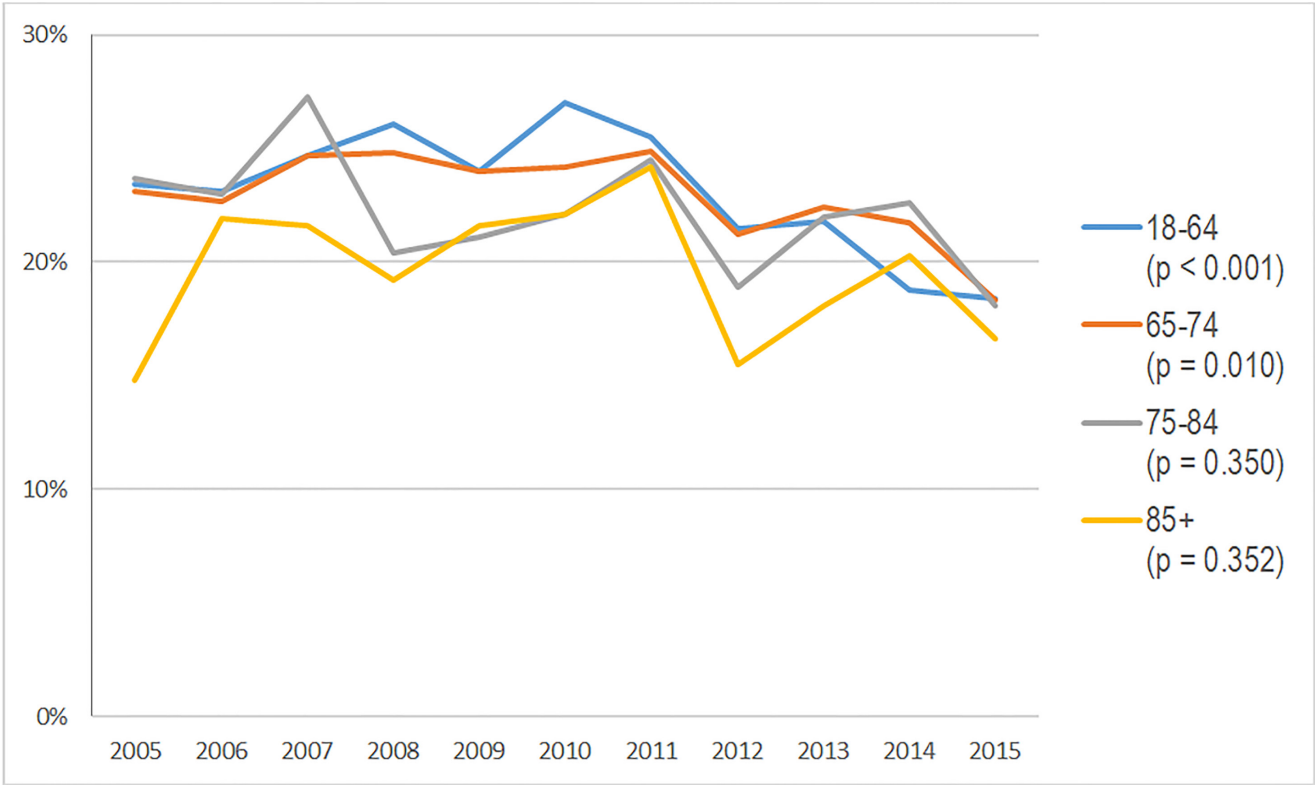

Figure 1A. Percentage of patients presenting to United States emergency departments with a painful condition and administered opioids, stratified by age, from the National Hospital Ambulatory Medical Care Survey: 2005-2015.

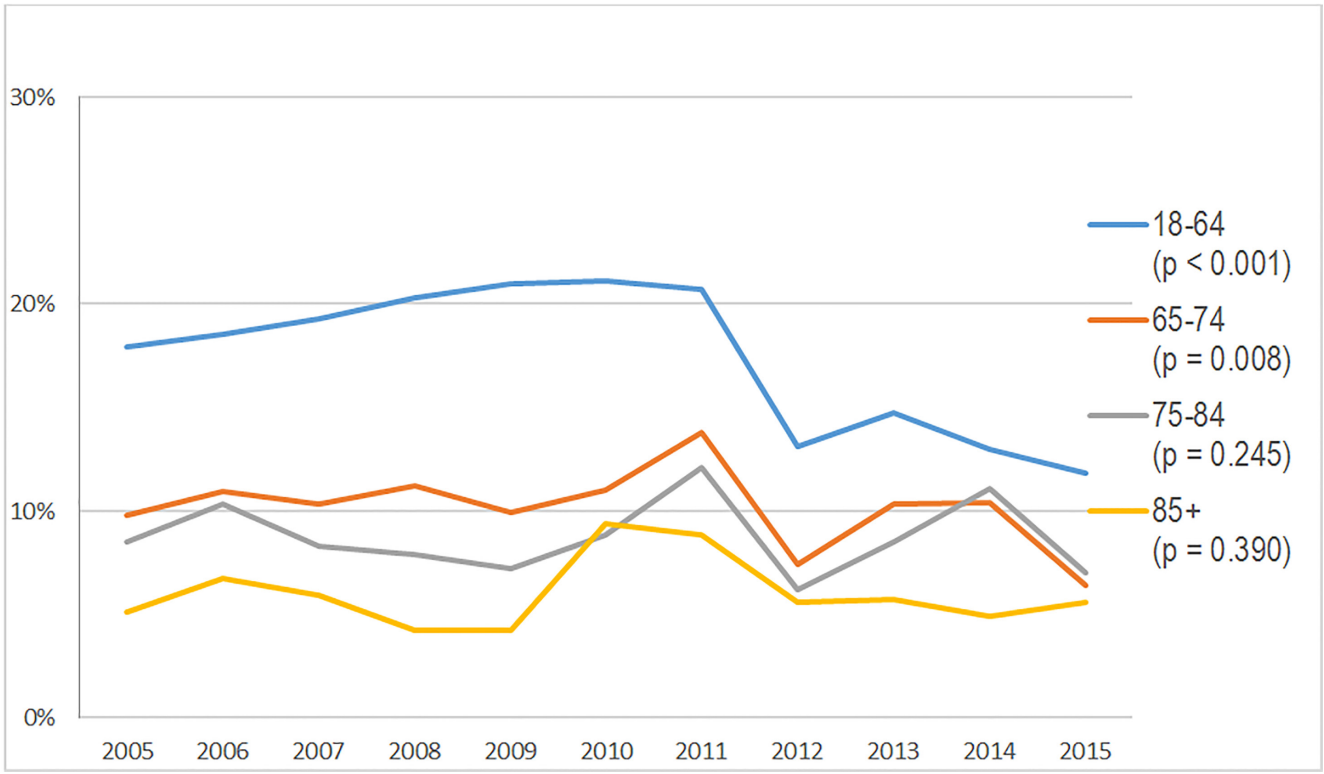

Figure 1B. Percentage of patients presenting to United States emergency departments with a painful condition and prescribed opioids, stratified by age, from the National Hospital Ambulatory Medical Care Survey: 2005-2015.

Table 2. Percentage of patients ≥ 65, presenting to United States emergency departments with a painful condition and administered or prescribed opioids, stratified by demographic factors and pain type, from the National Hospital Ambulatory Medical Care Survey: 2005-2015.

	2005-06	95% CI	2014-15	95% CI	Relative change	Absolute change	95% CI	P value
Opioids administered in the ED								
Male	19.7%	(16.9-22.5)	21.8%	(17.6-26.1)	10.7%	2.1%	(-2.9-7.2)	0.408
Female	23.7%	(21.2-26.1)	18.3%	(15.6-21.1)	-22.8%	-5.4%	(-9.2--1.5)	0.007*
White	22.6%	(20.5-24.7)	19.6%	(16.7-22.4)	-13.3%	-3.0%	(-6.7-0.6)	0.105
Non-white	19.9%	(15.5-24.2)	20.7%	(16.5-24.9)	4.0%	0.8%	(-5.4-7.0)	0.798
Admitted	28.1%	(24.7-31.4)	30.7%	(25.3-36.2)	9.3%	2.6%	(-3.9-9.2)	0.426
Discharged	19.6%	(17.2-21.9)	16.7%	(14.2-19.2)	-14.8%	-2.9%	(-6.4-0.7)	0.111
Northeast	17.7%	(15.0-20.4)	14.1%	(9.2-19.1)	-20.3%	-3.6%	(-9.2-2.1)	0.213
Midwest	25.1%	(20.1-30.0)	22.6%	(18.5-26.7)	-10.0%	-2.5%	(-9.2-4.3)	0.471
South	22.4%	(19.2-25.6)	21.0%	(16.0-26.1)	-6.3%	-1.4%	(-7.5-4.6)	0.644
West	23.2%	(18.7-27.6)	18.5%	(14.9-22.2)	-20.3%	-4.7%	(-10.4-1.1)	0.113
Chest pain	14.5%	(11.6-17.4)	14.3%	(10.4-18.3)	-1.4%	-0.2%	(-5.2-4.8)	0.944
Abdominal pain	30.3%	(25.8-34.7)	27.9%	(23.5-32.3)	-7.9%	-2.4%	(-8.5-3.8)	0.45
Back pain	29.3%	(23.9-34.8)	27.9%	(20.3-35.4)	-4.8%	-1.4%	(-11.0-8.0)	0.756
Headache	22.5%	(16.0-29.0)	11.6%	(6.7-16.4)	-48.4%	-10.9%	(-19.6-2.3)	0.013*
Musculoskeletal pain	25.8%	(22.3-29.2)	19.0%	(15.3-22.8)	-26.4%	-6.8%	(-11.8-1.7)	0.009*
Tooth/mouth pain	-	-	-	-	-	-	-	-
Opioids prescribed at discharge								
Male	9.5%	(7.5-11.6)	8.4%	(5.5-11.3)	-11.6%	-1.1%	(-4.9-2.6)	0.554
Female	9.6%	(7.9-11.3)	7.5%	(5.4-9.5)	-21.9%	-2.1%	(-4.8-0.4)	0.102
White	9.8%	(8.3-11.3)	7.7%	(5.4-10.0)	-21.4%	-2.1%	(-4.9-0.7)	0.146
Non-white	8.6%	(5.1-12.1)	8.4%	(5.0-11.7)	-2.3%	-0.2%	(-4.7-4.3)	0.924
Northeast	-	-	-	-	-	-	-	-
Midwest	8.3%	(6.2-10.4)	9.3%	(3.7-15.0)	12.0%	1.0%	(-5.1-7.2)	0.738
South	11.9%	(8.7-15.1)	8.9%	(6.0-11.9)	-25.2%	-3.0%	(-7.2-1.3)	0.17
West	9.4%	(7.2-11.7)	8.0%	(5.2-10.7)	-14.9%	-1.4%	(-5.1-2.1)	0.422
Chest pain	-	-	-	-	-	-	-	-
Abdominal pain	6.9%	(4.5-9.4)	4.6%	(2.5-6.8)	-33.3%	-2.3%	(-5.5-0.9)	0.164
Back pain	17.9%	(12.6-23.2)	16.5%	(9.3-23.6)	-7.8%	-1.4%	(-10.6-7.7)	0.758
Headache	-	-	-	-	-	-	-	-
Musculoskeletal pain	13.7%	(11.2-16.1)	9.8%	(6.8-12.9)	-28.5%	-3.9%	(-7.7-0.0)	0.053
Tooth/mouth pain	-	-	-	-	-	-	-	-

(-) = Insufficient data, (*) = Significant finding.
CI, confidence interval; *ED*, emergency department.

discharge, it has not been an issue with regard to administration of opioids in the ED. The noted decreases in administration and prescribing of opioids to adults 18-64, may have contributed to the similar rates in opioid use between age groups. The lack of significant decline in opioid administration and prescribing to older adults suggests that ED practitioners, although limiting the use of opioids in the general adult population, are aware of the importance of adequate pain control in older adults and of recent guidelines endorsing this.

Administration of opioids in the ED may be necessary for older adults presenting with acute pain or uncontrolled chronic pain. The Beers criteria, developed in 1991 and most recently

expanded and revised in 2015, and the screening tool of older people's prescriptions (STOPP) criteria introduced in 2008, provide physicians with lists of medications to avoid or use with caution in older adults. The Beers criteria note meperidine, muscle relaxants, benzodiazepines, tricyclic antidepressants and long-term use of non-cox selective non-steroidal anti-inflammatory drugs (NSAIDs) as medications to avoid in older adults, but does not list opioids as medications to avoid.[26,27] The STOPP criteria similarly recommends the avoidance of NSAIDs, tricyclic antidepressants, and benzodiazepines in older adults, and discusses avoidance of long-term opioid therapy in patients with chronic constipation, falls, dementia and in those with mild pain. The STOPP criteria explain, however, that opioid therapy is justified in patients with moderate to severe pain or in palliative care.[28]

Administering opioids to older adults is not without risks, and these risks need to be carefully considered prior to starting opioid therapies. A recent meta-analysis demonstrated that opioids are associated with an increased risk of developing delirium in adults (odds ratio [OR] [2.5], 95% confidence interval [CI] [1.2-5.2])[29] Yet it has also been shown that inadequate treatment of pain is related to increased rates of delirium.[30] Older adults are also frequently on multiple medications that increase their risks of adverse drug events related to interactions with opioids.[31] Not only are older adults susceptible to drug-drug interactions, but also to drug-disease interactions. A retrospective analysis of national-level data from Germany showed that 72% of patients prescribed an opioid had the potential for drug-disease interactions.[32] A population-based cohort study from Canada found a 37% greater risk of fractures or soft tissue injury with low-potency opioids and a 43% greater injury risk for high- potency opioids in adults ≥ 65.[33]

It is also important to note that although opioid addiction and abuse rates are low for older adults with no past medical history of substance abuse, prescribers should be aware of the epidemic of drug overdose deaths related to opioids in the U.S. There was a 200% increase in deaths related to drug overdoses involving opioid pain relievers and heroin from 2000 to 2014.[15] Awareness of the opioid epidemic can likely account for the declines in both opioid administration and prescribing in patients aged 18-64. Judicious prescribing is critical in the older adult population as well. Studies have reported increasing rates of abuse of prescription opioids and worse outcomes following misuse of opioids for older adults compared to younger adults.[34,35] U.S. ED visits for opioid overdose quadrupled between 1993 and 2010, with patients >50 years of age accounting for a 231% increase.[36] A study evaluating the shifting demographics of patients in opioid treatment facilities in New York from 1996-2012, found the largest increases in utilization of opioid treatment programs were in adults ≥50 and that by 2012, adults 50-59 made up the largest age group in treatment facilities.[37] Given these risks for misuse and opioid-related injuries, the American Geriatrics Society (AGS) recommends using initial assessment tools such as the Opioid Risk Tool and the Screener and Opioid Assessment for Patients with Pain (SOAPPR) to screen for patients at risk for opioid addiction and misuse.[38,39]

Over the studied time period, we found unique differences in demographics, visit and hospital-related factors between patients ≥65 who were administered or prescribed opioids. Race and gender only seemed to be a factor in administration of opioids to older adults in the ED, with women and patients of White race associated with higher rates of administration in the ED. This discrepancy was not seen in prescribing of opioids to older adults from the ED. Discrepancies in opioid prescribing have been noted in prior studies, with White patients and

Table 3. Specific opioid administration and prescribing rates to adults ≥ 65 presenting to United States emergency departments with pain, from the National Hospital Ambulatory Medical Care Survey: 2005-2015.

	2005-06	95% CI	2014-15	95% CI	Relative change	Absolute change	95% CI	P value
Opioids administered in the ED								
Hydrocodone	3.0%	(2.3-3.8)	2.7%	(1.9-3.5)	-10.0%	-0.3%	(-1.5-0.8)	0.556
Hydromorphone	4.5%	(3.4-5.6)	7.9%	(6.2-9.6)	75.6%	3.4%	(1.4-5.4)	0.001*
Morphine	10.0%	(8.5-11.5)	9.3%	(7.7-10.9)	-7.0%	-0.7%	(-3.0-1.6)	0.549
Any opioids	22.1%	(20.2-24.1)	19.7%	(17.2-22.2)	-10.9%	-2.4%	(-5.7-0.9)	0.151
Opioids prescribed at discharge								
Hydrocodone	6.9%	(5.6-8.2)	6.3%	(4.8-7.8)	-8.7%	-0.6%	(-2.5-1.4)	0.564
Any opioids	9.6%	(8.2-11.0)	7.8%	(5.8-9.8)	-18.8%	-1.8%	(-4.2-0.7)	0.157

(-) = Insufficient data, (*) = Significant finding.
CI, confidence interval; *ED*, emergency department.

Table 4. Characteristics of opioid administration and prescribing to patients ≥ 65 presenting to United States emergency departments with pain, from the National Hospital Ambulatory Medical Care Survey: 2005-2015.

	Administered in ED N=18,415,097			Prescribed at discharge N=7,718,120		
Total estimated number of visits	AOR	95% CI	P value	AOR	95% CI	P value
Age						
65-74	Ref	Ref	Ref	Ref	Ref	Ref
75-84	0.82	(0.73-0.92)	0.001*	0.72	(0.60-0.85)	0.001*
85+	0.66	(0.57-0.76)	0.001*	0.49	(0.39-0.62)	0.001*
Race						
Non-white	Ref	Ref	Ref	Ref	Ref	Ref
White	1.25	(1.06-1.49)	0.009*	1.01	(0.80-1.28)	0.905
Sex						
Male	Ref	Ref	Ref	Ref	Ref	Ref
Female	1.2	(1.07-1.35)	0.003*	0.94	(0.79-1.11)	0.441
Region						
Northeast	Ref	Ref	Ref	Ref	Ref	Ref
Midwest	1.81	(1.42-2.29)	0.001*	1.05	(0.80-1.39)	0.707
South	1.36	(1.09-1.69)	0.006*	1.41	(1.05-1.90)	0.022*
West	1.48	(1.18-1.86)	0.001*	1.48	(1.11-1.97)	0.007*
Admitted						
No	Ref	Ref	Ref			
Yes	1.64	(1.41-1.90)	0.001*			
Teaching status of hospital						
Teaching	Ref	Ref	Ref	Ref	Ref	Ref
Non-teaching	1.03	(0.83-1.27)	0.81	1.22	(0.94-1.57)	0.136
Severe pain (Pain score ≥8)						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	2.8	(2.50-3.14)	0.001*	1.75	(1.50-2.04)	0.001*
Imaging						
CT/MRI	1.73	(1.55-1.94)	0.001*	1.4	(1.17-1.68)	0.001*
X-ray	1.19	(1.06-1.34)	0.004*	0.99	(0.85-1.15)	0.887
Ultrasound	1.34	(1.01-1.78)	0.045*	1.02	(0.73-1.41)	0.926
Procedure in ED						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.85	(1.62-2.13)	0.001*	0.93	(0.78-1.11)	0.412
Blood work						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.25	(1.09-1.42)	0.001*	0.53	(0.44-0.63)	0.001*
Painful condition						
Other pain	Ref	Ref	Ref	Ref	Ref	Ref
Chest pain	0.62	(0.52-0.75)	0.001*	0.32	(0.23-0.45)	0.001*
Abdominal pain	1.29	(1.08-1.55)	0.006*	0.81	(0.63-1.03)	0.082
Back pain	1.74	(1.46-2.08)	0.001*	1.42	(1.15-1.77)	0.001*
Headache	0.87	(0.66-1.13)	0.29	0.7	(0.48-1.03)	0.07
Musculoskeletal pain	1.47	(1.25-1.73)	0.001*	1.28	(1.04-1.56)	0.017*
Tooth/mouth pain	0.47	(0.23-0.94)	0.033*	0.8	(0.43-1.48)	0.472

(*) = significant finding.
CI, confidence interval; *ED*, emergency department; *AOR*, adjusted odds ratio; *Ref*, reference; *MRI*, Magnetic resonance imaging; *CT*, Computed tomography.

women more likely to receive opioids for painful conditions than other ethnicities or men; however, we did not note this difference in our older adult population.[40,41] Older adults who were admitted to the hospital were more likely to be administered an opioid in the ED, suggesting that patients receiving opioids in the ED may have a higher acuity illness. Older adults with chest pain and dental pain were less likely to be administered and prescribed opioids. This is in keeping with current recommendations for treating acute coronary syndrome, which recommends opioids as second-line therapy for chest pain after the use of nitroglycerin.[42] Recent guidelines also do not recommend the use of opioids for dental pain.[43]

Specific opioids also deserve further discussion when considering the changing physiology of aging. Although there has been minimal change in overall opioid-prescribing rates to older adults and especially among the oldest old, we demonstrate a shift towards the use of more potent opioids. Hydromorphone had the greatest increase in administration from 2005-2006 to 2014-15 with a relative increase of 76%. Parenteral hydromorphone is 7-11 times more potent than parenteral morphine and eight times more potent orally than the equivalent morphine dose.[44,45] A prospective cohort trial evaluating intravenous (IV) opioids (morphine and hydromorphone) dosing and outcomes in the ED demonstrated that among patients receiving 1 mg of IV hydromorphone, 15% of patients were over-sedated and 4% were noted to be confused.[46]

While we were unable to determine dosing used in the ED, it is recommended that initial doses of opioid therapy for older adults be lower than those employed by a younger population and slow titration should be done in a carefully monitored setting.[47,48] This concept is even more important in patients who have hepatic or renal impairment. Opioids are primarily metabolized by the liver and create several active and inactive metabolites that undergo renal excretion.[49] Therefore, dose adjustments are required when prescribing opioids to patients with significant hepatic and renal impairment.[50]

Guidelines have been established to aid the physician in choosing appropriate therapeutic regimens. In response to the paucity of literature on pain management in older adults, the AGS published a set of guidelines in 1998 to establish pain evaluation and pharmacological recommendations for older adults. The guidelines emphasize the importance of completing a thorough assessment of pain, determining the effects of pain on activities of daily living and instrumental activities of daily living (i.e., key tasks that enable safe and independent living), optimizing disease management, and frequent reevaluation for improvement, deterioration or complications from treatment.[51]

LIMITATIONS

Our study has several limitations. First, it is unclear based on the data whether pain medication was indicated or desired by the patient based on the information available. Neither was it possible to assess for any cognitive deficits in the older-adult populations that may have affected opioid administration and prescribing. Additionally, although the data collection procedures were designed to make a sample representation of the population, there may be inaccuracies. However, the consistency of the NHAMCS methodology should protect against major inaccuracies.[52] Because information in the database was obtained from individual ED visits, it was impossible to obtain longitudinal information on individuals or determine appropriateness of therapy. Data regarding dosing of medications are also not included. Finally, the chosen reasons for visits, although reviewed by four authors, did not include all the reasons for visit for which an opioid may be prescribed.

CONCLUSION

In conclusion, we demonstrate the rise and fall of opioids in U.S. EDs from 2005-15, where there were clear disparities by age group, more so for prescribing than for administrations. ED providers need to be aware of increasing rates of opioid abuse and misuse in older adults and should use opioids judiciously. ED providers should also be aware of the multiple published guidelines that emphasize the importance of pain control in older adults, a thorough evaluation of painful conditions, low initial dosages of pain medications, careful titration and thorough follow-up. Further research needs to be conducted into the effects of such published guidelines on opioid use in older adults and the rates of divergence, misuse and abuse in this particularly vulnerable population.

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Cost of Routine Herpes Simplex Virus Infection Visits to U.S. Emergency Departments 2006-2013

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Introduction: Little is known about emergency department (ED) utilization for herpes simplex viruses (HSV) types 1 and 2 in the United States. Our goal was to determine the utilization and cost burden associated with HSV infection visits to U.S. EDs in recent years from 2006-2013.

Methods: We analyzed the Nationwide Emergency Department Sample (NEDS) database, the largest national database of hospital-based ED visits in the U.S., to determine the number of visits and the cost associated with HSV visits from 2006-2013. We also analyzed trends across years.

Results: From 2006-2013, there were 704,728 ED visits with a primary diagnosis of HSV infection. Of these, 658,805 (93.5%) resulted in routine discharges without inpatient admission, amounting to a total ED charge of $543.0 million. After adjusting for inflation, there was a doubling of total ED spending for HSV from 2006 to 2013 ($45.0 million to $90.7 million) and a 24% increase in number of visits (73,227 visits in 2006, vs. 90,627 visits in 2013). ED visits for genital herpes have increased while visits for herpes gingivostomatitis have decreased.

Conclusion: HSV-associated ED use and associated costs have increased between 2006-2013. Most of these cases could likely be managed in non-emergent outpatient settings as 93.5% of visits resulted in routine discharges without admission . Our findings add to knowledge regarding HSV utilization and epidemiology in the U.S. and highlight the need for continued prevention, patient education, and emphasis of care in non-emergency settings to prevent unnecessary ED utilization. [West J Emerg Med. 2018;19(4)689-692.]

INTRODUCTION

Herpes simplex virus type 1 (HSV-1) and type 2 (HSV-2) are common viral infections with an estimated seroprevalence of 53.9% and 15.7% in the United States, respectively, from 2005-2010.[1] Although both viruses can have systemic sequelae, uncomplicated HSV infections are most commonly self-limited and treated in an outpatient non-emergent setting. Despite the commonality of HSV, little is known about the incidence of symptomatic cases and the economic burden of HSV infection on national healthcare expenditures. In this study, we aimed to characterize the utilization and cost burden associated with HSV infection visits to U.S. emergency departments (ED) from 2006 through 2013.

METHODS

We used the Healthcare Cost and Utilization Project Nationwide Emergency Department Sample (NEDS) database, which is the largest all-payer national database of hospital-based ED visits in the U.S.[2] The database contains data for roughly 30 million ED visits each year and approximately 135 million weighted ED visits in total. The database contains information such as diagnoses of ED visits searchable through *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes, patient demographic information, ED charges for ED visits, and total hospital charges for ED-related admissions.[2] We searched the database for visits for HSV infection in the years 2006-2013 using ICD-9-CM codes 054.0-054.9. These codes have a positive predictive value of 86% in identifying cases of HSV infection.[3]

We identified HSV ED visits with routine discharges – defined as visits that did not result in an in-patient admission – in the NEDS database, and we calculated visit counts and total ED charges using demographic and clinical variables. Annual charges were adjusted for inflation to 2016 dollars using the Medical Care Consumer Price Index.[5] A multivariable linear regression model was constructed to calculate adjusted mean charges. We used survey procedures in SAS 9.4 to produce national estimates based on the stratified, single-stage cluster design of the NEDS database. This study was deemed exempt by the Partners Healthcare institutional review board.

RESULTS

From 2006-2013, a total of 1,024,771,257 visits were made to the ED, 704,728 (0.069%) of which were visits with a primary diagnosis of HSV infection. Of these, 658,805 (93.5%) were ED visits with routine discharges that did not result in an inpatient admission, amounting to a total ED charge of $543.0 million**.** The mean age of patients was 25.2 years, 63.6% of whom were female (Table 1).

Adjusted mean visit charges were higher for those age ≥ 50 years (p=.010), female (p<.001), diagnosed with genital herpes or herpes simplex with complication (p<.001), with concurrent chronic conditions (p<.001), or with private insurance (p<.001) (Table 1).

Total HSV ED visits and spending, after adjusting for inflation, increased annually from 2006-2013 (73,227 visits, $45.0 million in 2006 vs. 90,627 visits, $90.7 million in 2013). Annual visits for genital herpes have increased (n=24,747, 33.8% in 2006 vs. n=36,518, 40.3% in 2013) while visits for herpetic gingivostomatitis decreased (n=14,934, 20.4% in 2006 vs. n=12,061, 13.3% in 2013) (Table 2).

DISCUSSION

Our study demonstrates that routine HSV infection accounted for 658,805 ED visits and $543.0 million in ED charges over eight years from 2006-2013. Trends across years, after adjusting for inflation, show an approximate doubling of ED spending on routine HSV infections from 2006 to 2013 ($45.0 million to $90.7 million), and a 24% increase in number of visits (73,227 visits in 2006, vs. 90,627 visits in 2013).

ED visits for genital herpes between 2006 and 2013 have increased while visits for herpes gingivostomatitis have decreased. This finding is consistent with reports of increased rates of genital HSV-1 infections in the setting of possible lack of protection from pre-existing orolabial HSV-1 antibodies, and it highlights the evolving epidemiology of this disease. [1]

These findings add to the existing literature on HSV prevalence and epidemiology in the U.S. by providing data on the national ED utilization and charge pattern for HSV infection. Routine HSV infections can largely be treated in non-urgent, outpatient settings. In our cohort, 68% of the patients had insurance coverage, while only 3.9% had herpes simplex with complication, suggesting that the majority of ED utilization for HSV infection could have been transitioned to non-urgent care settings to prevent unnecessary ED use.

Adjusted mean ED charges were higher for females ($981, p<.001) or those with private insurance ($943, p<.001). Protocol differences between ED management of males vs. females (e.g., routine human chorionic gonadotropin urine tests for females) may have contributed to the differences; additionally, higher costs may also be charged to private insurances as compared to Medicare and Medicaid. The overall increase in cost could be a function of increased diagnostic evaluation such as direct fluorescent-antibody testing. Unfortunately, this dataset does not provide itemized charges, so direct contributors to cost cannot be determined.

Limited access to primary care, convenience of ED access, and patient alarm in the case of genital herpes may have played a role in the utilization of the ED for routine HSV infections. Younger patients are more likely to visit the ED for non-urgent conditions and may be a target for future intervention.[6] Public health efforts should focus on patient education and improving alternative access to care to reduce reliance on ED services for HSV. Efforts to provide easier access to medications via teledermatology consultation or over-the-counter access, especially for patients with established diagnoses may reduce utilization.

LIMITATIONS

Our findings should be interpreted in the context of the study design. The NEDS database provides ED/hospital charges but does not have information regarding reimbursed amounts or fees paid to physicians and other professionals.[2] As with other NEDS studies, charges may not be fully reimbursed, and thus our findings in this study may overestimate the overall costs. This limitation is

Table 1. Nationwide herpes simplex virus infection emergency department routine disposition visits and costs 2006-2013.

	Visits with primary diagnosis of herpes simplex, n (%)	Total ED charge amount , $	Adjusted mean ED charge amount, $ (SE)	P value
Overall	658805	543042020		
Age				
< 30	460176 (69.9)	377448792	893 (22)	0.010
30-49	147017 (22.3)	123345760	865 (23)	
≥ 50	51612 (7.8)	42247468	904 (27)	
Gender				
Male	239536 (36.4)	164701372	793 (22)	<0.001
Female	419168 (63.6)	378291212	981 (23)	
Month of visit				
December – February	133962 (24.5)	102712319	893 (23)	0.007
March – May	136142 (24.9)	101231443	868 (23)	
June – August	141704 (25.9)	108318381	886 (23)	
September – November	135313 (24.7)	105544641	902 (22)	
Primary diagnosis				
Genital herpes	245484 (37.3)	278335295	1069 (21)	<0.001
Herpetic gingivostomatitis	115726 (17.6)	71019956	773 (18)	
Herpetic whitlow	19976 (3.0)	13124601	771 (21)	
Herpes simplex with complication	25717 (3.9)	22295131	1079 (84)	
Herpes simplex without mention of complication	251903 (38.2)	158267035	743 (15)	
Chronic Condition Indicator				
Concurrent chronic condition present*	339708 (51.6)	338918844	986 (24)	<0.001
No concurrent chronic condition	319098 (48.4)	204123176	788 (22)	
Primary payer				
Medicare	32993 (5.0)	64007415	905 (29)	<0.001
Medicaid	233494 (35.6)	103960789	859 (22)	
Private insurance	179528 (27.4)	112467580	943 (25)	
Self-pay	177287 (27.0)	67474745	868 (22)	
Other	32985 (5.0)	12990891	861 (38)	

SE, standard error; *ED*, emergency department.
*The NEDS database defines a chronic condition as "a condition that lasts 12 months or longer and meets one or both of the following tests: (a) it places limitations on self-care, independent living, and social interactions; (b) it results in the need for ingoing intervention with medical products, services, and special equipment (see Perrin et al., 1993). The identification of chronic conditions is based on all 5-digit ICD-9-CM codes. E Codes, or external injury codes, are not classified, because all injuries are assumed to be acute." Subcategories may not sum to totals due to missing values.

unlikely to significantly impact the year-to-year comparison and overall trends.

CONCLUSION

In summary, our study demonstrates the increasing costs associated with treatment of HSV in U.S. EDs. As most of these patients were routine discharges, much of this care could have likely been provided in alternative, lower-cost settings. Our findings highlight the need for continued prevention, patient education, and emphasis of care in non-emergency settings to prevent unnecessary ED use for routine HSV infections.

Table 2. Nationwide herpes simplex emergency department (ED) visit and charges 2006-2013 by year.

Year, n	2006	2007	2008	2009	2010	2011	2012	2013
No. of visits, n	73227	77477	76227	78001	88063	86456	88729	90627
Age, n (%)								
< 30	51200 (69.9)	54599 (70.5)	54313 (71.3)	55495 (71.1)	61427 (69.8)	60395 (69.9)	61074 (68.8)	61671 (68.0)
30-49	16590 (22.7)	16945 (21.9)	16357 (21.5)	16642 (21.3)	19862 (22.6)	19086 (22.1)	20308 (22.9)	21227 (23.4)
≥ 50	5436 (7.4)	5932 (7.7)	5557 (7.3)	5863 (7.5)	6773 (7.7)	6975 (8.1)	7346 (8.3)	7729 (8.5)
Gender, n (%)								
Male	27736 (37.9)	28431 (36.7)	27927 (36.6)	28602 (36.7)	31353 (35.6)	31155 (36.0)	32163 (36.3)	32168 (35.5)
Female	45486 (62.1)	49030 (63.3)	48299 (63.4)	49343 (63.3)	56704 (64.4)	55301 (64.0)	56543 (63.7)	58459 (64.5)
Primary diagnosis, n (%)								
Genital herpes	24747 (33.8)	26440 (34.1)	27484 (36.1)	28440 (36.5)	33258 (37.8)	33095 (38.3)	35501 (40.0)	36518 (40.3)
Herpetic gingivostomatitis	14934 (20.4)	15620 (20.2)	14802 (19.4)	14154 (18.1)	14908 (16.9)	15691 (18.1)	13557 (15.3)	12061 (13.3)
Herpetic whitlow	2227 (3.0)	2305 (3.0)	2376 (3.1)	2144 (2.7)	2589 (2.9)	2606 (3.0)	2796 (3.2)	2934 (3.2)
Herpes simplex w/ complication	3762 (5.1)	2775 (3.6)	2047 (2.7)	2649 (3.4)	3413 (3.9)	3492 (4.0)	3455 (3.9)	4123 (4.5)
Herpes simplex w/o complication	27557 (37.6)	30336 (39.2)	29517 (38.7)	30615 (39.2)	33894 (38.5)	31572 (36.5)	33421 (37.7)	34991 (38.6)
Total ED charge amount, $	44973742	51725820	55437779	61336526	76707637	78232385	83950203	90677926

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Anaphylaxis-related Malpractice Lawsuits

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Introduction: Anaphylaxis continues to cause significant morbidity and mortality. Healthcare providers struggle to promptly recognize and appropriately treat anaphylaxis patients. The goal of this study was to characterize anaphylaxis-related malpractice lawsuits.

Methods: We collected jury verdicts, settlements, and court opinions regarding alleged medical malpractice involving anaphylaxis from May 2011 through May 2016 from an online legal database (Thomson Reuters Westlaw). Data were abstracted onto a standardized data form.

Results: We identified 30 anaphylaxis-related malpractice lawsuits. In 80% of cases, the trigger was iatrogenic (40% intravenous [IV] contrast, 33% medications, 7% latex). Sixteen (53%) cases resulted in death, 7 (23%) in permanent cardiac and/or neurologic damage, and 7 (23%) in less severe outcomes. Fourteen (47%) of the lawsuits were related to exposure to a known trigger. Delayed recognition or treatment was cited in 12 (40%) cases and inappropriate IV epinephrine dosing was reported in 5 (17%) cases. Defendants were most commonly physicians (n=15, 50%) and nurses (n=5, 17%). The most common physician specialties named were radiology and primary care (n=3, 10% each), followed by emergency medicine, anesthesiology, and cardiology (n=2, 7% each). Among the 30 cases, 14 (47%) favored the defendant, 8 (37%) resulted in findings of negligence, 3 (10%) cases settled, and 5 (17%) had an unknown legal outcome.

Conclusion: Additional anaphylaxis education, provision of epinephrine autoinjectors or other alternatives to reduce dosing errors, and stronger safeguards to prevent administration of known allergens would all likely reduce anaphylaxis-related patient morbidity and mortality and providers' legal vulnerability to anaphylaxis-related lawsuits. [West J Emerg Med. 2018;19(4)693-700.]

INTRODUCTION

Anaphylaxis is most simply understood as a multisystem and potentially life-threatening allergic reaction.[1] Although no universal definition for anaphylaxis exists, diagnostic criteria have been developed to help medical providers promptly recognize and initiate treatment in patients experiencing severe allergic reactions or anaphylaxis.[1] These criteria suggest treatment is appropriate for patients who develop hypotension after exposure to a known trigger or in patients who rapidly develop symptoms involving multiple organ systems, with or without confirmed exposure to a trigger.[1] Initial treatment of anaphylaxis requires administration of epinephrine intramuscularly (IM), with use of intravenous (IV) epinephrine reserved for cases that are refractory to IM epinephrine and IV fluids. Other medications, such as antihistamines and steroids, are recommended as adjunctive, second-line therapies. Timely

treatment is exceedingly important as the median time between exposure to cardiopulmonary arrest in fatal cases ranges from just five minutes in cases of medication reactions, to 15 minutes for insect stings, and 30 minutes for food.[2]

Although the dangers of anaphylaxis have been well recognized for over a century, patients with anaphylaxis are consistently underdiagnosed and inappropriately treated.[3] Providers frequently fail to both recognize anaphylaxis and to treat patients with the correct dose of epinephrine, often struggling with the different formulations of epinephrine.[4, 5] This has been best studied among radiologists and emergency physicians, who manage the majority of acute cases, but is almost certainly true for a broader range of medical providers.[3, 6, 7] These delayed diagnoses and inappropriate treatments contribute to the estimated 1,500 deaths caused by anaphylaxis each year in the United States alone.[7]

This study seeks to characterize the incidence, patient characteristics, and legal outcomes of cases in which healthcare providers were sued for their alleged mismanagement of patients with anaphylaxis. Our goal was to highlight these legal risks to serve as additional evidence for providers that knowledge of anaphylaxis diagnosis and management is essential in a broad range of clinical specialties and settings.

Population Health Research Capsule

What do we already know about this issue?
Patients with anaphylaxis are frequently underdiagnosed and inappropriately treated in many healthcare settings.

What was the research question?
What are the causes and outcomes of anaphylaxis related medical malpractice lawsuits?

What was the major finding of the study?
Delayed recognition, inappropriate treatment, and known allergen exposures are major causes of anaphylaxis related lawsuits.

How does this improve population health?
Additional provider education, use of epinephrine autoinjectors, and safeguards to prevent known trigger exposure would decrease anaphylaxis-related patient morbidity and mortality.

METHODS

Study Design

We searched an online subscription legal database (Thomson Reuters Westlaw) for all relevant court opinions, jury verdicts, and settlements, using a Boolean search of malpractice cases with the query terms starting with "anaphyla-," or "allergi-." We excluded cases with the term "Eighth amendment" as there were a significant number of cases not relevant to this study involving prisoners' claims that their Eighth Amendment rights had been violated due to failure to provide accommodations for their allergies. We included in this study all cases reported in the five-year period from May 15, 2011, through May 15, 2016. No medical records were accessed. This search strategy was similar to that used in previous legal case series and was exempted from review by the institutional review board.[8, 9]

Data Collection and Primary Data Analysis

Of the 327 unique cases identified in the initial search, most cases were excluded because they were unrelated to an allergic reaction or anaphylaxis. The most common reasons for exclusion were cases involving adverse rather than allergic reactions (n=32), allergic reactions that occurred outside of the medical context such as in restaurants or schools (n=22), or mild allergic reactions that did not qualify as anaphylaxis (n=15). Overall, the search yielded 30 unique cases alleging medical malpractice against providers regarding cases of anaphylaxis.

Per recognized chart-review methods,[10] we created a standardized data collection form to record patient and provider demographics, nature of the trigger, clinical management, and medical and legal outcomes. Two primary abstractors (RAL, EMM) piloted the data collection form by independently abstracting five full cases. Ambiguities in data collection were clarified with the entire investigative team. The two abstractors then independently abstracted the information for all 30 cases, with a senior investigator (RLC) adjudicating any disagreements or ambiguous data. Categorical data are presented as frequency of occurrence, and continuous data are summarized as means and ranges.

RESULTS

Table 1 summarizes the 30 cases involving malpractice lawsuits related to anaphylaxis. Additional details are found in Table 2.

Patient Characteristics and Outcomes

The majority of patients were females (n=22; 73%). Three (10%) of the cases involved pediatric patients. The most common inciting trigger was IV contrast, which was involved in 12 (40%) of the cases. Medications were the second most common trigger, resulting in anaphylaxis in 10 (33%) of the cases. The vast majority of the cases involved severe reactions with poor outcomes. Sixteen (53%) of the

Table 1. Characteristics of cases, patients, and outcomes of 30 lawsuits related to anaphylaxis.

	N (%)
Patient demographics	
Female	22 (73%)
Male	8 (27%)
Pediatric patient (age <18 yrs)	3 (10%)
Inciting trigger	
IV contrast	12 (40%)
Latex	2 (7%)
Cephalosporin	2 (7%)
Other medication	8 (27%)
Food	2 (7%)
Insect sting	2 (7%)
Not reported	2 (7%)
Patient outcome[a]	
Death	16 (53%)
Permanent neurologic damage[b]	5 (17%)
Permanent cardiac dysfunction	4 (13%)
Non-fatal cardiac arrest	4 (13%)
ICU admission	4 (13%)
Other severe reaction (hospitalization, long-term consequences)	3 (10%)
Defendant named in lawsuit[c]	
Physician	15 (50%)
Hospital	13(43%)
Nurse	5 (17%)
Other (clinic, radiology technician, school, EMS, rehab facility)	6 (20%)
Physician specialty (if specified)[c]	
Radiology	3 (10%)
Primary care (internal medicine, family medicine)	3 (10%)
Emergency medicine	2 (7%)
Anesthesiology	2 (7%)
Cardiology	2 (7%)
Other (plastic surgery, otolaryngology, urology, ophthalmology, neurology, obstetrics)	6 (20%)
Reason for lawsuit[d]	
Exposure to known trigger	14 (47%)
Delayed diagnosis/inadequate treatment	12 (40%)
Inappropriate administration of IV epinephrine	5 (17%)
Inadequate pretreatment for contrast	3 (10%)
Outcome of lawsuit	
No liability	14 (47%)
Negligence	8 (27%)
Settlement	3 (10%)
Unknown	5 (17%)
Amount of settlement/judgment	Mean (range)
Cases ending in finding of negligence	$1,407,368 ($27,500 – 4,500,000)
Cases ending in settlement	$376,667 ($250,000 - 440,000)

IV, intravenous; *ICU*, intensive care unit; *EMS*, emergency medical services.
[a]Some patients had more than one outcome.
[b]Includes case in which permanent neurologic injury was caused to baby in utero allegedly from maternal hypotension leading to fetal hypoxia.
[c]Some cases named more than one defendant or specialty.
[d]Some cases had more than one reason for the lawsuit.

Table 2. Summary table of Individual legal cases related to anaphylaxis.

Year of report	Legal outcome ($ amount)	Trigger	Defendant	Patient outcome	Reason(s) for lawsuit
2016	No Liability	Medication (cephalosporin)	Hospital	Anaphylaxis and hospitalization	[a]Exposure (prior cephalosporin allergic reaction)
2015	No Liability	Medication (ranitidine)	Hospital	[b]Hypoxic brain injury of fetus resulting in permanent neurologic dysfunction	Exposure (known allergy)
2015	No Liability	IV Contrast	Hospital and radiology technician	Death	Failure to identify risk factors for allergic reaction
2015	Negligence ($3,615,000)	IV Contrast	ED physicians, OB physician, and hospital	Permanent neurologic dysfunction	Exposure (known allergy)
2015	Negligence ($842,340)	IV Contrast	Radiologist	Fall, disfigurement, and disability	Inadequate treatment
2014	No Liability	IV Contrast	Radiologist	Cardiac arrest, permanent cardiac and neurologic dysfunction	Inadequate treatment (delayed)
2014	No Liability	Medication (cephalosporin)	Clinic and provider	Death	Inadequate treatment (delayed)
2014	Negligence ($4,500,000)	IV Contrast (MRI)	Neurologist	Death	Exposure (known allergy) and inadequate treatment
2014	Unknown	Bee sting	Hospital and emergency department nurse	Permanent cardiac dysfunction	Inappropriate IV epinephrine
2014	No Liability	Not reported	School district and nurse	Death	Inadequate treatment (no epinephrine)
2014	Unknown	Latex	Hospital, otolaryngologist, anesthesiologist	ICU admission	Exposure (known allergy)
2014	No Liability	Medication (acetaminophen)	Hospital	ICU admission	Inappropriate IV epinephrine
2014	No Liability	Medication (morphine)	Emergency medical services company	Death	Inadequate treatment (epinephrine after cardiac arrest)
2013	Unknown	IV Contrast	Hospital, physician	Death	Exposure (known allergy)
2013	No Liability	Food (blueberries)	School nurse, school, city	Death	Exposure (known allergy), inadequate treatment (epinephrine delayed)
2013	Unknown	Medication (methylprednisolone)	Home infusion nurse	Death	Inadequate treatment (no epinephrine available)
2013	Negligence ($375,000)	IV Contrast	Family med physician/clinic	Death	Inadequate treatment (delayed)
2013	No Liability	IV Contrast	Ophthalmologist	Death	Failure to premedicate patient with “iodine allergy,” inadequate treatment

IV, intravenous; *ICU*, intensive care unit; *MRI*, magnetic resonance imaging; *ED*, emergency department; *OB*, obstetrics.
[a]Patient’s prior medication allergy had been inappropriately documented.
[b]Secondary to maternal hypotension.
Exposure indicates exposure to substance to which the patient had had a prior allergic reaction.

Table 2. Continued.

Year of report	Legal outcome ($ amount)	Trigger	Defendant	Patient outcome	Reason(s) for lawsuit
2013	Negligence ($430,000)	Medication (Vicodin)	Urologist and hospital	Death	Exposure (to oxycodone) and inadequate treatment (delayed)
2013	Settlement ($440,000)	Not reported	Not reported	Cardiac arrest, permanent neurologic and cardiac dysfunction	Inappropriate IV epinephrine
2012	Settlement ($250,000)	Food (chocolate)	Rehabilitation facility	Death	Exposure (known allergy)
2012	Negligence ($1,000,000)	IV Contrast	Cardiologist	Death	Exposure (inadequate pretreatment for known contrast allergy)
2012	Settlement ($440,000)	IV Contrast	Radiologist	Cardiac arrest, permanent cardiomyopathy	Inappropriate IV epinephrine
2012	Unknown	IV Contrast	Internist, cardiologist, hospital	Death	Failure to premedicate patient with shellfish allergy
2012	No Liability	IV Contrast	Hospital	Debilitating fatigue	Exposure (known allergy)
2012	Negligence ($27,500)	Bee sting	Hospital	ICU admission	Inappropriate IV epinephrine
2011	Negligence ($4,691,000)	Latex	Hospital and surgical nurses	Death	Exposure (known allergy)
2011	No Liability	Medication (NSAID)	Emergency physician	ICU admission	Exposure (known allergy)
2011	No Liability	Medication (lidocaine)	Plastic surgeon	Cardiac arrest, permanent cardiac and neurologic damage	Exposure (known allergy)
2011	No Liability	Medication (not specified)	Anesthesiologist	Death	Delayed airway intervention

IV, intravenous; *ICU*, intensive care unit; *NSAID*, nonsteroidal anti-inflammatory drug.

cases resulted in death, five (17%) in permanent neurologic damage, four (13%) in an intensive care unit (ICU) admission, and four (13%) in non-fatal cardiac arrest. Seven of the 16 deaths (44%) were related to exposure to a trigger to which the patient had a known allergy (three IV contrast, two food, one medication, one latex). The remaining nine deaths (56%) were attributed to delayed or inadequate treatment or inadequate pre-treatment for IV contrast. There were no deaths attributed to inappropriate administration of IV epinephrine; however, two of the five patients who received inappropriate doses of IV epinephrine had permanent cardiac dysfunction, one patient had both permanent cardiac and neurologic dysfunction, and two patients required ICU admission without reported long-term morbidity.

Legal case characteristics and outcomes

Nearly half of the lawsuits (n=14; 47%) were related to exposure to a known trigger. Delayed recognition and treatment was cited in 12 (40%) cases, and inappropriate epinephrine dosing was reported in five (17%) cases. All of the cases of inappropriate epinephrine dosing were due to IV rather than IM administration of epinephrine. In one case the patient received 10 times the recommended dose of epinephrine as a result of confusion over route and concentration.

Among the 30 cases, 14 (47%) were decided in favor of the defendant, 8 (27%) resulted in findings of negligence, 3 (10%) cases settled, and 5 (n=17%) had an unknown legal outcome. The mean award amount in cases ending in findings of negligence was $1.4 million, compared to just over $375,000

for cases that settled. The most commonly named defendants were physicians (n=15, 50%) and nurses (n=5, 17%). The most common physician specialties named were radiology and primary care (n=3, 10% each), followed by emergency medicine, anesthesiology, and cardiology (n=2, 7% each).

DISCUSSION

In this review of five years of case law, we identified 30 lawsuits against healthcare providers related to anaphylaxis. The most common cause of the lawsuits was exposure to a known trigger followed by delayed recognition or treatment of anaphylaxis and inappropriate use of IV epinephrine, including both over- and under-dosing errors. Seventy-seven percent of the cases resulted in death or permanent neurologic or cardiac dysfunction. The healthcare providers involved in the lawsuits were from multiple specialties and healthcare settings, demonstrating the need for all providers to know how to recognize and treat anaphylaxis.

Many cases in this series (40%) revolved around providers' failure to recognize and treat anaphylaxis in a timely manner. The difficulty in diagnosing anaphylaxis in the acute setting has been well recognized for many years, exacerbated by previous definitions that focused largely on underlying mechanisms and physiological responses rather than clinical signs and symptoms.[11] The difficulty in applying these definitions to patients in acute care settings led to the development of clinical criteria to help providers identify patients with anaphylaxis within the first few minutes of assessment.[1] Despite the fact that these clinical criteria were endorsed over a decade ago and accompanied by clear instructions for management, evidence continues to demonstrate that anaphylaxis remains under-recognized and under-treated.[12] Our results suggest that this may be the case in a broad range of healthcare settings and highlights the need for all healthcare providers to be able to recognize and treat anaphylaxis expeditiously.

Beyond recognition of anaphylaxis, the appropriate administration of epinephrine has proven to be an additional and pervasive challenge for providers. Providers' discomfort with epinephrine dosing has been demonstrated in multiple countries and specialties including radiology, internal medicine, emergency medicine, and pediatrics.[6, 13, 14, 15] In the emergency department (ED) setting, for example, among patients with severe allergic reactions or anaphylaxis—all of whom should receive epinephrine as first-line treatment—less than one quarter actually received any epinephrine in any form.[16, 3] In a survey of over 250 North American radiologists, no radiologist was able to correctly identify the preferred dose and route of administration of epinephrine for patients with anaphylaxis, and only 11% knew which concentration of epinephrine was available to them in their own institution.[6] These numbers suggest a need to prioritize epinephrine-related education for providers, especially for those who routinely oversee the administration of medications and IV contrast.

Equally problematic to inadequate epinephrine dosing is the use of overly aggressive IV epinephrine dosing. In a literature review of complications of epinephrine administration in an ED setting, all identified cases involved IV rather than IM epinephrine, with most of these resulting in cardiac injury.[17] In our study, 17% of the lawsuits were related to inappropriate administration of IV epinephrine complicated by non-fatal cardiac arrest as well as permanent cardiac and neurologic dysfunction. The use of IV bolus epinephrine in patients presenting to an ED has been shown to be associated with a 61 times higher risk of overdose when compared to IM administration; furthermore, three-fourths of the IV epinephrine overdoses were associated with adverse cardiovascular events including cardiac ischemia and ventricular tachycardia.[5] Notably, the majority of these epinephrine overdoses occurred prior to ED arrival, including in post-operative areas, infusion therapy centers, and by prehospital emergency medical responders.[5] Radiologists have also demonstrated difficulty with epinephrine dosing; those surveyed about appropriate management of contrast-induced anaphylaxis selected epinephrine dosing that would have been a significant overdose in 17% of cases,[6] and in another study 42% of patients actually treated with IV epinephrine for a contrast reaction received an overdose.[18]

The availability of epinephrine autoinjectors may be one option to mitigate provider reluctance to administer epinephrine and decrease dosing errors. The introduction of epinephrine autoinjectors along with an anaphylaxis management order set was shown to increase the use of epinephrine in a study of ED anaphylaxis management.[19] In addition, a recent survey study of ED healthcare providers demonstrated that autoinjector administration of epinephrine was preferred to manual epinephrine injection and believed to reduce the risk of dosing errors.[20] The use of prefilled epinephrine syringes has also been suggested as an alternative to the more costly commercially manufactured autoinjectors, and the stability and sterility of the epinephrine has been demonstrated at three months after the preparation.[21]

Inadvertent exposure to a known allergen was the leading cause of lawsuits and the leading cause of patient death in this study. Exposures to triggers to which a patient has a known allergy represent avoidable medical errors, and healthcare institutions must continue to implement systems to avoid these errors. Specific systems designed to address these avoidable errors are beyond the scope of this paper. Medications, including IV contrast, have been demonstrated to be a leading cause of fatal anaphylaxis, as they were in this study.[2, 22, 23] This is likely due to a more rapid onset of cardiopulmonary arrest with medication exposure, with a median time of five minutes in cases of fatal anaphylaxis, compared to 15 and 30 minutes

for food and insect stings, respectively.[2] This underscores the need for healthcare facilities, particularly radiology departments, to have protocols in place to rapidly and safely treat iatrogenic anaphylaxis.

LIMITATIONS

This study is limited based on its reliance on court opinions as the primary source of data. No medical records were accessed. Court opinions are written by judges, court reporters, or other employees of the court with no standardized reporting formats, and therefore they include widely varying amounts of detail. As a result, certain pieces of information that may be relevant to clinicians were often not available in these reports and are missing from our data. In addition, although the legal database used contains tens of thousands of cases, it is not a comprehensive database of all legal cases; no such data source exists. Instead, the database is a combination of cases that have been appealed and a selection of trial court cases and settlements chosen for inclusion by individual court reporters. Consequently, the cases here provide descriptive data for a subset of anaphylaxis-related cases, not a comprehensive list of all lawsuits that occurred during our study period.

CONCLUSION

Our data suggest several possible lessons for moving forward. First, despite significant progress in the development of clinical criteria to facilitate prompt recognition and treatment of patients with anaphylaxis, providers continue to struggle in this realm, suggesting the need for additional education on this topic. The diversity of provider types and range of affected specialties are compelling, emphasizing the need for this education to be directed at a similarly broad range of providers, specifically to help them quickly identify when epinephrine is needed. Second, the inappropriate use and consequent morbidity and mortality associated with IV epinephrine in this study reflect the dangers of IV epinephrine demonstrated in previous studies; this leads us to echo prior recommendations to make epinephrine autoinjectors or other lower cost alternatives available, rather than relying on providers to navigate the different epinephrine formulations found in many acute care settings.

Finally, exposure to known triggers was a common problem in our cases and highlights the need for continued systems improvements to reduce these avoidable errors. These three interventions—additional provider education in a broad range of healthcare settings regarding recognition and management of anaphylaxis; provision of epinephrine autoinjectors or other alternatives to reduce doing errors; and stronger safeguards to prevent exposure to known triggers—would all likely decrease the patient morbidity and mortality associated with anaphylaxis as well as reduce providers' legal vulnerability to anaphylaxis-related lawsuits.

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Initial Standardized Framework for Reporting Social Media Analytics in Emergency Care Research

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The use of social media platforms to disseminate information, translate knowledge, change clinical care and create communities of practice is becoming increasingly common in emergency and critical care. With this adoption come new lines and methods of inquiry for research in healthcare. While tools exist to standardize the reporting of clinical studies and systematic reviews, there is no agreed framework for examining social media–based research. This article presents a publication and appraisal checklist for such work and invites further collaboration in the form of a Delphi technique to clarify, expand, improve, and validate the proposal. [West J Emerg Med. 2018;19(4)701-706.]

INTRODUCTION

Utilization of social media, defined by the *Oxford English Dictionary* as "websites and applications that enable users to create and share content or to participate in social networking," can potentially produce enormous data sets of information exchange between users and communities on online platforms. Social media clearly has an impact on healthcare,[1] and healthcare research performed and analyzed through social media metrics has become increasingly recognized.[2-4] Data may be extracted from social media platforms to demonstrate knowledge translation, education, or patient engagement; evaluate communication; and undertake real-time disease surveillance.[5,6]

As familiarity grows, social media is becoming valued as a source for insight into complex distributed systems, such as healthcare networks and communities of practice.[7] In particular, the emergency and critical care communities have embraced social media as a means to reduce the knowledge translation gap.[8-10] In their seminal review of the different mechanisms available to perform research on social media, Edwards et al.[11] described the complexity of social research and highlighted the promise of social media to allow a previously impractical task: examining the real-time communications and interactions of a community through pre-defined methods of analysis, in volume large enough to draw generalizations. Edwards[11] explained this by overlaying the features of intensive or extensive, and real-time or time-bound domains (Figure). "Intensive" methods such as ethnography (real-time) and interviews (time-bound) offer deep insights into communities but have limited generalizability. "Extensive" methods such as surveys and experiments offer potentially greater generalizability at the cost of being time bound.

The promise of large-scale, social media research lies in the domain of extensive and real-time features, and this has driven the development of new analytics platforms and softwares (termed "engines" for the proposed framework).[11] We believe this constitutes one of the cornerstones for understanding the use of social media metrics in research. The use of "engines" for research presents a major gap in current guidance for reporting or critique of social media research.

Previously, research obtained through social media channels has been met with some skepticism from traditional

		Data collection	
		Real-time	Timebound
Data analysis	Intensive	Ethnography	Interviews
	Extensive	Social Media Specific	Surveys and Experiments

Figure. A matrix of data collection and analysis. Adapted from Edwards et al.[11]

scientific bodies. In part, this is due to lack of familiarity with the nature of the data, paucity of standard data extraction and analytical tools, and heterogeneous reporting systems.[12] The ability to use consistent and reliable data abstractions, as well as standardize the data output, is important to the assessment for validity and applicability of social media research.[13]

Social media analysis is commonly understood as the amount of times a particular object, such as a member of a network or its interactions (e.g., an individual tweet or Facebook post or Instragram user) has been accessed, for example, "liked" or shared by others users. These metrics are often reported in the media. However, analysis is now far more complex and can look at aggregated objects over time, the interactions between users, and how communities develop within social media platforms.[7] To demonstrate the impact of social media, particularly on patient outcomes, understanding the methodology will be vital for objective appraisal of novel work. This article represents a call to action to develop standard methodology for the use of social media analytics in emergency care research, and an interim framework for critical appraisal of published research in this arena.

METHODOLOGY

To develop an initial framework for the use and reporting of social media analytics in emergency care research, we looked to established reporting guidelines for previous research. These mirror the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[14] and others collated by EQUATOR (Enhancing the QUAlity and Transparency Of health Research).[15] We propose this framework, recognizing the challenge of a standard approach to examining social media, using modern analytics to describe digital communities of practice in healthcare.[7] Also, we note that none of the 319 reporting guidelines listed by the EQUATOR Network[15] are concerned with research in social media.

The complexity and volume of data obtained from social media platforms have led to the development of numerous reporting tools, referred to as "engines" in our proposed framework, which simultaneously collect, curate, cross-reference and analyze data, presenting the end user with a refined and cleaned, or filtered, version. The analysis of social media data adds a significant layer of complexity because many of the mining and analytical tools are based at least in part on proprietary formulas and software. In light of this complexity and capacity for selective sampling, time-bound or retrospective sampling creates problems in rigor and reproducibility. We currently lack a methodology to examine whether research reporting on electronic data from a social media platform is robust, reliable, and valid. While the construct and design of social media research is different from basic[16] and clinical science, there is no reason why social media research should not at least have best practice guidance – something which can be iteratively developed and applied for critical appraisal.

INTIAL FRAMEWORK RECOMMENDATIONS

We framed our recommendations using the template developed by the PRISMA[14] group for the reporting of systematic review data, as both data sets and analysis represent variations of knowledge synthesis.[16] In social media research, the general aim is to describe a set of data related to an object (e.g., hashtag, social media user) in either a quantitative manner related to actions, such as sharing or accessing, or in a qualitative review of narrative content of the object (for example, sentiment or language analysis of the words used to describe a concept). The objective of this form of research is to uncover the knowledge held within a particular network and display that in an analytical fashion. This process needs to be well defined (similar to other forms of research); otherwise it is possible to purposefully select data in a biased manner and in large quantity to support or refute any thesis.

The PRISMA systematic review tool was chosen as a conceptual template, as the data sources for reviews can be heterogeneous, very similar to the data obtained from social media. Furthermore, the domains determining data quality in PRISMA mapped closely to those needed for extraction and analysis from social media sources.[7,16] Our broad expectation is that the following format would be used to frame any scientific work around social media analysis: Title and Abstract, Introduction, Methods, Results, Conclusions, Disclosures.

Within Introduction we have developed a framework, resembling the Population, Intervention, Control, Outcome (PICO) format, for defining the objectives of the study, which includes a description of the Network (the social media platform being studied, e.g., Twitter); Object (the item of the network being studied, e.g., hashtag such as #FOAMed); Engine (proprietary data extraction and/or analytics platform), Comparison (secondary object or outcome for comparison), Observation (the theoretical lens and methodology for analysis, e.g., discourse analysis of Twitter conversations or descriptive quantitative measures such as volume and users). We propose the use of the acronym NOECO = Network, Object, Engine, Comparison, Observation. The recommendations for using this format are described in Table 1.

Table 1. Checklist for publication of social media–based research, the NOECO statement.

Section/topic	No	Item	Page reported
Title	1	Identify manuscript as an analysis of social media data using specific analytical tools.	
Abstract			
Summary	2	Report the background; objectives: including the data source and time frame; methods: including analytical engine to extract the data as well as data management tools; results: description of raw data, description of post-analysis data and limitations; conclusions: key findings.	
Introduction			
Rationale	3	Describe what is already known about the topic and the rationale for the data extraction and analysis.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to defining the network and what is being evaluated, compared, and observed (**NOECO – Network, Object, Engine, Comparison, Observation**). **Network**: Defined as the digital platform where users (nodes) share resources such as data. Examples include Facebook and Twitter. **Object**: Defined as the component of the network to be studied. It can consist of the users of the network, a particular set of data shared among them of the structures created by these interactions. Examples include tweets around a hashtag, sharing of a particular content or sentiment analysis on a particular population. **Engine**: Defined as a networks analysis tool used to measure the objects. This is typically a proprietary software able to mine and analyze large amounts of data. Examples include NodeXL and Gephi. **Comparison**: Defined as the comparison against which the measure is made, similar to comparison between intervention and control groups. Examples include the number of interactions between users in Twitter compared to the same users in Facebook. **Observation**: Defined as the actual observation hypothesized for the study. Examples include healthcare users of Twitter that are clustered around few sources.	
Methods			
Protocol	5	Indicate whether a protocol (i.e., a pre-defined method to undertake the evaluation of the social media data) exists, if it was created prior to the data extraction and analysis, and where it can be accessed (e.g. permalink at website).	
Data source	6	Describe the data source in terms of platform and type of data (e.g., raw data, filtered by the researchers, or managed by platform automatically).	
Data appropriateness	7	Describe theoretical frameworks, characteristics of the data, inferences about data, and inferences about users. (e.g., does the data that is suggested to be used have internal validity for the question that is being asked.)	
Data inclusion	8	Describe data to be included and search strategy to be used and rationale.	
Data exclusion	9	Describe data to be excluded, nodes or uses to be excluded, (e.g., suspected spam [automatic commercial offerings] or bots [automatic nodes designed to influence networks]), and data arguments to be excluded and rationale.	
Data extraction	10	Describe data extraction engine to be used, program interface version if available, output format, and corruption data percentage. Describe how data was filtered.	
Data analysis	11	Describe analytical tool used, cite pertinent papers describing methods of the tool, and describe the output format of the data. If analysis is performed by the data extraction engine itself, the underpinning (e.g., network centrality calculation – who/what are the most important people or nodes in a network) methodology should be described.	
Synthesis of results	12	Describe the statistical analysis tool (e.g., univariate analysis), specifically if using large datasets statistical tools (e.g., eigenvectors).	

Table 1. Continued.

Section/topic	No.	Item	Page Reported
Results			
Data selection	13	Provide platform, dates, and magnitude of the data points and search strategy.	
Data corruption	14	Provide magnitude of data corruption, contamination (spam bots), unobtainable or missing data. Describe source of corruption/bias.	
Data quality	15	Describe whether the data quality is appropriate in terms of size, corruption and ability to make appropriate inferences. Describe whether the Objects and Engine (from NOECO) were appropriate.	
Analysis	16	Describe how the data analysis supports or disproves the original question. Describe whether end points or surrogate markers were met. Describe the Comparison and Outcomes from the NOECO question.	
Discussion			
Summary	17	Describe the main findings in the dataset, i.e., how they do (or do not) answer the NOECO data question.	
Limitations	18	Describe data source, set, and analysis limitations.	
Conclusions	19	Provide a general interpretation of the data question after the data analysis.	
Disclosures	20	Describe sources of funding, support, and conflict of interest, particularly regarding proprietary data extraction and analysis tools.	

In accompaniment, Table 2 demonstrates the application of the framework to an example social media publication from the field of plastic surgery.[17] In this paper the data analysis (Section no.11), synthesis of results (no.12) and data corruption (no.14) were not clearly defined or explained. This means that spam bots (computer-generated personas using soft artificial intelligence) may have been included in the analysis of data; the mechanism of evaluation by the social media engine is not clear; and the statistical analytical tool was not defined. These obviously may impact on the validity of the results and make it difficult to reproduce the evaluation undertaken.

DISCUSSION

The original PRISMA guidance reflects the consensus of experts in the field of evidence-based practice. Currently there is no clearly defined "evidence" base for the interpretation of social media analytics that relate to healthcare interventions, improvements, or observations. As more literature is published in this growing field, it is important that the same standards be applied to evaluation of arguments or hypotheses in social media-based studies as in clinical trials. Our initial framework, particularly the NOECO objectives, promotes debate in this area.

As with the original PRISMA document,[18] it is likely that evolution in social media analytics will require persistent and regular updates and derivatives to keep pace with advances in the field. We suggest that our checklist be publicly available and editable in the same way as Wikipedia[19] to allow ongoing innovation in its design and application. The desired extension of this work is to seek collaboration from emergency care researchers and beyond to develop a best-practice consensus framework, likely through the use of a Delphi methodology.[20]

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Table 2. Example of best practices for reporting and analysis on Branford OA, Kamali P, Rohrich RJ, et al. #PlasticSurgery. *Plast Reconstr Surg.* 2016;138(6):1354-65. Checklist items defined in Table 2.

Checklist item	Description on the paper	Page
1	The manuscript identifies itself implicitly as an analysis of social media data using the hashtag symbol in the title; however, it fails to specify analytical tools	1/1354
2	The manuscript reports background, objectives, data source (Twitter), description of the raw data, description of post analysis and conclusions. The abstract does not describe time frame, analytical engine, management tools or limitations.	1/1354
3	The article describes a round rationale of what is already known, particularly for the field of social media and plastic surgery.	1,2/ 1354-1355
4	The manuscript describes the objectives using a clear framework: • Network: Twitter • Object: Hashtag "Plastic-Surgery" (#Plastic-Surgery) and free text "plastic surgery" • Analytical Engine: Not explicitly described, but appears to be Symplur Signals per citation in the references section. • Comparison/Control: None apparent; this appears to be a descriptive netnographic analysis. • Observation: Clearly described: hashtag-use description, subject matter, links to plastic surgery journals and self-promotion.	2-3/ 1355-1356
5	No description of protocol for data extraction.	
6	The manuscript describes network source, type of data and filters.	2/1355
7	The manuscript describes characteristics of the data, surrogate markers, inferences about producers and users.	2/1355-1357
8	Description of data inclusion is clear.	2/1355
9	Description of data exclusion is clear (e.g., bots and non-English).	2/1355
10	Not described, but inferred from references and figures to be Symplur Signals. No details on data corruption or refinement method.	
11	Not described.	
12	Not described.	
13	The manuscript describes platform, dates and data points clearly.	3/1356
14	Not described.	
15	NOECO statement described previously, and there is an implicit assertion that it was appropriate for the analysis.	
16	The manuscript contains a clear analysis about the data supporting the original study aim (description of the hashtag use).	3-11/1356-1364
17	The manuscript describes the main findings that answer the NOECO question.	3-11/1356-1364
18	No clear description on limitations.	
19	The manuscript provides a general interpretation of the data source, set and analysis.	11-12/1364-1365
20	The manuscript describes clear disclosures, including support and conflicts of interest.	1/1354

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Suffocation Injuries in the United States: Patient Characteristics and Factors Associated with Mortality

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Introduction: Asphyxiation or suffocation injuries can result in multi-organ damage and are a major cause of morbidity and mortality among different age groups. This study aims to describe characteristics of patients presenting with suffocation injuries to emergency departments (EDs) in the United States (U.S.) and to identify factors associated with mortality in this population.

Methods: We conducted a retrospective cross-sectional study using the 2013 U.S National Emergency Department Sample database. ED visits with primary diagnoses of intentional or accidental suffocation injury, and injury by inhalation and aspiration of foreign bodies or food (ICD-9-CM codes) were included. We performed descriptive statistics to describe the study population. This was followed by multivariate analyses to identify factors associated with mortality.

Results: We included a total of 27,381 ED visits for suffocation injuries. Most suffered from either inhalation and ingestion of food causing obstruction of respiratory tract or suffocation (51.6%), or suicide and self-inflicted injury by hanging, strangulation, and suffocation (39.4%). Overall mortality was 10.9%. Over half (54.7%) of the patients were between 19 and 65 years old. Males were more common than females (59.1% vs. 40.9%). Over half of the patients (54.9%) were treated and released from the ED. Factors associated with increased mortality included male gender, young age (4-18 years), diseases of the cardiac, respiratory, genitourinary and neurologic systems, intentional self-harm, and self-payer status.

Conclusion: Mortality from suffocation injuries remains high with significant burden on children and adolescents and on patients with intentional injuries. Tailored initiatives targeting identified modifiable factors through implementation of behavioral and environmental change can reduce the risk of suffocation injury and improve clinical outcomes of affected victims. [West J Emerg Med. 2018;19(4)707-714.]

INTRODUCTION

Asphyxiation or suffocation can be defined as the deprivation of oxygen supply to body tissues and can result from mechanical or non-mechanical constriction of the airway or from a decrease in breathable gas in the respired surrounding atmosphere.[1] Suffocation and asphyxiation can vary at the forensic pathology level;[1] however, both can be used interchangeably to report a decrease in oxygen delivery to the lungs resulting in deprivation of oxygen or hypoxia.[2,3]

Suffocation injuries and death can result from suicidal attempt, assault or accidental injury. In parts of Europe and Asia, intentional asphyxiation by hanging is the leading

manner of suicide attempts.[4,5] In the United States (U.S.), the rate of suicide by intentional asphyxiation is second only to suicide by firearms.[6] Choking is a form of unintentional asphyxiation: choking was the third leading cause of unintentional deaths in the U.S. between 2000 and 2013 in adults aged 65 years or older[7] and a leading cause of morbidity and mortality among children aged less than 3 years.[8] In addition to death and multi-organ damage, complications of asphyxiation include cardiopulmonary injuries and neurological injuries, in addition to orthopedic injuries with hangings and strangulation.[9-11]

The current medical literature describing suffocation injuries and clinical outcomes is limited and is mostly focused on death from asphyxiation by hanging or strangulation injuries.[12-16] Available medical literature suggests that cardiopulmonary resuscitation at the scene of suffocation injury is associated with improved clinical outcomes while longer duration of hanging is associated with increased mortality in cases of hanging asphyxiation.[17] Low Glasgow Coma Scale on arrival to the emergency department (ED) has also been associated with poor clinical outcomes.[18] Understanding the epidemiology of suffocation injuries, characteristics of affected victims and factors associated with mortality is important for physicians and policymakers to tailor prevention initiatives and mitigation strategies.

Our goal was to describe the characteristics of patients presenting with suffocation injuries to EDs in the U.S and to identify factors associated with mortality in this population.

Population Health Research Capsule

What do we already know about this issue?
Suffocation injuries result in multi-organ damage and are a major cause of morbidity and mortality among different age groups.

What was the research question?
What are the characteristics of patients with suffocation injuries and factors associated with mortality in the United States?

What was the major finding of the study?
Mortality from suffocation is high with a significant burden on younger individuals and those with intentional injuries

How does this improve population health?
Familiarity with patients at risk of suffocation injuries can improve clinical outcomes and allow for implementation of initiatives that target behavior changes in this population.

METHODS

Study Design

This retrospective cross-sectional study used the 2013 public release U.S National Emergency Department Sample (NEDS). NEDS is the largest all-payer (ED) database available in the U.S. and is part of the Healthcare Utilization Project (HCUP), which is supported by the Agency of Healthcare and Research Quality.[19] The NEDS database contains data from approximately 30 million ED visits each year.[20] In 2013, the NEDS database collected data for 134,869,015 ED visits from 947 hospitals across 30 states, representing an approximate 20% stratified sample of U.S. hospital-based EDs. The NEDS dataset is released three years after its collection.

All members of the research team who were involved in using the NEDS database completed the HCUP data use agreement training course and signed the Nationwide Data Use Agreement. The institutional review board (IRB) at the American University of Beirut provided IRB exemption for the use of the NEDS public release dataset.

We identified ED visits for patients with suffocation injury using diagnosis codes (*International Classification of Disease - 9 - Clinical Modification* [ICD-9-CM]) listed in Table 1. These encompassed injuries by accidental mechanical suffocation, intentional and unintentional injuries by hanging, strangulation and suffocation, injury by inhalation and aspiration of foreign bodies or food.

Variables available from the NEDS database included patient characteristics and comorbidities, type of injury and injury intent, patient disposition, admission rates, hospital length of stay and cost. Clinical outcome was defined as mortality in ED or during hospital stay (yes/no).

Statistical Analysis

We performed statistical analysis with SPSS (version 24) statistic software package. The description of the sociodemographic, clinical and administrative characteristics was presented as frequencies, percentages, and 95% confidence interval (CI) for the categorical variables and mean and 95% CI for the continuous variables. We used the Rao-Scott chi-square test for complex sample design to determine the significance of the statistical association between the independent variables and mortality (yes/no), the dependent variable. All variables that were found to be statistically significant in the bivariate level were included in a logistic regression model to determine the factors significantly associated with mortality. We presented results of the multivariate analysis as odds ratio (OR) along with the corresponding 95% CI. Convenient methods including

CSDESCRIPTIVES, CSTABULATE, and CSLOGISTIC for complex survey design were performed to calculate accurate estimates. A value was considered statistically significant at a p-value less than or equal to 0.05.

RESULTS

We included a total of 27,381 ED visits for suffocation injuries in the study. The resulting incidence for suffocation injuries in 2013 in the U.S. was 20 per 100,000 ED visits. Inhalation and ingestion of food causing obstruction of respiratory tract or suffocation was the most common presentation (51.6%), followed by suicide and self-inflicted injury by hanging, strangulation, and suffocation (39.3%) (Table 1).

Table 1. International Classification of Disease - 9 - Clinical Modification (ICD-9-CM) codes with injury description.

Injury description	ICD-9 CM codes	N (%)
Accidental mechanical suffocation	E913.0, E913.1, E913.2, E913.3, E913.8, E913.9	602 (2.2)
Suicide and self-inflicted injury by hanging, strangulation, and suffocation	E953.0, E953.1, E953.8, E953.9	10,765 (39.3)
Hanging, strangulation, or suffocation, undetermined whether accidentally or purposely inflicted	E983.0, E983.1, E983.8, E983.9	513 (1.9)
Inhalation and ingestion of food causing obstruction of respiratory tract or suffocation	E911	14,140 (51.6)
Asphyxiation and strangulation	994.7	4,565 (16.7)

Over half of the patients (54.7%, 95% CI [53.5 – 55.9]) were between 19-65 years. Males (59.1%, 95% CI [57.9 – 60.2]) were more common than females, and most patients had chronic conditions (72.8%, 95% CI [71.8 – 73.9]). The most common body system indicators (defined as a collective designation of body system specific ICD-9-CM codes) were injury and poisoning (80.2%, 95% CI [79.2 – 81.1]) and mental disorders (47.4%, 95% CI [46.2 – 48.5]). The majority of patients had reported injuries on presentation (80.3%, 95% CI [79.4 – 81.2]) and the most common reported method of injury was injury by assault (3.4%, 95% CI [3.0-3.9]) followed by injury by poisoning (2.0%, 95% CI [1.7-2.3]). Patients had mainly minor injuries (Injury Severity Score <15) (99.5%, 95% CI [99.3 – 99.7]). Intentional self-harm was recorded in 40.1% (95% CI [38.9 – 41.2]) of cases with injuries. ED suffocation related visits were similar across all seasons. Most visits (71.9%, 95% CI [70.8 – 72.9]) were during weekdays and Medicare was the most common type of

Table 2. Study characteristics of patients with suffocation injuries.

Characteristics	Frequency (N=27381)	Percentage (95% CI)
Gender		
Male	16173	59.1 (57.9 – 60.2)
Female	11209	40.9 (39.8 – 42.1)
Age		
Newborn -3	2057	7.5 (6.9 – 8.1)
4 -18	3892	14.2 (13.4 – 15.1)
19 – 65	14972	54.7 (53.5 – 55.9)
≥66	6446	23.6 (22.6 – 24.6)
Chronic conditions		
Chronic conditions	19943	72.8 (71.8 – 73.9)
No chronic conditions	7438	27.2 (26.1 – 28.2)
Body system indicator[1]		
Injury and poisoning	21951	80.2 (79.2 – 81.1)
Mental disorders	12968	47.4 (46.2 – 48.5)
Factors influencing health status and contact with health services[2]	9659	35.3 (34.2 – 36.4)
Symptoms, signs, and ill-defined conditions	9298	34.0 (32.9 – 35.1)
Diseases of the circulatory system	9007	32.9 (31.8 – 34.0)

CI, Confidence Interval.

[1]Only the five most common body system indicators are shown. Other body system indicators listed from most to least frequent are as follows: (1) Disease of the respiratory system; (2) endocrine, nutritional and metabolic disease and immunity disorders; (3) diseases of the nervous system and sense organs, (4) disease of the digestive system; (5) diseases of the musculoskeletal system; (6) diseases of the genitourinary system; (7) disease of the blood and blood-forming organs; (8) infectious and parasitic disease; (9) diseases of the skin and subcutaneous tissue; (10) neoplasms; (11)congenital anomalies; (12) certain conditions originating in the perinatal period; and (13) complications of pregnancy, childbirth and the perineum.

[2]Includes (1) newborns and infants; (2) vaccinations and inoculations; (3) suspected exposure to communicable diseases; (4) patients who are either a carrier of a disease or have the sequelae or residual of a past disease or condition; (5) patient's past medical condition that no longer exists and is not receiving any treatment, but that has the potential for recurrence or patients with family member(s) who has had a particular disease that causes the patient to be at higher risk of also contracting the disease; (6) screening encounter;, (7) observational encounters; (8) aftercare encounters; (9) follow-up encounters; (10) donors; (11) counseling encounters,;(12) encounters for obstetrical and reproductive services; (13) routine and administrative examinations; and (14) miscellaneous encounters.

Table 2. Continued.

Characteristics	Frequency (N=27381)	Percentage (95% CI)
Injury diagnosis reported on record		
Injury reported	21995	80.3 (79.4 – 81.2)
No injury diagnosis reported	5386	19.7 (18.8 – 20.6)
Method of injury[3]		
Injury by assault	940	3.4 (3.0-3.9)
Injury by poisoning	535	2.0 (1.7-2.3)
Injury by falling	328	1.2 (1.0-1.5)
Injury by cutting or piercing	309	1.1 (0.9-1.4)
Injury from being struck	273	1.0 (0.8-1.3)
More than one injury diagnosis reported on record		
One or no injury diagnosis reported	23728	86.7 (85.8 – 87.4)
More than one injury diagnosis reported	3654	13.3 (12.6 – 14.2)
Injury severity score		
Minor trauma (0-15)	27239	99.5 (99.3 – 99.7)
Major trauma (16-75)	130	0.5 (0.3-0.7)
Intentional self-harm indicated on record		
Intended self-harm	10967	40.1 (38.9 – 41.2)
No intended self-harm	16414	59.9 (58.8 – 61.1)
Season of admission		
Summer	6325	26.4 (25.2-27.5)
Spring	6188	25.8 (24.7-26.9)
Autumn	6073	25.3 (24.2-26.4)
Winter	5411	22.5 (21.5-23.6)
Admission day		
Monday – Friday	19675	71.9 (70.8 – 72.9)
Saturday - Sunday	7706	28.1 (27.1 – 29.2)
Urban-rural location of patient residence		
Large central metropolitan	6721	24.8 (24.1 – 25.5)
Medium metropolitan	6196	22.8 (22.2 – 23.5)
Large fringe metropolitan	5718	21.1 (20.4 – 21.8)
Micropolitan	3271	12.1 (11.6 – 12.5)
Small metropolitan	2871	10.6 (10.0 – 11.2)
Not metropolitan or micropolitan	2356	8.7 (8.3 – 9.1)
Primary expected payer		
Medicare	7991	29.3 (28.3 – 30.4)
Medicaid	6023	22.1 (21.1 – 23.1)
Private including Health Maintenance Organization (HMO)	7225	26.5 (25.5 – 27.6)
Self-payer	3836	14.1 (13.3 – 14.9)
No charge	242	0.9 (0.7 – 1.1)
Other	1916	7.0 (6.4 – 7.7)
Median household income		
$1 - $37,999	7417	28.0 (27.0 – 29.0)
$38,000 - $47,999	7496	28.3 (27.3 – 29.4)
$48,000 - $63,999	6582	24.9 (23.9 – 25.9)
$64,000 or more	4987	18.8 (18.0 – 19.7)

CI, confidence interval.

[3]Only the five most common Injury methods are shown: Other Injury methods listed from most to least frequent are as follows: (1) injury involving motor vehicle traffic; (2) injury involving natural or environmental causes; and (3) injury by fire, flame, or hot objects.

coverage (29.3%, 95% CI [28.3 – 30.0]) (Table 2).

Most patients were either treated and released from the ED (54.9%, 95% CI [53.8 – 56.1]) or admitted to the same hospital as presentation (33.6%, 95% CI [32.6 – 34.7]). Patients who were admitted had an average length of stay of 6.2 days (95% CI [5.8– 6.7]). Overall mortality in the study population was 10.9% (95% CI [10.2 – 11.7]). Mortality rates ranged from 9.6% (95% CI [8.6 – 10.8]) for patients with "suicide and self-inflicted injury by hanging strangulation and suffocation" to 30.7% (95% CI [22.5 – 40.4]) for patients with "hanging, strangulation, or suffocation, undetermined whether accidentally or purposely inflicted." Those with accidental mechanical suffocation had a mortality rate of 11% (95% CI [10.0-12.0]). The mean for total ED charges was $3,620.20 (95% CI [3531.6 – 3708.7]) (Table 3).

We performed a bivariate analysis (not shown) to compare patients' characteristics by outcome (mortality); significant differences were noted between the two groups. Patients who died were more likely to be older, have chronic conditions and be of male gender. They also had more admissions during weekends and had more injuries reported. Higher frequencies of mental health disorders, of intentional self-harm, injury by poisoning and injury by assault were, however, noted in the group of patients who survived. There was no difference in patient outcomes by season of admission or by injury severity.

In the multivariate analysis, factors that were significantly associated with increased mortality after suffocation (Table 4) included male gender (OR [1.3], 95% CI [1.1-1.6]), disease of the circulatory system (OR [11.6], 95% CI [8.9-15.1]), diseases of the nervous system (OR [3.0], 95% CI [2.4-3.8]), diseases of the respiratory system (OR[1.9], 95% CI [1.6-2.4]) and diseases of

Table 3. Outcomes after suffocation injuries.

Outcomes – categorical variables	Frequency (N=27381)	Percentage (95% CI)
Disposition from the ED		
ED visit in which the patient is treated and released	15041	54.9 (53.8 – 56.1)
ED visit in which the patient is admitted to the same hospital	9210	33.6 (32.6 – 34.7)
ED visit in which the patient is transferred to another short-term hospital	1941	7.1 (6.5 – 7.7)
ED visit in which the patient died in the ED	1076	3.9 (3.5 – 4.4)
ED visits in which patient was not admitted, destination unknown	112	0. 4 (0.3 – 0.6)
Death		
Death in ED/hospital	2976	10.9 (10.2 – 11.7)
No death	24280	89.1 (88.3 – 89.8)

Outcomes-continuous variables	N	Mean (95% CI)
Total charge for ED ($)	27358	3620.2 (3531.6 – 3708.7)
Length of stay (days)	9210	6.2 (5.8 – 6.6)

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

Table 4. Factors associated with mortality after suffocation injury.

Variables	Odds ratio	95% CI	P value
Gender			
Female	1.0	-	-
Male	1.3	1.1-1.6	0.008
Age (years)			
≥66	1.0	-	-
19 – 65	1.2	0.9-1.6	0.256
4 -18	2.2	1.4 -3.4	0.001
0 – 3	0.9	0.5-1.8	0.912
Admission day			
Weekend	1.0	-	-
Weekday	0.8	0.7-1.0	0.078
Body system indicators			
Diseases of the circulatory system (No)	1.0	-	-
Yes	11.6	8.8-15.1	<0.001
Diseases of the nervous system and sense organs (No)	1.0	-	-
Yes	3.0	2. 5-3.8	<0.001
Diseases of the respiratory system (No)	1.0	-	-
Yes	1.9	1.6-2.4	<0.001
Diseases of the genitourinary system (No)	1.0	-	-
Yes	1.5	1.1-1.9	0.003
Factors influencing health status and contact with health services (No)	1.0	-	-
Yes	0.8	0.7-0.9	0.010
Diseases of the digestive system (No)	1.0	-	-
Yes	0.6	0.4-0.7	<0.001
Diseases of the musculoskeletal system (No)	1.0	-	-
Yes	0.4	0.3-0.6	<0.001
Mental disorders (No)	1.0	-	-
Yes	0.4	0.3-0.5	<0.001
Injury and poisoning (No)	1.0	-	-
Yes	1.1	0.6-2.0	0.739
Intentional self-harm			
Unintentional self-harm	1.0	-	-
Intentional self-harm	2.1	1.5-2.7	<0.001
More than one injury diagnosis			
More than one injury diagnosis	1.0	-	-
One or no injury diagnosis	1.5	1.1-2.0	0.011

CI, confidence interval.

the genitourinary system (OR [1.5], 95% CI [1.1-1.9]). Additional factors that were also associated with increased mortality included age category 4-18 years (OR [1.8], 95% CI [1.2-2.7]), intentional self-harm (OR [2.0], 95% CI [1.5-2.7]) and having one or no injury reported (OR [1.5], 95% CI [1.1-2.0]). Mental health disorders (OR [0.4], 95% CI [0.3-0.5]) were found to be negatively associated with mortality.

DISCUSSION

This study examined suffocation injuries in a large national sample of ED visits; it is the largest study to date to report on this medical condition and to attempt to identify its burden using a national sample in the U.S. While the mechanisms of injury resulting in suffocation and asphyxiation are numerous, several forms of asphyxiation are uncommon and under-reported. This is evident in the medical literature with several forms of asphyxiation described only in case reports or case series.[21,22].Some studies have reported mortality rates in more common forms of suffocation injuries such as hanging and strangulation.[10,17,18,23,24] Our study, however, addressed all forms of suffocation injuries using a national sample, in

Table 4. Factors associated with mortality after suffocation injury.

Variables	Odds ratio	95% CI	P value
Injury diagnosis reported on record			
No injury diagnosis reported	1.0	-	-
Injury reported	1.5	0.8-2.7	0.180
Method of Injury			
Injury by falling (No)	1.0	-	-
Yes	1.3	0.7-2.6	0.446
Injury by poisoning (No)	1.0	-	-
Yes	0.4	0.1-1.3	0.124
Injury by assault (No)	1.0	-	-
Yes	1.1	0.6-1.8	0.912
Primary expected payer			
Self-payer	1.0	-	-
Medicare	0.4	0.3 – 0.6	<0.001
Medicaid	0.3	0.2-0.4	<0.001
Private including Health Maintenance Organization (HMO)	0.5	0.3 – 0.6	<0.001
No charge	0.4	0.2 – 1.0	0.063
Other	0.5	0.4 – 0.8	0.003

CI, confidence interval.

an attempt to identify the burden of this disease and avoid overlooking under-reported and uncommon forms of injury that result in suffocation and asphyxiation.

The incidence of suffocation injury in 2013 among ED patients was 20 per 100,000 individuals, and the mortality rate was 10.9% (95%CI [10.1-11.7]) with varying mortality rates, ranging from 9.6% (suicide and self-inflicted injury by hanging, strangulation, and suffocation) to 30.7% (undetermined if self-inflicted or accidental). A study in Japan showed a 77% mortality rate in individuals presenting with suicidal-intent hanging injury,[17] whereas another study in Australia showed a mortality rate of 12% for the same form of injury.[18] This discrepancy in mortality rates could be attributed to different factors including lack of standardized management of suffocation injuries,[25-27] higher injury acuity, or different groups of patients included in other studies.

Additionally, 47.4% of patients in this study had a mental health condition and 40.1% had intentional injury reported. These results are in line with previous studies suggesting that suffocation injuries are commonly a result of intentional self-harm or suicidal attempt and are likely to occur in patients with a history of psychiatric disorders.[23] In fact, a previous study examining deaths in adolescents due to hanging injury revealed that the majority of hangings (98.4%) were the result of a suicidal attempt.[28] Similarly, deaths due to plastic-bag suffocation were mostly in adults and resulted from suicidal attempts.[22] Our results also showed that intentional self-harm was associated with higher odds of mortality after controlling for confounding factors in the multivariate analysis. While the literature assessing the impact of intentional injury on mortality in patients with suffocation injuries is scarce, studies exploring this impact in injury/trauma patients in general have reported higher mortality associated with intentional injury.[30, 31]

Males were both more likely to present with and die from suffocation injuries. The available published literature reports conflicting data on the gender role in suffocation injuries by hanging.[12,17,18,23,26] by inhalation of helium gas,[6,32],by plastic-bag suffocation,[22] and by autoerotic asphyxiation.[21] The various mechanisms of suffocation may have contributed to this inconsistency in impact of gender on outcomes after suffocation. Other confounding factors such as intentional injury may also explain this inconsistency. Several studies have suggested that suffocation related to suicidal intent is more common in males,[9,32,33-35] while suffocation related to assault or homicidal intent is more likely to occur in females.[5,36,37].

Patients aged 4-18 years were observed to have higher odds of mortality compared to other age groups. The existing literature does not provide clear evidence for this. However, some studies suggest that children are more vulnerable to have complete airway obstruction and are more prone to delayed airway edema after strangulation, due to the relatively small size of the airway.[38, 39] Additionally, we can speculate that children are more likely than adults to experience prolonged unintentional suffocation as they are often left unattended and incapable of self-help. More research investigating the relationship between age and mortality among patients with suffocation injuries could help develop age-specific prevention strategies.

This study also showed that individuals with disease of the circulatory system, nervous system, respiratory system and genitourinary systems are significantly more likely to die from suffocation injuries. This was expected since patients with baseline cardiac, respiratory and kidney diseases are more likely to have poorer clinical outcomes.[40-42] Mental disorders seemed to be negatively associated with mortality in patients presenting with suffocation injuries. While mental disorders are associated with higher natural and unnatural cause mortality,[43] some studies have demonstrated mental disorders to be protective in trauma patients.[44,45] Individual with

suffocation injuries who survive are more likely to undergo psychiatric disease evaluation and to get diagnosed in the ED and in hospital with a psychiatric disorder, which may result in a higher frequency of mental disorders in surviving patients. Additionally, patients could suffer from psychiatric disorders that are a result of the traumatic injury experienced. However, further studies are needed to evaluate the effect of pre-existing mental disorders on patients with suffocation injuries.

LIMITATIONS

This study has limitations inherent to its retrospective nature. NEDS is, however, a large U.S. national database of ED visits and the study results can be generalized to other patients presenting with suffocation injuries in the U.S. or in other developed settings. The data was obtained from the NEDS database using ICD-9-CM codes for suffocation diagnosis. There could be an underestimation of the actual suffocation injury rates due to variations in coding in the 947 hospitals included in the database. It is also possible that many patients who died as a result of suffocation might not have been transported to the ED and therefore were not included in this study, which could potentially have led to underestimation of mortality rate of asphyxiation. The NEDS database is de-identified, so we could not identify patients with suffocation injury readmissions. Considering that a high percentage of patients had mental disorders or a history of injury and poisoning, it is likely that the number of readmissions in our selected population is significant. Other studies excluding readmissions might identify other factors associated with mortality in patients with suffocation injury. Patients presenting with a recurrent suffocation injury are also more likely to have poorer prognosis than those presenting with a suffocation injury for the first time.

This study included patients with suffocation from different mechanisms. Even though mortality rates were reported for different mechanisms when possible, restrictions related to availability of clinical variables limited our ability to draw more specific recommendations about clinical management or to identify whether the associated clinical conditions were co-morbid conditions or arose as a result of the asphyxiation.

CONCLUSION

Mortality from suffocation injuries remains high in the U.S with a significant burden on children and adolescents and on patients with intentional injuries. Familiarity with the characteristics of patients at risk of suffocation injuries and with factors associated with increased mortality after such injuries is important to help improve clinical outcomes. Additionally, tailored initiatives implementing behavior and environment change and targeting populations at risk of suffocation injuries are needed.

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Computed Tomography Risk Disclosure in the Emergency Department: A Survey of Pediatric Emergency Medicine Fellowship Program Leaders

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Introduction: Given the potential malignancy risks associated with computed tomography (CT), some physicians are increasingly advocating for risk disclosure to patients/families. Our goal was to evaluate the practices and attitudes of pediatric emergency medicine (PEM) fellowship program leaders' regarding CT radiation-risk disclosure.

Methods: We conducted a cross-sectional survey study of the United States and Canadian PEM fellowship directors and associate/assistant directors. We developed a web-based survey using a modified Dillman technique. Primary outcome was the proportion who "almost always" or "most of the time" discussed potential malignancy risks from CT prior to ordering this test.

Results: Of 128 physicians who received the survey, 108 (86%) responded. Of those respondents, 73%, 95% confidence interval (CI) [64-81] reported "almost always" or "most of the time" discussing potential malignancy risks when ordering a CT for infants; proportions for toddlers, school-age children, and teenagers were 72% (95% CI [63-80]), 66% (95% CI [56-75]), and 58% (95% CI [48-67]), respectively (test for trend, p=0.008). Eighty percent reported being "extremely" or "very" comfortable discussing radiation risks. Factors of "high" or "very high" importance in disclosing risks included parent request for a CT not deemed clinically indicated for 94% of respondents, and parent-initiated queries about radiation risks for 79%. If risk disclosure became mandatory, 82% favored verbal discussion over written informed consent.

Conclusion: PEM fellowship program leaders report frequently disclosing potential malignancy risks from CT, with the frequency varying inversely with patient age. Motivating factors for discussions included parental request for a CT deemed clinically unnecessary and parental inquiry about risks. [West J Emerg Med. 2019;19(4)715-721.]

INTRODUCTION

There is increasing awareness among the medical community[1] and the media[2] of the potential carcinogenic risks from medical radiation. Recent epidemiological studies have added to concerns relating to computed tomography (CT), particularly from exposure during

childhood.[3] As a result, some physicians advocate for disclosure of possible malignancy risks prior to ordering CT imaging in children. CT is a commonly ordered test by pediatric emergency medicine (PEM) physicians,[4] and children are among the most sensitive to the potential long-term effects of radiation.[5] Despite this, there has been limited investigation and no firm recommendations for implementing risk disclosure practices for CT imaging of pediatric patients in the emergency department (ED). Further, various approaches towards implementing consent for radiological procedures that expose patients to radiation are currently under debate.[6] A study of Canadian PEM physicians' knowledge of potential CT malignancy risks suggested that nearly 70% usually disclose risks to patients and families.[7] However, there are differences in imaging practices between the United States and Canada,[8] which may translate into differences in risk-disclosure practice.

The primary objective of this study was to evaluate the frequency with which PEM fellowship program leaders disclose potential malignancy risks from CT to pediatric patients and families. As secondary objectives, we determined physician comfort with risk disclosure and knowledge of malignancy risks, factors deemed of high importance in engaging in risk-disclosure discussions, and respondent preference for disclosure method.

Population Health Research Capsule

What do we already know about this issue?
Radiation exposure from Computed Tomography may be associated with an increased risk of future cancer, which has raised concerns among patients and clinicians.

What was the research question?
How often do physicians, specifically pediatric EM fellowship program leaders, disclose potential malignancy risks from CT?

What was the major finding of the study?
These physicians report frequently disclosing potential risks, with the frequency inversely proportion to patient age.

How does this improve population health?
Pediatric patients and their families may be increasingly informed of the potential risks of CT prior to undergoing imaging.

METHODS

Study Design and Population

This was a web-based survey of PEM fellowship program directors and associate/assistant directors in the U.S. and Canada from April 10 to June 25, 2015. We compiled an initial list of directors and emails based on data updated and published annually[9] and information available on the Royal College of Physicians and Surgeons of Canada website (http://www.royalcollege.ca/rcsite/documents/arps/ped-emergency-e). We confirmed names and email addresses for program leadership at each program via the program website, program coordinator, or directly with a program director or associate/assistant director. We excluded those whose email address we were unable to verify or who were no longer in active clinical practice. The University of Pittsburgh Institutional Review Board approved the study.

Survey Development and Content

We developed survey items in accordance with the methods advocated by Burns et al,[10] and Dillman.[11] We derived questions initially from relevant literature[7, 12-15] and an expert panel of two emergency physicians, two PEM physicians, and one pediatric radiologist, all of whom had survey and/or content expertise. Questions related to lifetime malignancy risk from CT imaging were based on published estimates.[16-19] The expert panel generated items for the survey until no new items emerged and the final items were agreed upon. We pre- and pilot-tested the initial survey draft with 14 PEM physicians (not involved in fellowship leadership) at three different U.S. academic medical centers. Survey questions were removed or modified in accordance with feedback from all testing phases. In its final form, there were a total of 13 questions (online appendix-survey), and the median time to complete the survey was less than 10 minutes.

The survey included three specific content domains: 1) radiation risk disclosure practice patterns and attitudes; 2) knowledge of radiation exposure from CT imaging; and 3) participant demographics. Respondents were instructed to provide responses assuming they pertained to stable patients for whom there was time for discussion of management options and ability of the parent/guardian to participate in such discussions. We structured questions as either categorical or Likert-scale response types. For all questions, we offered an "other" category in which we solicited a free-text response.

Survey Administration

We administered the survey through an online survey tool (Qualtrics, Provo, UT) using a modified Dillman's tailored design method for mail and internet surveys.[11]

An initial e-mail including an introductory letter and link to the survey was sent to eligible participants. Three reminder e-mails were sent at two-week intervals to those who had not yet completed the survey. Each notification described the study, assured confidentiality, and requested participation. Survey responses were de-identified. To incentivize participation, individuals who completed the survey were given the option of being entered into a lottery for a $100 gift card.

Outcomes

The primary outcome was the proportion of respondents who "almost always" or "most of the time" discussed potential CT malignancy risks prior to ordering CT imaging in stable pediatric patients. Secondary outcomes included the proportion of respondents who felt "extremely" or "very" comfortable discussing potential risks with patients/families, and those factors deemed as being of "very high" or "high" importance in the decision to discuss or not to discuss potential CT risks. We also evaluated the proportion of respondents that favored verbal informed discussion, those educational resources deemed "very" or "somewhat" useful for risk communication, and national campaigns with which respondents were "very" or "highly" familiar. Finally, we examined the proportion that was able to correctly identify estimated relative malignancy risks from a non-contrast head CT. Head CT was chosen given the frequency of its use in the pediatric ED setting.[20] For questions involving Likert scales, we combined responses into two or three meaningful groups for ease of interpretation.

Data Analysis

There were 127 PEM fellowship program leaders. Assuming a response rate of 85% based on previous surveys of this population,[21,22] a final sample size of 107 would produce a 95% confidence interval (CI) around the sample proportion of ±9% when the estimated proportion of physicians who at least "most of the time" discussed future potential malignancy risks was 70%.[7] Partially completed surveys were included, with completed questions used in the analysis. We used proportions with respective 95% CIs to describe the data and the chi-squared test for linear trend to evaluate the relationship between disclosure practices and patient age. We considered a p-value less than 0.05 significant. Stata 12.0, (StataCorp, LP, College Station, TX) was used for statistical analysis.

RESULTS

Study Population

We verified information for all 127 fellowship directors and associate/assistant directors from the 78 PEM fellowship programs in North America. One associate program director was excluded for lack of any clinical care responsibilities. Of the 126 eligible physicians, 108 responded to the survey, yielding a response rate of 86%. One hundred and four of the respondents completed the survey in its entirety (96%). Fifty-three percent of respondents were in practice since PEM fellowship for ≤10 years. Respondents represented all regions of the U.S., with 31% from the northeast, 26% from the South, 22% from the Midwest, and 14% from the West. Those from Canada comprised 7% of survey respondents.

Risk Disclosure Practices and Attitudes

The following proportions of physicians reported discussing potential future malignancy risks "almost always" or "most of the time" for infants, toddlers, school age, and teenage patients, respectively: 73% (95% CI [64-81]), 72% (95% CI [63- 80]), 66% (95% CI [56-75]), 58% (95% CI [48- 67]), (chi- squared test for linear trend, p=0.008) (Table 1).

Eighty percent of physicians reported feeling "extremely" or "very" comfortable discussing the potential future malignancy risks from CT with parents/guardians; 17% reported feeling "somewhat" comfortable; and 4% reported feeling "a little" or "not at all" comfortable. Of the 108 respondents, 102 (94%) indicated that family request for a CT not deemed to be clinically indicated was of "very high" or "high" importance in their decision to discuss the potential malignancy risks associated with CT (Table 2).

Direct patient/family request for risk information was of "very high" or "high" importance in risk disclosure for 79% of respondents. Sixty-one percent responded that medico-legal implications for not discussing risks were of "very low"

Table 1. Frequency of physician disclosure of potential malignancy risk from computed tomography, by patient age group (N=108).

Age group	Almost always	Most of the time	Sometimes	Not very often	Almost never
Infants, n (%)	41 (38)	38 (35)	24 (22)	1 (1)	4 (4)
Toddlers, n (%)	40 (37)	38 (35)	24 (22)	3 (3)	3 (3)
School-age, n (%)	37 (34)	34 (32)	29 (27)	5 (5)	3 (3)
Teenagers, n (%)	30 (28)	32 (30)	32 (30)	11 (10)	3 (3)

Table 2. Factors influencing physician decision to discuss potential malignancy risks from computed tomography with parents/guardians (N=108).

Factor	Very high importance	High importance	Moderate importance	Low importance	Very low importance
The patient/family is requesting the CT but I do not think it is clinically indicated n (%)	69(64)	33(30)	4 (4)	1 (1)	1 (1)
Patient/family directly asks me for more information, n (%)	50 (46)	36 (33)	16 (15)	4 (4)	2 (2)
It is my duty to let patients/families know about the potential risks and benefits of any test, n (%)	33 (31)	41 (38)	26 (24)	6 (6)	2 (2)
Patients/families often worry about the potential risks, even if they do not ask, n (%)	23 (21)	41 (38)	30 (37)	9 (8)	5 (5)
There may be medico-legal implications if I do not discuss the risk, n (%)	3 (3)	8 (7)	31 (28)	42 (39)	24 (22)

CT, computed tomography.

Table 3. Factors influencing physician decision NOT to discuss potential malignancy risks from computed tomography with parents/guardians (N=106).

Factor	Very high importance	High importance	Moderate importance	Low importance	Very low importance
Time pressure, n (%)	3 (3)	27 (26)	30 (28)	30 (28)	16 (15)
Concern that the patient's health will be compromised due to refusal, n (%)	8 (8)	19 (18)	22 (21)	42 (40)	15 (14)
Concern that patients/families will refuse the CT and/or ask for alternative tests/strategies not easily available, n (%)	6 (6)	9 (9)	29 (27)	44 (42)	18 (17)
Most patients/families will not understand the complexities of these discussions, n (%)	1 (1)	9 (9)	23 (22)	45 (43)	28 (26)
Discussion is not necessary because I as a physician have considered the balance of benefit and risk, n (%)	1 (1)	9 (9)	18 (17)	36 (34)	42 (40)
Discussion is not relevant because there is a lack of consensus on the level of risk, n (%)	2 (2)	5 (5)	18 (17)	45 (43)	36 (34)
Discussion is not relevant for children with reduced life expectancy, n (%)	1 (1)	3 (3)	17 (16)	37 (35)	48 (45)
Lack of confidence in my knowledge of the potentail risk, n (%)	0 (0)	2 (2)	17 (16)	49 (46)	38 (36)

CT, computed tomography.

or "low" importance. Regarding factors influencing the decision not to discuss the potential malignancy risks from CT, 29% reported that constraints of time pressure and 26% concern that the child's health would be compromised due to refusal were of "very high" or "high" importance (Table 3).

Survey respondents were asked how they thought risk disclosure should be performed if disclosure became the standard of care. Of the 104 respondents to this question, 40% endorsed verbal discussion without documentation in the medical record, 42% endorsed verbal discussion with documentation in the medical record, and 17% favored written informed consent.

Physician Knowledge of Radiation Risks

When asked about current estimates[16-19] of the potential increase in lifetime cancer mortality from head CT imaging, one physician responded there was no risk. For the risk to a 5-10 year-old child receiving a head CT compared to an adult, 29% knew the risk was approximately double and 55% thought it was five times greater than for an adult (Table 4).

Proportions of respondents that selected each of the proposed educational tools to assist with communication of risks and benefits from diagnostic imaging as potentially "very" or "somewhat" useful were as follows: online lecture/

Table 4. Physician knowledge of potential increase in lifetime cancer-mortality estimate associated with a single head computed tomography in an adult and pediatric patient.

Risk (N=104)	n (%)
Adult patient (30-50 years-old)	
1 in 100	1 (1)
1 in 1000	17 (16)
1 in 10,000*	38 (37)
1 in 100,000	15 (14)
1 in 1,000,000	4 (4)
Don't know	28 (27)
There is no risk	1 (1)
Pediatric patient (5-10 years-old)^	
1/5 the risk	0 (0)
1/2 the risk	0 (0)
Similar to adult risk	2 (2)
2 times the risk*	30 (29)
5 times the risk	57 (55)
Don't know	15 (14)

*Correct Response, ^Assumes appropriate adjustments to technical settings.

educational webinar (85%); smartphone app/web-based interactive tool (83%); automated feature of the electronic medical record when ordering a CT (75%); in-person lecture or workshop (68%); and pocket card or short booklet (66%).

Finally, physicians were asked their familiarity with imaging utilization and radiation awareness and safety campaigns and principles. Of the 104 respondents, 59 (57%) were "very" or "highly" familiar with the ALARA (as low as reasonably achievable) principle; 35 (34%) with the Image Gently Campaign; 25 (24%) with the Choosing Wisely® campaign; 22 (22%) with the Image Wisely campaign; and, 19 (18%) with the American College of Radiology Appropriateness Criteria®. Nearly all respondents (96.2%) reported that technical settings on CTs were adjusted for pediatric patients, and four (3.8%) were unsure.

DISCUSSION

Among PEM fellowship program leaders in North America, the majority reported discussing potential future malignancy risks routinely with parents/guardians. Disclosure frequencies significantly decreased with increasing age of the child, and most physicians reported feeling comfortable with these discussions. The most important motivating factors for initiating risk discussions were family request for a CT that the physician felt was not clinically indicated and direct patient/family request for more information about risk. Most endorsed a verbal process for disclosing potential CT malignancy risks.

Previous studies of physician disclosure of CT malignancy risks have focused on general emergency physicians[12,13,23] who primarily care for adult patients,[24] radiologists,[25] and pediatric surgeons.[26] These studies show only a minority (9%-37%) of physicians disclose potential malignancy risks to patients and families. In contrast, a study of Canadian PEM physicians found the majority (69%) reported disclosing risks most or all of the time prior to CT. These findings and ours support a higher rate of risk disclosure among PEM academic physicians. This may reflect greater attention from the medical community[1,5] as well as from the media,[2] toward highlighting radiation risks in children. Further, our study also suggests a patient age-related trend in risk disclosure practice, consistent with PEM physician awareness of the widely accepted inverse relationship between age of exposure and malignancy risk.[16]

Most respondents knew that the estimated malignancy risk from CT for a child is greater than that for an adult patient, although only a minority of respondents selected the correct relative increase in risk. Many in fact overestimated the relative increased risk. A previous systematic review including seven studies investigating physician awareness of radiation risks found that only an average of 54% believed that ionizing radiation increased the risk of developing cancer.[27] In our study, all but one respondent believed there was a risk. This may reflect an increase in awareness by PEM physicians, specifically in academic medicine. Publicity surrounding the ALARA principle, as well as high-profile scientific studies,[3] may have contributed to these findings. Nonetheless, most physicians in our study did advocate for resources to assist with risk-disclosure practices in the ED, in particular an online educational lecture or webinar and a smartphone or web-based interactive tool. This suggests a continued need for education and support for physicians to effectively engage in radiation-risk discussions with patients and families. Interdepartmental collaboration between PEM physicians and radiologists for a consistent and informed approach will be an important element in developing such tools. Furthermore, the majority of respondents were unfamiliar with many of the campaigns designed to increase radiation-risk awareness and imaging appropriateness, indicating organizations need to improve the scope of their imaging awareness campaigns to better include more of the PEM community.

We found that for nearly all respondents, the decision to disclose the potential malignancy risks from CT was strongly influenced by parent/guardian request for a CT that was not deemed clinically indicated. This may be one strategy physicians use to dissuade parents/guardians from requesting unnecessary imaging. This approach

relies on "anticipated regret;" that is, it aims to influence a parent's/guardian's decision to have their child exposed to the radiation from CT.[28] It assumes the parent/guardian will no longer request the CT after considering their future regret if the CT is normal but their child develops cancer at some future date. Physicians also identified that initiation of discussion was often prompted by patient/family requests for more information, which reinforces that parents are increasingly aware of possible risks due to media coverage on this topic.[2] Parents may want to be informed about possible risks before undergoing CT imaging, as demonstrated by one study in which 90% of parents surveyed reported a preference for disclosure.[29] Most of the potential barriers to risk disclosure proposed in our survey were only identified by a minority of physicians as important factors dissuading them from radiation-risk discussions. More work is needed to further explore facilitators and barriers to radiation-risk disclosure in the pediatric ED in order to promote consistent and effective communication strategies.

To date, risk disclosure for CT imaging has been a matter of debate in the medical community, which is in contrast to other procedures that carry similar and even lower risks.[30] Consequently, some contend that CT imaging should be subject to written informed consent.[6,31] However, the lack of consensus and certainty of radiation-risk estimates contributes to the argument against a formal, informed consent process. As a result, others advocate for an informed or shared decision-making process,[32-33] which acknowledges the uncertainty in the precise level of risk but accepts that there is likely some small risk. In a commentary published in *Pediatric Radiology*, two steering committee members of the Image Gently campaign advocated that "educational materials be provided to every parent or patient prior to the performance of every CT scan as part of medical safety and practice quality improvement and that receipt of this information be documented…in the electronic medical record."[33] Radiologists and PEM physicians will need to collaborate at the hospital, regional, and national level to determine the optimal way to provide information regarding radiation risks from CT to parents/guardians. Additionally, future studies should evaluate the manner in which CT risk disclosure should occur as well as the effects of implementing a standardized consent process on CT utilization rates, parent/guardian satisfaction, and patient outcomes.

LIMITATIONS

There are limitations to our study. Our study was limited to PEM fellowship program leaders, and thus our data are not generalizable to all PEM physicians. However, practices and attitudes from this physician group may provide information regarding PEM physicians in academic centers, and it is often these centers that shape the direction of PEM in a variety of practice settings.[34] Further, program directors lead the education of future PEM physicians, who go on to practice PEM in community and academic sites. Nonetheless, further work regarding a broader sample of PEM physicians is needed.

In addition, in some cases there were multiple respondents from a single institution; therefore, some of the responses may not be independent of each other if there is teaching consistency within the program. As with all survey studies, ours is subject to selection bias, in that those who do engage in radiation-risk discussions with parents/guardians may be more willing to complete the survey. However, given the relatively high response rate, this is unlikely to substantively affect our results. Our data indicate what physicians report doing, which may not reflect actual practices. In addition, it is possible that some responses were influenced by social desirability[35] and resulted in physicians reporting assumed "ideal" practice. These factors may have resulted in an overestimation of disclosure frequencies.

CONCLUSION

Our study indicates that PEM fellowship program leaders report commonly discussing potential malignancy risks with patients' parents/guardians, with the frequency increasing with younger patient age. Radiation risk disclosure is often driven reactive to parent/guardian requests. These physicians are aware of the increased CT radiation risk; however, they are in need of more resources to better communicate these risks, and most support a verbal strategy for mandatory risk communication. These data provide information for future work to standardize and optimize the manner in which CT radiation risks are disclosed to patients and families in the ED.

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Patient Preference for Pain Medication in the Emergency Department Is Associated with Non-fatal Overdose History

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Introduction: Opioid overdose is a major public health problem. Emergency physicians need information to better assess a patient's risk for overdose or opioid-related harms. The purpose of this study was to determine if patient-reported preference for specific pain medications was associated with a history of lifetime overdose among patients seeking care in the emergency department (ED).

Methods: ED patients (18-60 years) completed a screening survey that included questions on overdose history, ED utilization, opioid misuse behaviors as measured by the Current Opioid Misuse Measure (COMM), and analgesic medication preferences for previous ED visits for pain with specific responses for preference for hydromorphone (Dilaudid®), morphine, ketorolac (Toradol®), "no preference" or "never visited the ED for pain." We compared individuals who reported a lifetime history of overdose descriptively to those without a lifetime history of overdose. Logistic regression was used to determine factors associated with a history of overdose.

Results: We included 2,233 adults in the analysis (71.5% response rate of patients approached) with 532 reporting at least one lifetime overdose. In the univariate analysis, medication preference was significantly associated with overdose history ($p < .001$); more patients in the overdose group reported preferring morphine and hydromorphone and those without a history of overdose were more likely to have no preference or say they had never visited the ED for pain. In the logistic regression analysis, patients with higher odds of overdose included those of Caucasian race, participants with a higher COMM score, preference for ketorolac, morphine or hydromorphone. Those who were younger, female and reported never having visited the ED for pain had lower odds of reporting a lifetime overdose. Having "any preference" corresponded to 48% higher odds of lifetime overdose.

Conclusion: Patients with a pain medication preference have higher odds of having a lifetime overdose compared to patients without a specific pain medication preference, even after accounting for level of opioid misuse. This patient-reported preference could cue emergency physicians to identifying high-risk patients for overdose and other substance-related harms. [West J Emerg Med.2018;19(4)722–730.]

INTRODUCTION

Overdose is a serious public health problem in the United States, where the rate of opioid-related deaths has increased 200% since 2000.[1] Additionally, non-fatal overdoses and hospitalizations for opioid overdose have increased significantly[2] and approximately half of all drug-related emergency department (ED) visits in 2011 involved misuse of a pharmaceutical or prescription drug (e.g., opioid, sedative, stimulant).[3] In an effort to curb this public health epidemic, there has been a concerted effort to promote safe opioid prescribing and limit opioids for chronic, non-cancer pain. Specifically, agencies such as the Centers for Disease Control and Prevention (CDC) have published guidelines for chronic opioid prescribing,[4] and the American College of Emergency Physicians has published an evidence-based clinical policy regarding issues around opioid prescribing from the ED.[5] However, many of these guidelines do not provide useful measures for identifying patients at risk for overdose or other opioid-related harms.

Emergency medicine providers are often charged with seeing patients with acute pain or acute exacerbations of chronic pain under hectic conditions without the benefit of an existing relationship or extensive information on the patient's background. While there are many different self-report screening tools to understand individual patient risk for opioid-related harms when prescribing opioids, these tools are not routinely used in the ED. Many of these tools were developed specifically for patients initiating chronic opioids such as the Opioid Risk Tool,[6] making it difficult to interpret scores for patients in acute pain in the ED. State-based prescription drug monitoring programs (PDMP) that contain a registry of controlled substance prescribing linked to specific patients can be used to determine risk for diversion and has been shown to decrease prescribing of controlled substances.[7] However, the PDMP does not pick up on risky opioid behavior unrelated to diversion and doctor shopping and does not provide clinical outcomes regarding dispensed opioids such as previous overdose.

There has recently been much effort devoted to understanding patient-related risk factors associated with opioid-related harms including overdose. Patients on high daily opioid doses, concurrent use of sedative medications such as benzodiazepines, substance-use comorbidity, or patients who are prescribed extended-release or long-acting opioids are at increased risk for having an overdose.[8-12] Additionally, patients with a previous non-fatal overdose are at elevated risk for having subsequent overdose.[13-16] Many physicians use historical data from the electronic medical record (EMR) to review these treatment- and patient-related factors, including prior history of overdose or a history of polysubstance use.[10,14] However, historical EMR data can offer an incomplete picture if patients seek care across different health systems or use different EDs.[17]

Population Health Research Capsule

What do we already know about this issue?
Overdose is a major public health issue and emergency physicians don't have good validated tools to assess risk for previous overdose.

What was the research question?
Is self-reported preference for pain medication during an emergency department (ED) visit associated with a previous overdose.

What was the major finding of the study?
ED patients with a self-report preference for any pain medication have increased odds of previous overdose.

How does this improve population health?
Patient-reported preference for pain medication should be explored further and could cue emergency physicians to identifying high-risk patients.

Information provided directly by patients could be a rapid and easy way to obtain useful information to supplement other tools such as the EMR or PDMP to understand opioid-related risks. Patients presenting for pain-related ED complaints may provide information regarding their preference for certain pain medications. Asking for a specific medication by name is one of the aberrant drug-related behaviors noted by pain medicine experts[18] but this behavior has not been investigated in ED samples where patients often present for acute pain. To date, there have been no studies that seek to understand the association between a patient's preference for a certain pain medication and risk for overdose. Researchers have theorized that ED patients' chief complaints or requests for specific opioid medications may be predictive of non-therapeutic use,[19] but there is little published data addressing these questions.

The objective of this study was to determine whether self-reported preference for pain medication during a visit to the ED was associated with a previous overdose among patients using the ED for care. We hypothesized that the odds of having a previous overdose will increase respectively as patients prefer hydromorphone (Dilaudid®), morphine, or ketorolac (Toradol®)compared to patients with no preference for a certain pain medication.

METHODS

We conducted a secondary analysis of cross-sectional screening data obtained as part of the screening and recruitment phase of the Safety and Prevention Outcomes Study (SPOS), an ED-based, brief intervention aimed at reducing opioid overdose behavior in at-risk patients.[20]

Study Setting and Population

We recruited participants from the University of Michigan Health System ED, a Level I trauma center located in Washtenaw County, MI, with a census of 85,000 adults annually. Participants were recruited Monday through Friday and two weekends per month between the hours of 6:30 am and 1:59 pm, from April 2013 to March 2014. Two trained research assistants (RAs) identified patients 18-60 years old without regard for chief complaint using computerized tracking logs, and they approached those placed in private treatment rooms. At the beginning of the shift, RAs would be randomly assigned areas of the ED to start recruitment and approach all potentially eligible patients in that zone who weren't receiving medical care or talking with medical staff. Patients were excluded from screening if they did not understand English; were in police or corrections custody; had cognitive or other impairment precluding ability to consent (e.g., visual or hearing impaired); were medically unstable requiring immediate resuscitation (e.g., from major injury or sepsis), or were presenting for evaluation and treatment of sexual assault or suicidal ideation.

RAs obtained written informed consent and facilitated a brief, self-report screening survey using a tablet computer or pen-and-paper survey (when computers were unavailable), for which participants received a $1.00 gift. Participants were given the option to complete the screening independently using the tablet computer or by having the RA read the questions and input the answers (e.g., RA administered). During the consent process, we told possible participants we would be gathering information on physical and mental health and substance-use behaviors and depending on their answers they might be eligible for the next part. Participants who completed the screening did not know the intervention was to prevent overdose-risk behaviors. See figure for a more-detailed participant flowchart.

Measurements

Outcome

The primary outcome measure was lifetime overdose, where overdose was defined as "*taking too much drugs or medications/pills and/or drinking too much alcohol," i.e., "'poisoning,' 'passing out,' 'nodding off,' 'blacking out,' or an*

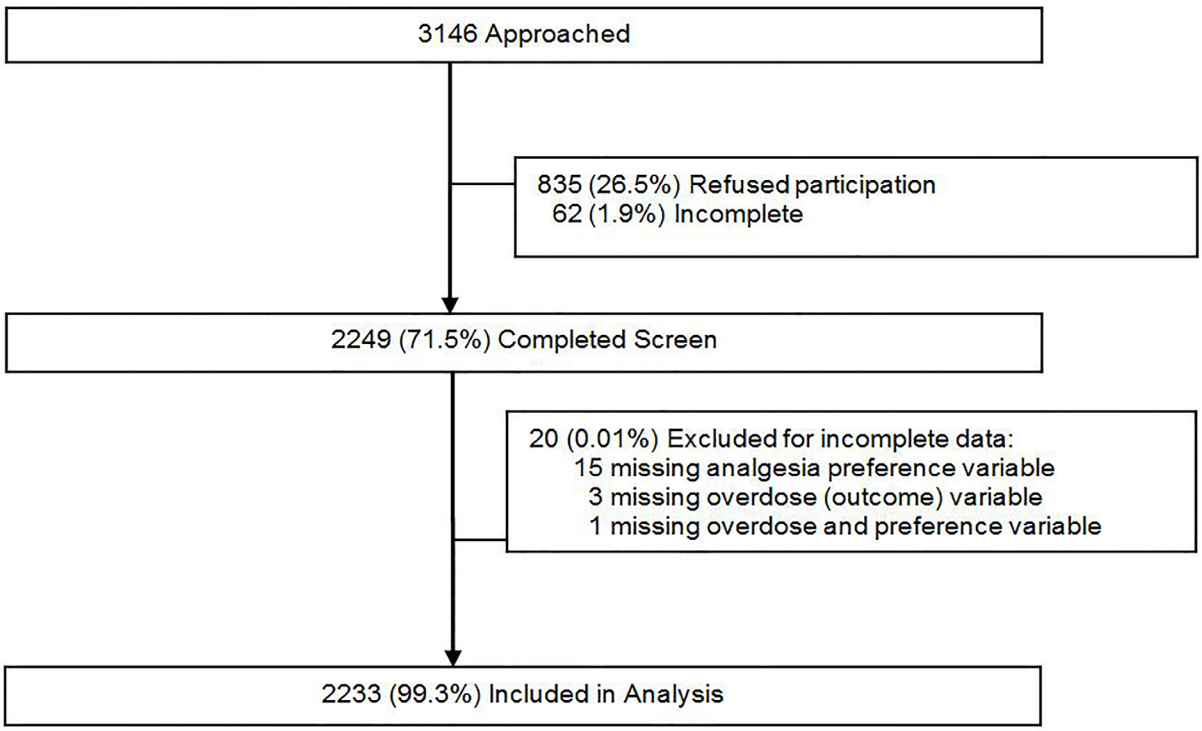

Figure. Study participation flowchart.

'overdose' or 'OD.'" We designed this question to err on the side of high sensitivity, as we hypothesized that many patients in the ED would not identify these serious or life-threatening experiences with the term "overdose." Lifetime overdose was determined by the answer to the question, "*How many times in your life has this kind of situation happened to you*?" Any answer other than "*never*" was coded as positive.

Demographics

Age, gender, race/ethnicity, employment status, annual income, and years of education were determined by self-report. Race/ethnicity categories included African-American, White, Hispanic/Latino, Asian, American Indian, and other, and were not mutually exclusive. Annual income was collapsed into four categories (≤ $19,999, $20,000-59,999, ≥ $60,000, or "Don't know"), and employment was dichotomized as employed (full-time or part-time) or not employed (unemployed or retired). Years of education was categorized into three groups (high school or less, some college, graduated college).

ED Service Utilization and Visit Characteristics

ED utilization was determined by the self-reported number of ED or urgent care visits in the prior 12 months (including the baseline visit), and measured as 1, 2-3, 4-6, 7-9, 10-20, and ≥ 21. For this analysis, these scores were dichotomized as < 4 or ≥ 4. This cut-off was chosen to be consistent with previous definitions of "frequent utilizers" in the literature.[21] Participants were queried as to whether they believed their current ED visit was related to "*drinking too much alcohol*," "*taking too many medications*," or "*taking too many substances*" (each reported as yes/no), and whether they had used opioid analgesics within the six-hour period prior to the current ED visit.

Analgesic Preferences and Opioid-misuse Behaviors

The key independent variable of interest was patient preference for analgesic medication, which was assessed by asking in the survey, "*When you visit the ER, what type of pain medication usually helps relieve your pain best?*" Patients were asked to choose among the following: hydromorphone, morphine, ketorolac, "no preference," "I don't know," or "never visited ER for pain." Patients who had no preference or reported "I don't know" were combined into one category. We also included the level of non-medical use of prescription opioids (or "opioid misuse") in the prior three months as measured by the sum of eight items (e.g., frequency of using prescription opioids not as prescribed) from the Current Opioid Misuse Measure (COMM). At the beginning of the COMM questions, participants were reminded that '*Pain medications also called "opioids" include Vicodin, codeine, Oxycontin, morphine, oxycodone, hydrocodone, methadone, hydromorphine, meperidine, fentanyl, or Norco, among others'* and then were able to provide answers to the eight COMM questions, which is a validated tool for assessing opioid misuse behaviors.[22] Responses were measured on a 5-point scale (0: never, 1: rarely, 2: sometimes, 3: often, 4: very often); individuals' scores were computed as the sum of these items to produce a 0-32 score. Patients responding with "No" to a lead-in question about previous non-medical use of prescription opioids received a total score of 0.

All analyses were performed using *R version 3.2.3* (R Core Team). We first calculated descriptive statistics among the total sample and among both those that did, and did not, have the outcome variable (lifetime history of overdose). We excluded from the sample participants with incomplete data for the outcome variable or the key independent variable of "analgesic preference." Between-group comparisons of the distributions of each independent variable (e.g. univariate comparisons) were made using Kruskal-Wallis tests for quantitative variables and χ^2 tests for categorical variables, respectively.

For adjusted comparisons, we used logistic regression. Variables included in the logistic model were selected based on clinical and theoretical considerations required to get properly adjusted estimates of the effect of patient analgesic preference. We preferred this approach to a stepwise selection procedure because such methods are known to produce anti-conservative inference (e.g., the resulting standard errors and *p*-values are biased low, and parameter estimates are biased high).[23] To guard against separation issues in logistic regression, we ensured that there were at least 10 events per predictor variable included in the logistic regression. ED utilization was significant in the univariate analysis, but was not included in the adjusted model because this variable was hypothesized to be too similar to the preference variable, as participants who have a preference for pain medications were more likely to be exposed to previous ED visits for acute pain. Thus, the multivariable model included basic demographics (age, gender, race, education), opioids within six hours of ED visit, COMM score and preference for pain medication in the ED. Our first adjusted model provides separate adjusted odds ratios (aOR) for preference of ketorolac, morphine and hydromorphone. As a separate analysis, we also present an aOR combining these medication preferences into a variable labeled "any preference." The included predictors were checked for collinearity and no variance inflation factors exceeded 1.8, indicating that the effect of collinearity was minimal. Individuals missing values on any of the included predictors (n=20) were excluded from this adjusted analysis for an analytic sample size of 2,213.

RESULTS

A total of 3,146 eligible patients were approached, 2,249 completed the screen and 2,233 had complete data on the outcome variable as well as the analgesic preference variable and were included in this analysis (Figure).

In the univariate analysis, those with a lifetime overdose were older (p<0.001) and more likely to report being Caucasian (p<0.001) compared to participants who did not report a lifetime overdose; gender was not significant. (p<0.01). With regard to ED utilization, participants in the lifetime overdose group were more likely to have visited the ED at least four times in the prior year compared to those without a history of lifetime overdose (p < 0.001), and participants with a previous overdose were also more likely to report their current ED visit as related to too much alcohol or drugs (p < 0.001) and noted more pain medications and/or opioids within six hours of the ED visit (p<0.05); although overall frequency of these variables was low. Participants in the lifetime overdose group reported a mean COMM score of 2.6 (standard deviation [SD] 5.4) compared to those without a lifetime history of overdose, who reported a mean COMM score of 0.9 (SD 2.5) (p>0.001), indicating a higher level of current opioid misuse or nonmedical prescription opioid use among participants with a lifetime overdose. Likewise, more patients with a previous lifetime overdose had taken opioids (for appropriate medical purposes or inappropriate use) in the prior three months compared to those without a lifetime overdose (p <0.01). Overall, medication preference for acute pain varied across the two groups, with more participants in the lifetime overdose reporting preference for morphine (15.4% vs. 10.5%, p<0.01) and hydromorphone (16.0% vs. 8.2%, p<0.001) compared to those in the group without a history of lifetime overdose. There was no difference in the univariate analysis between groups for preference of ketorolac. Those without a lifetime overdose were more likely to report having never visited the ED for pain (p<0.001) or having no preference or an unknown preference (p<0.001) compared to those with a lifetime overdose (Table 1).

Nearly one-third of the sample (31%, n=532) reported a history of a lifetime overdose. Among those with overdose, the average number of previous overdoses was 3.1 (SD 1.91). In the logistic regression model evaluating factors associated with a lifetime overdose each analgesic medication (e.g. ketorolac, morphine, hydromorphone) was first included as a separate variable to understand how specific medication preferences were associated with a history of lifetime overdose (Table 2). In this adjusted model, demographic factors associated with a lifetime history of overdose include younger age (aOR [0.85]; 95% confidence interval [CI] [0.78-0.95]), female gender (aOR [0.80]; 95% CI [0.65-0.99]) and Caucasian race (aOR [2.03]; 95% CI [1.57-2.65]). COMM score indicating current opioid misuse was associated with increased odds of overdose (aOR 1.12 for each unit increase in COMM score, 95% CI [1.08-1.15]). Additionally, preference for hydromorphone at the current ED visit was associated with lifetime overdose (aOR [1.46], 95% CI [1.03-2.05]) as was preference for morphine (aOR [1.44], 95% CI [1.05-1.97]) and preference for ketorolac (aOR [1.62], 95% CI [1.01-2.57]). Participants who reported having never visited the ED for a pain-related complaint had a decreased odds of having a lifetime overdose compared to having visited an ED for pain but having no opioid preference (odds ratio [OR] [0.64]; 95% CI [0.48-0.86]).

To understand the association of lifetime overdose with any pain medication preference, we performed a second logistic regression model predicting lifetime overdose but with the medication-preference variables (e.g. hydromorphone, morphine, ketorolac) combined into one category to understand if "any preference" provided similar results. Interestingly, "any medication preference" had increased odds of lifetime overdose (OR [1.48], 95% CI [1.16-1.89]) suggesting that preference for any pain medication is associated with a history of overdose (Table 3); the OR for all other predictors remained virtually unchanged. Both models produced non-significant Hosmer-Lemeshow test results (for Table 2 and for Table 3), indicating no serious lack-of-fit in either model.

DISCUSSION

Preference for pain medication type has not been examined previously as a predictor of lifetime overdose. In this investigation, patients' specific preference for hydromorphone, morphine and ketorolac were all associated with a history of previous overdose after accounting for patient characteristics, including level of opioid misuse with ORs suggesting a modest but significant association. The overall conclusions did not change when ketorolac, morphine and hydromorphone preferences were combined, suggesting that any specific preference for pain medication is associated with a lifetime history of overdose.

Previous research has shown that patients who get opioids from the ED are at risk for opioid-related problems and those who misuse prescription opioids have elevated rates of ED utilization. Specifically, adolescent patients who receive parenteral opioids in the ED are more likely to report non-medical use of prescription opioids,[24] and patients who receive opioids at discharge from the ED are at increased risk for long-term opioid use.[25,26] Likewise, adults who reported using prescription opioids non-medically are more likely to have visited the ED compared to those who don't report non-medical prescription opioid use.[27] Preference for ketorolac was also independently associated with increased risk of previous overdose in the adjusted analysis suggesting that any pain medication preference is an important risk factor and not just preference for opioids.

Recent studies have shown that previous overdose history is an important predictor of future overdose risk.[14-16] Approximately one in three participants (31%) in this study noted a lifetime history of overdose. The definition of overdose used for this study was intentionally broad, allowing for capture of adverse events associated with drug or alcohol use. A recent study by Bohnert and colleagues used a similar definition of overdose in a more urban ED population, which sampled patients presenting in the evening hours and found a prevalence of 12.1%,[28] which is consistent with demographic

Table 1. Demographics, emergency department (ED) utilization and opioid use and experiences among ED patients.

Variable	Total (n=2233)	No previous lifetime overdose (n=1701)	Previous lifetime overdose (n=532)
Demographics			
Age***[a]		38.0 (12.8)	35.6 (12.4)
Female	(n=2233)	1074 (63.1%)	313 (58.8%)
Race***			
Caucasian***	1677 (75.1%)	1238 (72.8%)	439 (82.5%)
African American**	421 (18.9%)	346 (20.3%)	75 (14.1%)
Other (includes Asian and American Indian)	133 (5.9%)	107 (6.3%)	26 (4.9%)
Hispanic/Latino ethnicity	90 (4.0%)	75 (4.4%)	15 (2.8%)
Currently employed***	1451 (65.0%)	1146 (67.4%)	305 (57.3%)
Income*[b]			
≤19,999**	634 (28.4%)	454 (26.7%)	180 (33.8%)
$20,000-$59,000	662 (29.6%)	514 (30.2%)	148 (27.8%)
≥ $60,000	736 (33.0%)	577 (33.9%)	159 (29.9%)
Don't know	181 (8.1%)	138 (8.2%)	43 (8.1%)
Schooling completed[c]			
Completed high school or less	512 (22.9%)	386 (22.7%)	126 (23.7%)
Completed some college	868 (38.9%)	652 (38.3%)	216 (40.6%)
Graduated college	515 (23.1%)	394 (23.2%)	121 (22.7%)
Emergency department (ED) utilization			
≥4 or more ED visits in the past year***[d]	421 (18.9%)	279 (16.4%)	142 (26.7%);
ED visit today due to alcohol or too many substances***	40 (1.8%)	13 (0.8%)	27 (5.1%)
Pain meds/opioids within 6 hours of ED visit*[e]	233 (10.4%)	165 (9.7%)	68 (12.8%)
Overdose experience			
Previous overdose in the last year***	196 (8.8%)	0 (0.0%)	196 (36.8%)
Current opioid misuse			
Taken any opioids in the past 3 months (yes)**[e]	794 (35.6%)	573 (33.7%)	221 (41.5%)
COMM score (mean)***[f]	1.3 (3.4)	0.9 (2.5)	2.6 (5.4)
Medication preference in the ED**			
No preference or don't know***	1178 (52.8%)	915 (53.8%)	263 (49.4%)
Ketorolac	93 (4.2%)	63 (3.7%)	30 (5.6%)
Morphine**	260 (11.6%)	178 (10.5%)	82 (15.4%)
Hydromorphone***	225 (10.1%)	140 (8.2%)	85 (16.0%)
Never visited***	477 (21.4%)	405 (23.8%)	72 (13.5%)

COMM, Current Opioid Misuse Measure.
*p < 0.05, ** p < 0.001, *** p≤ 0.0001 for univariate comparisons of "no overdose" compared to "overdose" groups.
[a]n=7 missing, [b]n=20 missing, [c]n= 5 missing, [d]n=6 missing, [e]n=1 missing, [f]n=9 missing.

trends for overdose. It is also important to note that alcohol contributes to overdose experiences. Banta-Green and colleagues reported on an opioid overdose intervention trial that recruited adult patients from an urban ED at elevated risk for opioid overdose, in which one-third of the participants reported they used alcohol when using prescription or illicit opioids.[29] Overdose screening and intervention efforts from the ED have recently focused on opioids;[29,30] however, alcohol may contribute to more severe overdose experiences, and patients using alcohol to the point of overdose either alone or in combination with other substances should be identified and receive education and intervention.

Table 2. Logistic regression predicting lifetime overdose with medication-preference variables separate.

Variable	Lifetime overdose with medication preference variables separate odds ratio (95% CI)
Demographics	
Age	0.85 (0.78, 0.92)***
Female	0.80 (0.65, 0.99)*
Caucasian race	2.03 (1.57, 2.65)***
High school or less	[ref]
College graduate	1.11 (0.84, 1.47)
Some college	1.04 (0.79, 1.36)
ED Utilization	
Opioid within 6 hrs of ED visit	0.83 (0.59, 1.17)
Current opioid misuse	
COMM score	1.12 (1.08, 1.15)***
Medication preference in the ED	
No preference	[ref]
Hydromorphone preference	1.46 (1.03, 2.05)*
Morphine preference	1.44 (1.05, 1.97)*
Ketorolac preference	1.62 (1.01, 2.57)*
Any preference	n/a
Never visited	0.64 (0.48, 0.86)**

CI, confidence interval; *ED*, emergency department; *COMM*, Current Opioid Misuse Measure.
*p < .05 , **p < .01 , ***p < .001

Table 3. Logistic regression predicting lifetime overdose with medication-preference variables combined.

Variable	Lifetime overdose with medication preference variables combined odds ratio (95% CI)
Demographics	
Age	0.85 (0.78, 0.92)***
Female	0.80 (0.65, 0.99)*
Caucasian race	2.03 (1.57, 2.65)***
High school or less	[ref]
College graduate	1.11 (0.84, 1.47)
Some college	1.04 (0.79, 1.36)
ED Utilization	
Opioid within 6 hrs of ED visit	0.83 (0.59, 1.17)
Current opioid misuse	
COMM score	1.12 (1.08, 1.15)***
Medication preference in the ED	
No preference	[ref]
Hydromorphone preference	n/a
Morphine preference	n/a
Ketorolac preference	n/a
Any preference	1.48 (1.16, 1.89)**
Never visited	0.64 (0.48, 0.86)**

CI, confidence interval; *ED*, emergency department; *COMM*, Current Opioid Misuse Measure.
*p < .05, **p < .01, ***p < .001

Using patient-reported preference for a specific pain medication as a marker or tool to identify elevated risk for previous overdose could allow for further targeted screening of patients at elevated risk for future opioid-related harms. These results suggest that information about analgesic preference that is commonly volunteered by patients during an ED visit for pain may have utility in informing an assessment and could be a way to identify patients who would benefit from additional screening or intervention to prevent misuse and/or overdose.

Previous investigators have shown that it is feasible to administer a self-report screening tool for opioid misuse at the time of discharge from the ED, which could help guide opioid prescribing.[31] In this analysis, an increasing score based on eight items from the COMM a self-reported survey assessment, was associated with a lifetime history of overdose. Currently, there are no validated, self-report measures for opioid misuse in ED populations, and like other self-report tools the COMM has previously been used and validated in non-ED settings.[32,33] Unlike other self-report screening tools for opioid misuse[34] the COMM is relatively short and could easily be administered to patients in the ED.[35] The high prevalence of endorsement of the COMM items suggests there was not a social desirability bias in answering these questions in the context of survey research when confidentiality is maintained and questions are answered privately using a tablet computer. In the logistic regression analysis, patient preference for pain medication still predicted increased odds of lifetime overdose after adjusting for COMM score, suggesting that preference for pain medication provides additional information about overdose compared to using only the COMM score alone. Importantly, the COMM and the self-reported medication preference provide information about potential opioid-related harms and both measures could be used in tandem as part of a way to understand individual risk for lifetime overdose. For example, clinicians could be cued in to pursuing validated, self-report screens such as the COMM in patients who self-report a pain medication preference to identify patients at risk for prescription opioid harms.

Interestingly, patients who had never been to the ED with a pain-related complaint had decreased odds of having a lifetime overdose. This is consistent with prior literature, which notes that patients on chronic opioid therapy have increased use of healthcare services including the ED.[35] Also, patients without a prior visit to the ED for pain are less likely to be exposed to opioids. This suggests that prudent opioid prescribing at the point of an ED visit is important toward the goal of curbing the epidemic of overdose.

LIMITATIONS

While this study provides novel information around correlations of previous overdose for patients currently in the ED, there are some important limitations to note. This is a cross-sectional analysis that supports an association between lifetime overdose and self-reported preference for pain medication but does not support a causal conclusion. Clinical characteristics including the reason for ED presentation was not obtained, although the screening strategy was broad and systematic. Patients were recruited during day-shift hours and we did not collect data during evenings or nights. Future studies should account for possible differences in patient presentation during evenings and overnight hours.

Consistent with all other self-report opioid-misuse measures, the COMM has not been validated in ED settings. The definition of overdose was intentionally broad. While this could be viewed as limiting generalizability, it also likely captures a wide range of overdose behaviors that wouldn't be captured by a definition that was narrower in scope. The SPOS study occurred at a single institution and thus may not be generalizable to other settings such as rural EDs or to patients with different sociodemographic characteristics. Many measures were obtained through self-report including the main outcome of lifetime overdose. The survey question that provided the main exposure of interest (patient preference) was not cognitively tested with a similar population prior to this study.[36] While this could be viewed as a limitation, there are several studies documenting the reliability and validity of self-report for risk behaviors using similar methods when privacy and confidentiality are protected,[37-39] albeit not in the ED setting.

CONCLUSION

ED patients with a preference for a specific pain medication have higher odds of having a lifetime overdose compared to patients without a specific pain-medication preference, above the association-attributed current opioid misuse. To our knowledge, this is the first such study to examine and find this association. Further study is needed to determine if patient preference for specific pain medication would lead to a prospective risk of overdose or other opioid-related problems. Emergency medicine providers should be cued to this patient-reported preference, which could assist in further understanding risk for overdose and other opioid-related harms.

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Transaminase and Creatine Kinase Ratios for Differentiating Delayed Acetaminophen Overdose from Rhabdomyolysis

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Introduction: Rhabdomyolysis and delayed acetaminophen hepatotoxicity may be associated with elevated serum transaminase values. Establishing the cause of elevated transaminases may be especially difficult because of limited or inaccurate histories of acetaminophen ingestion. We hypothesized that the comparative ratios of aspartate aminotransferase (AST), alanine aminotransferase (ALT), and creatine kinase (CK) can differentiate acetaminophen hepatotoxicity from rhabdomyolysis.

Methods: A retrospective chart review of patients in four hospitals from 2006 to 2011 with a discharge diagnosis of acetaminophen toxicity or rhabdomyolysis was performed. Subjects were classified into three groups: rhabdomyolysis, acetaminophen overdose (all), and acetaminophen overdose with undetectable serum acetaminophen concentrations [acetaminophen(delayed)]. Ratios of AST, ALT, and CK were compared using non-parametric statistical methods.

Results: 1,353 subjects were identified and after applying our exclusion criteria there were 160 in the rhabdomyolysis group, 68 in the acetaminophen overdose (all) group, and 29 in the acetaminophen (delayed) group. The AST/ALT ratio for the rhabdomyolysis group was 1.66 (Interquartile range: 1.18- 2.22), for the acetaminophen overdose (all) group was 1.38 (1.08-1.69, statistically lower than the rhabdomyolysis group, $p = 0.018$), and for the acetaminophen (delayed)group was 1.30 (1.06-1.63, $p = 0.037$) . CK/AST ratios were 21.3 (12.8-42.2), 5.49 (2.52-15.1, $p < 0.001$), and 3.80 (1.43-13.8, $p < 0.001$) respectively. CK/ALT ratios were 37.1 (16.1-80.0), 5.77 (2.79-25.2, $p < 0.001$), and 5.03 (2.20-17.4, $p < 0.001$) respectively. Increasing CK to transaminase ratio cutoffs resulted in increasing test sensitivity but lower specificity.

Conclusion: AST/ALT, CK/AST and CK/ALT ratios are significantly larger in rhabdomyolysis when compared to patients with acetaminophen toxicity. This result suggests that the ratios could be used to identify patients with rhabdomyolysis who otherwise might have been diagnosed as delayed acetaminophen toxicity. Such patients may not require treatment with N-acetylcysteine, resulting in cost savings and improved resource utilization. [West J Emerg Med. 2018;19(4)731-736.]

INTRODUCTION

Differentiating delayed presentations of acetaminophen toxicity from rhabdomyolysis can be difficult for many reasons. First, both rhabdomyolysis and acetaminophen toxicity can be associated with increased aspartate aminotransferase (AST) and alanine aminotransferase (ALT) values.[1,2] Second, though patients may go on to develop hepatotoxicity from acetaminophen, their serum acetaminophen concentrations may be low or undetectable because of a delay between ingestion and hospital presentation. Lastly, patients with these conditions can be found in an unconscious state and may be able to provide little or no clinical history. Medical toxicologists and poison centers are frequently consulted with the question of whether the transaminase elevations could be due to delayed acetaminophen toxicity and if treatment with N-acetylcysteine (NAC) is required.

No common clinical tool or laboratory test can be used to help differentiate the transaminase elevation of acetaminophen toxicity from that of rhabdomyolysis. Investigators have evaluated measurement of gamma-glutamyltransferase, isoforms of ALT, and acetaminophen adducts for this purpose, but these are impractical or not routinely available in clinical practice.[3-6] Many physicians rely on their clinical experience in differentiating between these two conditions, whereas others treat all patients with possible acetaminophen toxicity with NAC in order to avoid possible hepatic injury.[2] Given the lack of specific findings on examination or data-driven guidance from the literature, both practices are reasonable.

Since there are no objective measures to determine whether a transaminase elevation is from a delayed acetaminophen overdose or from rhabdomyolysis, we sought to determine if the relative values of ALT, AST and creatine kinase (CK) could be used for this purpose. We hypothesized that the ratios of AST/ALT, CK/AST, and CK/ALT would be higher in patients with rhabdomyolysis than in patients with acetaminophen toxicity.

Population Health Research Capsule

What do we already know about this issue?
Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) elevations can be seen in both acetaminophen overdoses and rhabdomyolysis, and differentiating between the two can often be difficult.

What was the research question?
Can commonly obtained labs be used to differentiate between rhabdomyolysis and acetaminophen toxicity?

What was the major finding of the study?
An elevated AST/ALT, creatine kinase (CK)/ALT, or CK/ALT ratio suggests that rhabdomyolysis may be more likely than acetaminophen toxicity.

How does this improve population health?
A rule similar to this may help improve resource utilization for patients with rhabdomyolysis in whom acetaminophen toxicity is unlikely.

METHODS

We performed a multi-center, retrospective chart review of admitted patients seen at four tertiary care, university hospitals, including one children's hospital, from January 2006 to October 2011. We obtained electronic medical records (EMR) on all patients with the discharge diagnosis of rhabdomyolysis or acetaminophen overdose. Subjects were included if they had a discharge diagnosis of acetaminophen overdose or rhabdomyolysis and age ≥ 10 years. Data on those patients were extracted from the EMR, de-identified, and then evaluated for inclusion and exclusion criteria by two authors (JR and DA). The data extracted included age, sex, diagnosis, and laboratory values including AST, ALT, and CK. We excluded subjects if laboratory data were incomplete (CK, AST, or ALT values missing), or if the subject was a prisoner or pregnant. Children less than 10 years old were also excluded because the children's hospital provided care for neuromuscular diseases, inborn errors of metabolism, and other genetic diseases that might have caused transaminase elevations for reasons other than rhabdomyolysis. The concentrations used for CK, AST, and ALT were the values on presentation, as these would likely be the results used to determine whether or not NAC is indicated for possible acetaminophen toxicity.

We abstracted data from the EMRs and entered them into an Excel spreadsheet (Microsoft Corp, Redmond, Washington, USA). The data were analyzed by the use of R© (The R Foundation for Statistical Computing, version 3.1.1). We categorized the patients into three groups for analysis based on discharge diagnosis (based on ICD-9 coding by hospital coders): rhabdomyolysis, acetaminophen overdose (all), and acetaminophen overdose (delayed). The acetaminophen group was broken into two separate groups because we are most interested in differentiating between cases of rhabdomyolysis and patients with a delayed presentation of acetaminophen overdose with an undetectable acetaminophen level. The acetaminophen (all) group included all patients who had a discharge diagnosis of acetaminophen overdose, regardless of initial acetaminophen concentration. The acetaminophen

(delayed) group only included those who had a discharge diagnosis of acetaminophen overdose, but had an undetectable acetaminophen level on admission. The primary outcome measures were the ratios of AST to ALT, CK to AST, and CK to ALT. We tested data normality with the Shapiro-Wilk test. Because all data were non-parametric, we used the Kruskall-Wallis test to determine if there were differences between groups; when differences were present, we performed pairwise testing by use of the Mann-Whitney-Wilcox test with a Bonferroni correction for multiple-hypothesis testing. In all cases, a p-value of <0.05 was considered statistically significant. We also analyzed the sensitivity, specificity, positive likelihood, and negative likelihood ratio of various CK/AST and CK/ALT ratio cutoffs as a test to differentiate between rhabdomyolysis cases and acetaminophen overdose cases (both acute and chronic).

The study was approved by the institutional review board of each participating hospital, with approval for data to be shared and coordinated through the University of California, Davis.

RESULTS

We identified 1,353 subjects with rhabdomyolysis or acetaminophen overdose. A majority in each group were excluded from statistical analysis due to missing laboratory data needed to calculate one or more of the ratios. Excluding those with incomplete data resulted in 160 in the rhabdomyolysis group, 68 in the acetaminophen overdose (all) group, and 29 in the acetaminophen overdose (delayed) group.

Patient demographics and the ratios of AST to ALT, CK to AST, and CK to ALT along with the results of the Kruskall-Wallis comparisons are summarized in Table 1. There was a statistically significant difference in the AST/ALT ratio between the rhabdomyolysis group and the two acetaminophen overdose groups (p=0.018 for acetaminophen (all) and p=0.037 for acetaminophen (delayed). There was no difference between the two acetaminophen groups (p=1.00). Medians and interquartile ranges (IQR) are demonstrated in Figure 1.

The CK/AST ratios for the rhabdomyolysis, acetaminophen overdose (all), and acetaminophen overdose (delayed) groups were 21.3 (IQR 12.8-42.2), 5.49 (IQR 2.52-15.1), and 3.80 (1.43-13.8) respectively (Figure 2, p<0.001). Pairwise comparisons revealed statistically significant differences between the rhabdomyolysis group and the acetaminophen overdose (all) group (p<0.001), as well as the rhabdomyolysis and the acetaminophen overdose (delayed) group (p<0.001). There was no statistical difference in the CK/AST ratio between the two acetaminophen-overdose groups (p=1.00).

The CK/ALT ratios for the rhabdomyolysis, acetaminophen overdose (all), and acetaminophen overdose (delayed) groups were 37.1 (IQR 16.1-80.0), 5.77 (2.79-25.2), and 5.03 (2.20-17.4) respectively (Figure 3, p<0.001). Pairwise comparisons revealed statistically significant differences between the rhabdomyolysis group and the acetaminophen overdose (all) group (p<0.001), as well as the rhabdomyolysis and the acetaminophen overdose (acetaminophen negative) group (p<0.001). There was no statistical difference in the CK/ALT ratio between the two acetaminophen overdose groups (p=1.00).

The test characteristics for different CK-to-transaminase ratios are presented in Table 2 (with ratios below the cutoff designated as positive for acetaminophen overdose). Increasing the ratio cutoff resulted in improved sensitivity but markedly reduced specificity.

DISCUSSION

Measurements of AST and ALT and their relationship with CK would seem to be useful in helping to differentiate rhabdomyolysis from delayed acetaminophen toxicity. AST and ALT are enzymes that play many vital roles, including amino acid metabolism and gluconeogenesis.[7] ALT is found predominantly in the liver, but is also present in skeletal and heart muscle. AST is found more widely throughout the body including the heart, brain, skeletal muscle, and liver.[8] Despite the wide distribution of these enzymes, clinically they are used mainly as markers of hepatic injury, when they are thought to "leak out" of damaged

Table 1. Demographics and results summary. Ratios are expressed as medians, with interquartile ranges.

	Rhabdo	APAP all	APAP delayed	P value
Age	48 (34-56)	42 (29-52)	46 (37-55)	NA
Male	115 (71.9%)	38 (55.9%)	18 (62%)	NA
AST/ALT	1.66 (1.18-2.22)	1.38 (1.08-1.69)	1.30 (1.06-1.63)	0.003396
CK/AST	21.33 (12.75-42.21)	5.49 (2.52-15.10)	3.80 (1.43-13.83)	<0.001
CK/ALT	37.06 (16.08-79.95)	5.77 (2.79-25.18)	5.03 (2.20-17.36)	<0.001

P values represent the results of the Kruskall-Wallis test of comparison between the rhabdomyolysis group and the acetaminophen (delayed) group.
APAP, acetaminophen; *rhabdo*, rhabdomyolysis; *AST,* aspartate aminotransferase*; ALT*, alanine aminotransferase; *CK*, creatine kinase.

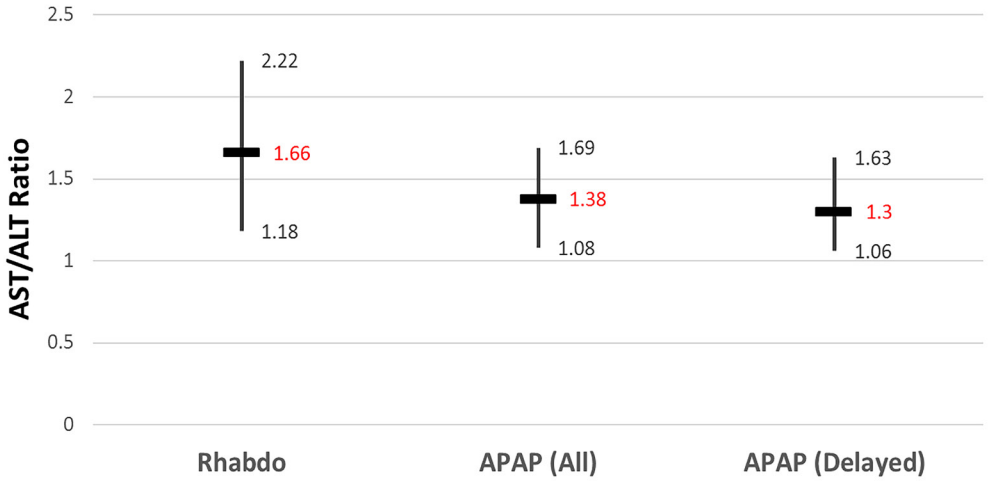

Figure 1. AST/ALT ratios of the three patient groups.
Rhabdo, rhabdomyolysis group; *APAP (all)*, all patients with acetaminophen overdose; *APAP (delayed)*, patients with delayed acetaminophen toxicity. Vertical bars indicate interquartile range of values; horizontal bars indicate median values.

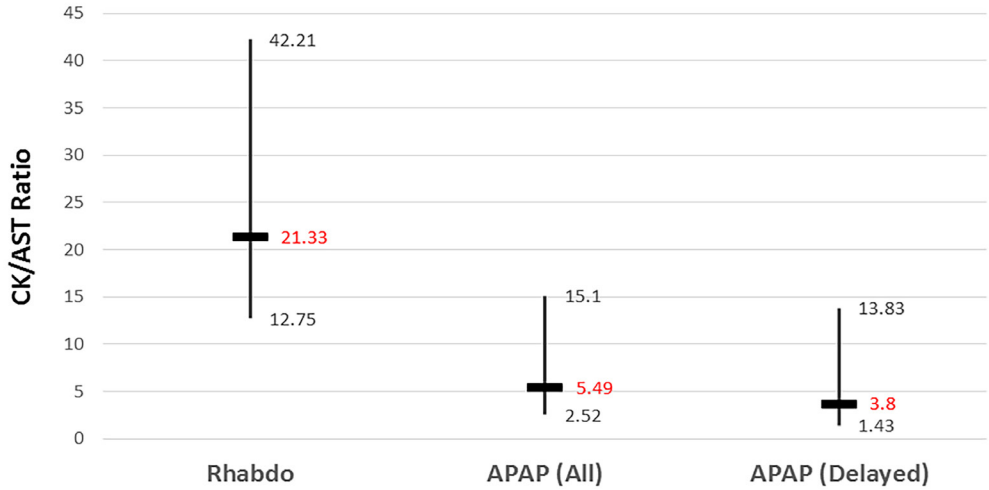

Figure 2. CK/AST ratios of the three patient groups.
AST, aminotransferase; *CK*, creatine kinase; *Rhabdo*, rhabdomyolysis group; *APAP (all)*, all patients with acetaminophen overdose; *APAP (delayed)*, patients with delayed acetaminophen toxicity. Vertical bars indicate interquartile range of values; horizontal bars indicate median values.

cells into the blood.[9] Since AST and ALT are present throughout the body, they may be elevated in conditions not involving the liver; and indeed both AST and ALT can be elevated in rhabdomyolysis in the absence of liver injury.[10]

In the search for the cause of abnormally elevated transaminases, serum CK is often measured. The biological role of CK is that of catalyzing the phosphorylation of creatine, thus producing phosphocreatine. Phosphocreatine, in turn, rapidly produces ATP in tissues that have high energy demand.[11] CK is predominantly located in skeletal muscle, myocardium, and the brain, and serum CK values can be elevated and used as a marker of injury to these organs.[8] Although CK is present in the liver, its concentration in hepatic tissues is significantly lower than in other tissues.[8,12]

The results of this study support our hypothesis that the ratios of AST/ALT, CK/AST and CK/ALT would be

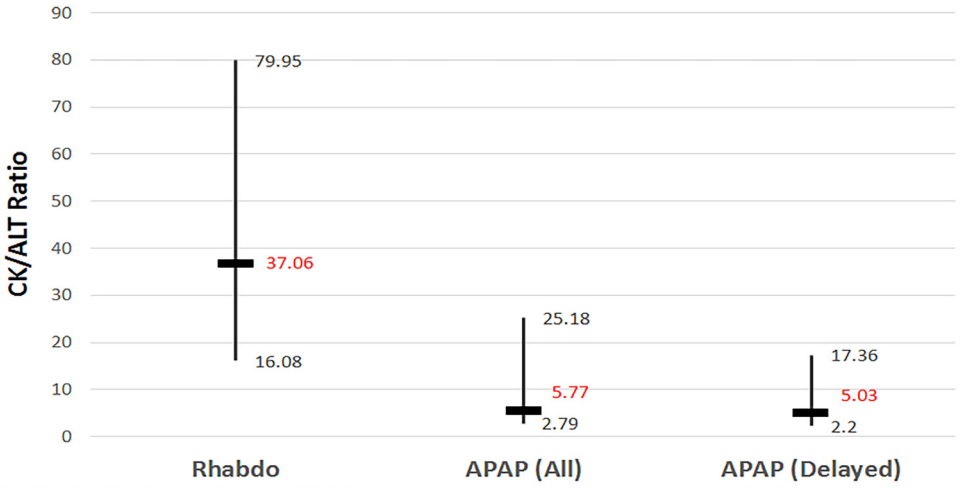

Figure 3. CK/ALT ratios of the three patient groups: rhabdomyolysis group; patients with acetaminophen overdose (all); and those with acetaminophen overdose (delayed).
Rhabdo, rhabdomyolysis group; *APAP (all)*, all patients with acetaminophen overdose; *APAP (delayed)*, patients with delayed acetaminophen toxicity. Vertical bars indicate interquartile range of values; horizontal bars indicate median values.

higher in patients with rhabdomyolysis than in patients with acetaminophen toxicity. This observation may be useful in differentiating patients with rhabdomyolysis from those who otherwise might be considered candidates for treatment with NAC for possible delayed acetaminophen poisoning. Avoiding the unnecessary treatment of patients with NAC, and possibly longer hospital length of stay, could reduce the cost of care.

Additionally, our finding of a higher ratio of CK to ALT than that of CK to AST is consistent with the tissue distribution of these enzymes; that is, higher values for AST than for ALT are more likely in rhabdomyolysis because the concentrations of AST in skeletal muscle are higher than those of ALT. [8]

Besides possible cost savings, it is important to minimize risk of exposure to unnecessary medications for our patients. Although NAC is generally safe, anaphylactoid reactions, sometimes resulting in death, have been reported with intravenous (IV) administration.[13] Deaths have also been attributed to iatrogenic errors with IV formulations of NAC. [13,14] In patients with rhabdomyolysis, taking the risk of an iatrogenic complication from NAC may not be warranted. [15,16]

Our data suggest higher CK/AST or CK/ALT ratios are more likely to be seen with rhabdomyolysis than acetaminophen ingestion. This is not to say that the ratio can be used in a vacuum to differentiate patients with rhabdomyolysis from those with acetaminophen toxicity. Instead, it would ideally be used in those patients for whom there is an already-low likelihood of acetaminophen toxicity that cannot be excluded due to a limited history.

LIMITATIONS

Our study has several limitations. First, it is retrospective, with the inherent shortcomings associated with this study design. Second, patient-selection bias could be present because the majority of the patients in each group were excluded because of missing laboratory data; in the cases of acetaminophen overdose, the CK values often were absent, likely because CK is not a routinely ordered lab test on patients who have suspected overdose. Third, the discharge diagnoses may not have always been accurate, and coding errors may have existed that resulted in patient misclassification. We also did not verify each of the discharge diagnoses. Finally, the values of AST, ALT, and resulting ratios could have been different depending on when they were drawn in the course of a patient's toxicity, as AST and ALT concentrations rise and fall at different rates.[17]

CONCLUSION

In summary, we found the AST/ALT, CK/AST, and CK/ALT ratios were significantly higher in patients with rhabdomyolysis than in patients with acetaminophen toxicity. This result suggests that the ratios could be used to identify patients with rhabdomyolysis who otherwise might have been diagnosed as delayed acetaminophen toxicity. Such patients may not require hospitalization and treatment with N-acetylcysteine, resulting in considerable cost savings and decreased resource utilization. Based on the limitations of our study, however, these ratios are not ready for clinical use. Prospective validation of our findings in a diverse patient population is needed before these ratios can be applied in regular clinical practice.

Table 2. Sensitivity and specificity of different CK* to transaminase ratio cutoffs.

Ratio cutoff	Sensitivity (95% CI)	Specificity (95% CI)	Positive likelihood ratio (95% CI)	Negative likelihood ratio (95% CI)
CK/AST				
15	75.3% (65.5-83.5%)	68.8% (61-75.8%)	2.41 (1.86-3.11)	0.36 (0.25-0.52)
20	83.5% (74.6-90.3%)	53.2% (45.1-61.2%)	1.78 (1.48-2.16)	0.31 (0.19-0.5)
25	84.5% (75.8-91.1%)	43% (35.1-51.1%)	1.48 (1.26-1.74)	0.36 (0.22-0.59)
30	89.7% (81.9-94.9%)	35.3% (27.8-43.3%)	1.39 (1.21-1.58)	0.29 (0.16-0.55)
CK/ALT				
15	67% (56.7-76.2%)	76.9% (69.6-83.2%)	2.9 (2.11-3.97)	0.43 (0.32-0.58)
20	73.2% (63.2-81.7%)	71.8% (64-78.7%)	2.6 (1.97-3.43)	0.37 (0.26-0.53)
25	76.3% (66.6-84.3%)	64.1% (56-71.6%)	2.13 (1.68-2.69)	0.37 (0.25-0.54)
30	83.55 (74.6-90.3%)	59% (50.8-66.8%)	2.04 (1.65-2.51)	0.28 (0.18-0.45)

CK, creatine kinase; *AST*, aspartate aminotransferase; *ALT*, alanine aminotransferase; *CI*, confidence interval.

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Proceed with Caution Before Assigning "Red Flags" in Residency Applications

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To the Editor:

We read with interest the paper by Bohrer-Clancy et al.[1] regarding variables in applications to emergency medicine residency that correlate with "adverse outcomes" in training programs. We have some concerns regarding the methods of this paper, and therefore the validity and generalizability of its results.

Inclusion of "extension of residency" as an isolated "adverse outcome" is problematic. These residents were not placed on formal remediation, nor did they fail to complete the residency. Is the extension of residency training for non-academic reasons an "adverse outcome" that should be avoided, or should residency programs and institutions provide a supportive environment such that residents who need additional time due to personal, medical, or family reasons can receive the support they need in order to finish successfully and go on to productive careers? This is the central tenet behind the ACGME's (Accreditation Council for Graduate Medical Education) Next Accreditation System, which places clinical competency and educational outcomes before program length. In addition, it is unclear with which domains or competencies residents with adverse outcomes had difficulties. Ability to predict issues with medical knowledge, communication, or professionalism may be an important distinction to make depending on the resources of the program to address these issues.

Another concern is the inclusion of a leave of absence (LOA) for any reason as an indicator of potential difficulty. While some reasons for LOA may portend future challenges in medical training, all LOAs are not created equal. It is the responsibility of student advisors to make recommendations regarding LOAs during medical school, and to attach a stigma to any LOA may pressure students to make decisions that are not in their best interest for fear that it will impact their chances of successfully matching.

Although some of these limitations are addressed in the paper, program directors may not have the time or inclination to dive into the details of the study and may take the results at face value, thereby unfairly disadvantaging students who may have taken a LOA for a variety of legitimate reasons during medical school. As educators with a responsibility for providing support, guidance and accountability in medical education, we must not claim that we want students and physicians to achieve educational milestones and also cultivate their own wellness, and then penalize them and future applicants for taking steps to do so.

With respect,

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Reply: "Proceed with Caution Before Assigning 'Red Flags' in Residency Applications"

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To the Editor:

We would like to thank the Editor for the opportunity to respond to the thoughtful comments from Drs. Asher and Kilby.

Residents who have delayed graduation from residency for non-academic reasons such as the birth of a child, bereavement, and medical reasons were not included in this cohort since while their graduation date might shift, there was no modification of the curriculum on their behalf. We considered an extension of residency to be a situation in which the curriculum was modified with additional clinical time to address one or more deficits in the Accreditation Council for Graduate Medical Education (ACGME) Core Competencies. While the respondents point out that ACGME has introduced the notion of variable progression through residency curriculum with the Next Accreditation System, it is clear that stakeholders in the medical community do not yet accept the concept of a fluid duration of training as a routine matter given the significant amount of additional documentation and justification required from medical licensing boards and hospital credentialing committees. Any substantial change in the residency curriculum or duration of training most certainly involves the disciplinary process of the program and the residency's Graduate Medical Education Committee. These actions, even when accepted by trainees without the potential for multiple layers of appeals or legal action, are highly time-consuming and stressful for residency faculty and staff. As such the authors reiterate that an extension of residency training represents a negative outcome for a resident.

We recognize that there are many reasons for students to take a leave of absence, all of which we assume to be necessary and appropriate. As in the application of the conclusions of a clinical trial to the care of a specific patient, we expect program faculty to seek the "big picture" in assessment of a specific applicant, not to substitute the findings of our study for good judgment about the likelihood of success for an applicant. In formulating this study the authors did not seek to assign a value judgment or to stigmatize any of the factors examined in this study; rather we were seeking to identify any potential patterns in the overwhelming sea of data available to program faculty in the residency application process.

Most sincerely,

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Closing the Gap Between Entrustment and Resuscitation

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In 2014, the American Association of Medical Colleges (AAMC) and the American Association of Colleges of Osteopathic Medicine more specifically defined the skills required of graduating medical students. These skillsets are rooted in the United States' and Canada's movement toward a competency-based undergraduate medical education (UME) and are termed the Core "entrustable professional activities" (EPAs).[1] EPA 10 is most germane to emergency physicians, asking that newly minted medical students be able to "recognize a patient requiring urgent or emergent care and initiate evaluation and management.[1]" EPA 10 highlights a desperate gap in UME, as evidence confirms that interns are wholly unprepared to identify and manage emergencies independently on day one of residency.[2,3] Clear discrepancies remain between UME and graduate medical education (GME) that make the transition to residency challenging for novice physicians, and potentially unsafe for patients. As currently written, EPA 10 lacks depth in content and provides only a limited discussion of the importance of rapid decision-making. A clear gap exists between the educational objectives of EPA 10 and successful resuscitation practices. We advocate for restructuring and reconsideration of the curricular recommendations of EPA 10. We propose that EPA 10 include a consensus-based list of emergencies in addition to recommendations on teaching medical students situational leadership, crisis resource management, and decision-making in emergencies.

EPA 10 provides a list of emergencies to consider for an UME curriculum.[1] While the authors attest that this list is incomplete, such deficiencies should be quickly resolved. Trauma-related injuries, cardiac arrest and the acute abdomen are absent from the list. A comprehensive, consensus-based list of emergencies should be determined by experts in the field. The list of emergencies recommended by EPA 10 should be paired with an explicit discussion of the broader skills and heuristics needed to manage common emergent problems.

In the Core EPA document, a clinical vignette is provided to paint a picture of the ideal young physician in training who successfully manages a critically ill patient.[1] The post-graduate year 1 resident described in EPA 10 can recognize an emergency, communicate effectively with team members in emergencies, activate and carry out a plan, and accept and incorporate feedback when managing similar situations in the future. In an ideal situation, an intern does call the senior and muster the team. But how and when does one decide to activate this intended plan? Is knowledge of a disease-specific treatment algorithm (i.e., cardiac arrest, stroke protocol, etc.) both necessary and sufficient to initiate and lead the care of a critically ill patient? Two studies have demonstrated methods of assessing EPA 10 and maintain the importance of leadership in acute care situations.[4,5] Leadership is mentioned in two of the AAMC General Physician Competencies, specifically Interpersonal and Communication Skills (ICS 3) and Personal and Professional Development (PPD 6).[6] However, in the Core EPA document describing EPA 10, leadership is not explicitly mentioned.

If we describe a more realistic version of a long shift, full of complex, rapid decision-making that occurs on little sleep with limited time, then we can cultivate a curricular strategy to focus on the skills to succeed.[7] Instead of disease-specific knowledge, the curricular approach to teach EPA 10 should foster the growth of skills such as situational leadership, crisis resource management, and recognition primed decision-making. In his book, *Decisions of Power*, Gary Klein describes the art and science of rapid decision-making.[8]

In summary, EPA 10 appropriately contends that education in resuscitation should extend to UME, and the AAMC should be applauded for pushing UME in this direction. Emergency care and resuscitation specialists are responsible for leading the path of knowledge translation for this set of skills. Educational objectives for teaching the evaluation and management of emergencies to medical

students should include situational leadership, crisis resource management, and decision-making in emergencies. In the interest of patient safety and physician wellbeing, the gap between what is taught to undergraduate medical students on emergency care and what is expected on day one of residency should be the first subject that is examined. The heuristics of leadership and decision-making in emergencies has been delivered to bystanders, paramedics, and residents. Why not to medical students? It's time to close the gap.

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Scholarship in Emergency Medicine: A Primer for Junior Academics: Part II: Promoting Your Career and Achieving Your Goals

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Scholarship is an important component of success for academic emergency physicians. Scholarship can take many forms, but all require careful planning. In this article, we provide expert consensus recommendations for improving junior faculty's scholarship in emergency medicine (EM). Specific focus is given to promoting your research career, obtaining additional training opportunities, networking in EM, and other strategies for strategically directing a long-term career in academic medicine. [West J Emerg Med. 2018;19(4)741–745.]

INTRODUCTION

Think about the future, 30 years from now. What do you want to be doing in your academic career? Become a full-professor? Travel and speak internationally? Be responsible for the academic career path of many mentees? Own a body of literature or an innovation that has somehow changed medical practice or education? Be a clinical leader in your department, institution, or the government? Consult in academics or industry? Influence public policy? Train the next generation of physicians?

These goals are all realistic, but they require you to think strategically about your career and make periodic and detailed plans. In this second part of the primer series, we will offer tools to promote your academic career and achieve your goals. These include learning critical skills for peer review, understanding your academic track, focusing and promoting your research career through social media and other electronic means, and networking within emergency medicine (EM) organizations and societies.

SCHOLARSHIP

To really succeed in academic EM, there must be a focus on scholarship. Scholarship can be defined in many ways, including excellence, higher learning, or achievement. Traditionally, scholarship was synonymous with research, but this definition is not adequate. The Carnegie Foundation for the Advancement of Teaching concluded in a landmark report that there needs to be a more comprehensive view of scholarship, and suggests that scholarship incorporates "a recognition that knowledge is acquired through research, synthesis, advanced practice, and teaching."[1] Scholarship as research focuses on discovery of new science that can guide future practice. Scholarship as applied practice focuses on quality improvement. Scholarship as synthesis (or integration) focuses on making connections and building different perspectives across multiple disciplines.[2] Scholarship as teaching would identify strategies for improving instructional design, curriculum, and teaching processes. These four domains of scholarship are all potential paths to improving scholarship.[3,4] Some might excel in practice or in teaching, while others in research or applied paths. Be sure to examine your own motivation behind your choices.[5]

All residents undertake a scholarly project during their residency training. The goals of the project are primarily to "instruct residents in the process of scientific inquiry," but they often take multiple paths and shapes.[6] Some are more focused on methodology and data, while others are more practical and

applied. Improving your scholarship starts with the residency but continues throughout an academic career. In this article, we sought to incorporate expert consensus recommendations on improving scholarship in EM. We direct this primarily to residents, fellows, and junior faculty at universities and teaching hospitals who strive for long-term successful careers in academic EM.

UNDERSTAND YOUR ACADEMIC TRACK

The form of scholarship you select is partially guided by the academic track you are in, as each track values research, teaching, service, and clinical endeavors differently.[7] Previously mentioned, publication-related factors (e.g., impact factor, ranking of the journal within the specialty, authorship position of the faculty member) are important considerations for scholarly production for all academic tracks. Knowing the requirements set forth by the promotions and tenure committee helps you know by which criteria you will be judged. One direct resource for this would be your department's vice chair or the school of medicine senior associate dean for faculty affairs.

Although academic tracks can vary among institutions, some factors remain common. The most common tracks to be considered are 1) clinical; 2) clinical scholar; and 3) tenure track. Another factor of importance is the institutional requirements, which may be independent of the specific academic track.

The clinical track encompasses the vast majority of faculty, and their record is evaluated by teaching, clinical effectiveness and efficiency. They can also be judged by the number of publications and their authorship position. First-author position is most important for assistant professors and final author or corresponding author for full professors.

The clinical scholars (educators) track criteria for promotion are not uniform among academic institutions, but they often have a requirement for focused original research as well. It is possible to achieve scholarly work in teaching of residents and students, as well as program evaluation of curriculum. Scholarship in this form requires different types of journals the faculty would be able to submit to and the corresponding difficulty in successfully being published. However, there are multiple types of scholarship beyond traditional publications. There are good articles that describe criteria and options for scholarship. Publications are not all the same, however. Original research articles are usually considered most scientifically significant and are at the top of the publication "hierarchy." Systematic reviews and focused topic reviews fall just beneath this in the hierarchy. Case reports and images are typically less significant. Letters to the editor (although important in academic discussion) and book reviews might not be considered for promotion. Regardless of which publication type, we encourage junior faculty to get multiple articles in production early in their career.

The tenure track is the traditional research track with very little clinical responsibility and the majority of time dedicated to focused research. Criteria for promotion in this track are quite strict, requiring high-impact, first-author publications and significant grants with the National Institutes of Health or other government agencies. This track is only for faculty who strive to make a difference through a career in a very narrow field of research. The need for continued future research funding remains one of the greatest challenges for this very important academic track.

Learning Critical Skills for Peer Review

Regardless of your specific academic pathway, scholarly activities are an essential component of the promotion and tenure process. While scholarship can involve a number of formats, often this involves conducting research and publishing. It should be noted that academic writing and communication is a distinct skill and markedly different from creative writing taught in high school and college.[8] Academic writing focuses on the shortest direct prose that communicates the message. Journal editors strive to include as many papers as possible in the allotted pages of an issue. Therefore, brief, concise, to-the-point articles are preferred. Note that Watson and Crick's hallmark paper on the structure of DNA was only 1.5 pages in length, proving that a paper need not be long to be impactful.[9]

How do you develop this skill? There are only two ways: practice writing academic papers and read scientific papers written by other authors. Volunteering your time as a peer reviewer offers a vital service to academic medicine and society, while improving your own writing. Most developing journals welcome junior reviewers after they have shown a modest number of publications in a specific specialty. Another way to become a reviewer is to be recommended by a senior faculty member who is known to the editor-in-chief or senior editors on the journal. Peer review can be a difficult and time-consuming process—a well-done review can take two or more hours—but your topic expertise and writing skills will grow through experience.[10] There is an excellent tutorial from the *Annals of Emergency Medicine* on the peer-review process for those interested in learning further.[11]

Peer review is an extension of the training you received in journal club during residency. Your task is to judge whether the authors properly framed the research question and used the appropriate study design; additionally, to the extent of your knowledge, your task is to critique the statistical methods employed, identify confounding factors and limitations, and comment on the appropriateness of the conclusions based upon the study's data. Most importantly, you should analyze the presentation of the information such that a clinician can understand the paper and modify practice, if indicated. If you didn't understand the author's logic or argument, then it is unlikely others will.[12]

Although there are certainly expert reviewers with formal training in methodology and statistics, this is not required for the average reviewer. Journals typically have methodology experts on staff to analyze and critique these components. The editor is most interested in whether the paper is clear, concise, well-organized, appropriately novel, and that the authors performed an appropriate literature review. Any junior scientist can certainly fill that role. Think about what you understood from their argument, and what could have been presented more clearly. When you read another's writing, you will quickly discover pitfalls and areas of confusion with how the information is presented. However, just as this is valuable to share with the author, it is also useful for you when you write your next paper, as you will avoid the same mistakes.

When you apply for promotion in the academic hierarchy, this service as peer reviewer is valued as a demonstration of commitment to your specialty, community, and science in general. Keep track of the journals for which you have reviewed, and the number of reviews. Many journals provide recognition for top quality and quantity, and publish such names on their websites and within their pages.

Promoting Your Scholarship

One of the most important milestones for academic emergency physicians is the publication of your first article. It's a time to celebrate. However, it is important to note that this is not the end. Once you get the manuscript published, it's important to make it available for others to read. While anonymity has a role in some things, academic promotions are based on visibility and impact. This requires you to think about how to best disseminate your findings and "promote" the scholarship to gain visibility and prestige. Consider how best to translate your findings, so that other clinicians and the community in general can benefit. While visibility is essential to transferring research into practice, it is equally important for your academic promotion and tenure. This is becoming increasingly challenging given the huge amount of scientific information being published today in EM.[13] Your scholarship (whether it's research, teaching, application, or innovation) needs to be seen and read.

Here we discuss five strategies to promote your scholarship. These include: 1) presentations; 2) collaborations and citations; 3) social media and blogs; 4) open access repositories; and 5) institutional and personal platforms.

The traditional route to achieving visibility after publication is to present your research at society meetings and conferences in abstract form. Presenting at regional and national conferences is a great way to share your findings. Presenting will also help you meet others in your research area, which can lead to future collaborations and research ideas. Building practical collaborations and research partnerships are additionally useful for designing future projects and obtaining funding. You should note that most research is collaborative in nature. The largest clinical research studies—such as SIREN (Strategies to Innovate EmeRgENcy Care Clinical Trials Network) or PECARN (Pediatric Emergency Care Applied Research Network)—are large collaborations between researchers at multiple institutions. Developing research projects on your own is very time-consuming; networks help to build sufficient critical mass and increase the number of patients to demonstrate external validity. Collaboration is vital to getting involved with projects, receiving funding, and publishing significant results.

In addition, through collaboration multiple individuals share the task of promoting your works. This helps broaden the network and provide greater visibility. In the process, be sure to cite yourself and others in the field. Citations themselves can also serve as promotion tools. When you cite others, it shows that you understand the current research. Additionally, when you share your findings with researchers you cited, others get to know you and your research, further increasing your available collaboration network. As editors and senior researchers (those who make decisions) become familiar with your research, they will likely cite you as well. Most journal editors enjoy publishing the work of established names in research.

Some journals offer authors the option of recording an audio or video summary to be posted on the journal website. If offered, avail yourself of this opportunity, as it can further increase your academic profile and article visibility. Another strategy to engage with researchers is to join academic society committees or interest groups, and meet others doing research in your field. Both have websites and email listservs, which can share collaboration ideas and grant opportunities. You may also want to attend research conferences outside of EM, to further interface with researchers in your area of interest. It would also be beneficial to consider attending conferences in subspecialties, such as cardiology, education, emergency medical services, geriatrics, neuroscience, public health, pediatrics, toxicology, and trauma to name a few.

The use of online social media is becoming increasingly common within EM, with platforms such as Twitter, Facebook, and LinkedIn allowing researchers to engage larger audiences through simplified messages. Twitter especially has emerged as a method of distributing research findings. A recent study published in the *Western Journal of Emergency Medicine: Integrating Emergency Care with Population Health* (*West*JEM*)*, examined the most influential and connected emergency physicians in the country, discovering that certain physicians who are highly active on social media serve as major influencers in medical education.[14] Another study shows strong correlation between tweets and citations, especially in the first few days after publication.[15] Frequently-tweeted papers are many times more likely to be highly cited.[16] As an example of its power, Twitter enabled the International Conference on Emergency Medicine (ICEM) in

2012 to become the most tweeted EM conference on record.[17]

Additional resources include LinkedIn, Facebook, and Doximity, which enable others to find you and connect for future projects. Social media portfolios have been shown to be instrumental in the promotion and tenure process.[18] Alternatively, the use of free open access medical education (FOAM) resources, such as blogs and podcasts, can be useful in further defining one's niche.[19] Many EM faculty maintain blogs and share their findings with others from the field.

Self-archiving through open access repositories, such as ResearchGate, Academia.edu, Mendeley, Kudos and other sites, provides a wider circulation of published work. Institutional repositories and websites also provide an online presence in perpetuity. This is why it is important to actively update and maintain your faculty websites, personal websites, and biographies so others can find your work through search engines. The use of Google Scholar as a research tool has expanded greatly so maintaining updated biographies and research interests helps ensure that searches find your articles. We encourage all junior faculty to create a Google Scholar profile. You have the option to either make your profile public or keep it private. It obviously provides much greater visibility to make it public.

Gaining visibility for your research career requires a strategy. It is important to plan in advance of your publication and continue to highlight your research. The above strategies can help to increase your success.

Pursue Additional Training

Achieving additional levels of training can help improve your scholarship and your career. You can do this in a number of ways. Some might consider the American College of Emergency Physicians (ACEP) teaching fellowship, which is designed to improve skills of instruction. The Council of Emergency Medicine Residency Directors offers a medical education research certificate program (MERC) ,which also focuses on faculty and educational development. Some physicians might choose to pursue additional graduate degrees or certificates in other areas to extend their niche. Fellowships in anything from clinical research to education or policy might be interesting to consider. Advanced training, whether in health services research, medical informatics, public health, business administration, or even secondary clinical specialties, is a factor to consider as a means to improve scholarly capacity. Base the decision on your interests, skills, and long-term vision of your own career.

Collaboration and Networking

For those early in their academic career, it is critical to appreciate the value of networking with colleagues in EM societies, organizations, and conferences. Networking is simply connecting with others to build relationships, exchange professional experiences and ideas, collaborate around topics of mutual interest, and develop contacts that go beyond your traditional hospital borders. Networking has been shown to be valuable for making new-hire decisions, securing research funds, and ensuring overall career success.[20] When you visit one of the major academic assemblies, be sure to set up meetings in advance or arrange for coffee to introduce yourself to others from your specialty. SAEM offers junior faculty development workshops, and ACEP has a wide variety of events, receptions, and workshops in which you can participate. The exhibit halls are also a great way to introduce you to new concepts. When you get back from the event, be sure to follow up and stay in touch with the people you have just met.[21]

The time you spend meeting your peers with similar interests and research is invaluable to developing and promoting your career. Nearly every professional society has networking events where you can connect with others with whom you might form research or clinical relationships. Seek out opportunities for leadership roles in your local and state EM organizations. Seek out senior faculty who have conducted interesting research or who work in an area you would like to learn more about. Since most conferences publish the list of attendees well in advance, you can usually find out who will be attending and approach them by email or phone well in advance. When you go to a research presentation, stay afterward and ask questions of the presenters. Network and exchange business cards with others who do the same.

Lastly, you should form a mentor relationship with someone senior in your field, especially if you are considering a focused research or clinical subspecialty in EM. Mentors are very important for the academic emergency physician, offering access to different professional experiences and existing networks. There are many choices you will make along the way (e.g., which journal to submit to, which research to pursue, which job offer to take). Before making these choices you could benefit from the expertise of more-senior colleagues. Additionally, securing a mentor can be valuable when applying for grants and collaborating without outside departments and institutions. When seeking out mentorship, ensure that your goals align and that the mentorship relationship is a good fit. For further information, junior faculty are encouraged to review the excellent summary by Straus and colleagues.[22]

CONCLUSION

Scholarship in emergency medicine should be broadly focused. While research is the most traditional path, it is equally as important to consider excelling in the scholarship of application, integration, or teaching. It is important that junior faculty conduct periodic planning and develop both short- and long-term plans outlining directions and goals for their career. If your goal is to build a career in academic EM, be sure to focus on promoting and bringing visibility to yourself and your scholarship. Remember there are differences by academic track, which might influence the type of scholarship you pursue. In all areas, be sure to include peer reviews, mentorship, networking, and social media to expand your visibility and knowledge.

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Journal Club in Residency Education: An Evidence-based Guide to Best Practices from the Council of Emergency Medicine Residency Directors

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Journal clubs are an important tool for critically appraising articles and keeping up-to-date with the current literature. This paper provides a critical review of the literature on the design and structure of journal clubs in residency education with a focus on preparation, topic selection, implementation, and integration of technology. Recommendations for preparation include developing clearly defined goals and objectives that are agreed upon by all journal club participants; mentorship from experienced faculty members to ensure appropriate article selection, maintenance of structure, and applicability to objectives; distribution of articles to participants 1-2 weeks prior to the scheduled session with reminders to read the articles at predetermined intervals; and the use of a structured critical appraisal tool for evaluating the articles. Recommendations for topic selection include selecting a primary objective of either critical appraisal or informing clinical practice and ensuring that the articles align with the objective; involving learners in the topic- and article-selection process; and having the article selection driven by a specific clinical question. Recommendations for implementation include hosting sessions in the evening and away from the hospital environment; providing food to participants; hosting meetings on a monthly basis at regularly scheduled intervals; mandating journal club attendance; and using theories of adult learning. Recommendations for integration of technology include using previously established, effective strategies and determining the feasibility of creating an online journal club versus joining an established journal club. It is the authors' intention that after reading this paper readers will have new strategies and techniques for implementing and running a journal club at their home institutions. [West J Emerg Med. 2018;19(4)746-755.]

BACKGROUND

While the concept of the journal club is most commonly attributed to Cushing's description of Sir William Osler's meetings in 1875, the first reference dates back to 1835 when Sir James Paget would meet with a group of students near St. Bartholomew's Hospital to review articles.[1-3] Initially, the journal clubs served as a method "for the purchase and distribution of periodicals to which [members] could ill afford to subscribe as an individual."[1] As time progressed, the focus expanded to serve as a medium to teach critical appraisal skills.[4,5]

While many programs use journal clubs in their graduate medical education training, there is significant variation in

the structure and goals.[6,7] Additionally, success can vary with wide ranges in attendance, participation, and longevity.[4] It is important to use effective strategies to increase the likelihood of creating and maintaining a successful journal club. This article provides a narrative summary of the literature and recommendations for best practices for journal clubs in graduate medical education with a focus on the application to emergency medicine (EM) residency programs.

Critical Appraisal of the Literature

This article is the first in a series of evidence-based best practice reviews from the Council of Emergency Medicine Residency Directors (CORD) Best Practices Subcommittee. The first two authors independently performed a search of PubMed for articles published from inception to August 20, 2017, using the keywords "journal club." Bibliographies of all relevant articles were reviewed for additional studies. The search was further augmented by several calls via social media to the #FOAMed and #MedEd communities requesting additional article recommendations. Articles were screened independently by two authors to evaluate for any papers addressing the following four themes, which were determined a priori: preparation for journal club; topic selection; strategies for successful implementation; and incorporation of technology. Articles were included if either author recommended inclusion.

The search yielded a total of 2,102 articles, of which 67 were deemed to be directly relevant for inclusion in this review. When supporting data was not available, recommendations were made based upon the authors' combined experience and consensus opinion. Level of evidence was provided for each statement according to the Oxford Centre for Evidence-Based Medicine criteria (Table 1).[8] Prior to submission, the manuscript was reviewed by the entire CORD Best Practices Subcommittee.

Table 1. Oxford Centre for Evidence-based Medicine criteria.[8]

Level of evidence	Definition
1a	Systematic review of homogenous RCTs
1b	Individual RCT
2a	Systematic review of homogenous cohort studies
2b	Individual cohort study or a low-quality RCT*
3a	Systematic review of homogenous case-control studies
3b	Individual case-control study**
4	Case series or low-quality cohort or case-control study***
5	Expert opinion

RCT, randomized controlled trial.
*, defined as <80% follow up; **, includes survey studies; ***, defined as studies without clearly defined study groups

Preparation for Journal Club

Successful journal clubs are predicated upon thorough preparation and the development of clear, specific goals and objectives. Defining and articulating the goals and objectives of any educational experience is an important pedagogical step;[4] in fact, developing clear goals and objectives has been suggested to be the first and most important step in the creation of a successful journal club.[9-11] Reflection on the defined goals will guide further decisions regarding journal club format, the selection of facilitators, and the types of articles to review. Goals should be reviewed regularly and approved by journal club participants.[10] Explicit statement of the goals, creation of learning objectives, and selection of the most appropriate session format were all found to be factors that increase the educational benefit among journal club participants.[4,11]

Several surveys across multiple medical specialties have assessed the most common goals for a journal club. These include teaching critical appraisal skills, providing an impact on clinical practice, remaining current on medical literature, allowing residents and faculty to work together on a common project, and learning research methodology.[4,6,12-14] Among these, teaching critical appraisal skills was considered the most important goal for journal clubs. In their recommendations for journal club implementation, Lee and colleagues have defined a set of objectives for teaching and assessing practice-based learning, which is illustrated in Table 2.[15] In his paper describing the role of journal clubs in orthopedic residencies, Greene identified similar goals to those defined by Lee; however, he added the benefits of residents to learn a specialty and the development of camaraderie between residents and faculty.[16]

Another important aspect is support and mentorship from more experienced faculty members in the form of advice and technical support to resident physicians. Mentorship includes assistance in the selection of an article for critical appraisal and preparing the associated presentation.[16] Similarly, faculty mentors should prepare the residents to lead the discussion by

Table 2. Objectives for journal club (adapted from Lee et al).[15]

- Acquiring, disseminating, and applying new medical information
- Teaching and assessing critical appraisal skills for reading and writing a scientific paper
- Promoting lifelong learning skills in evidence-based medicine
- Improving reading habits
- Providing an interactive and social opportunity for peer-to-peer learning
- Improving small group participation, presentation, and communication skills
- Documenting practice-based learning and improvement in patient care

both ensuring the mastery of the chosen article's critical appraisal and planning the interactive discussion. This supportive approach ensures maintenance of a consistent format and systematic presentation without restricting resident creativity.[18] When in-person mentorship is not feasible, Kattan and colleagues have advocated for journal club leaders to receive telephone- or email-based coaching instead.[19] Learners were coached on enhancing their discussion leadership skills, while focusing on the standard journal club aims of critical reading, interpretation, and developing content knowledge. Additionally, coaches assisted the learners with the development of structured outlines, effective teaching strategies, and visual aids for the journal club session.[19]

Studies unanimously agree that selected articles should be distributed to all members of the journal club prior to the session. A systematic review by Deenadayalan and colleagues found that the preparation time for those who attended journal clubs varied widely and recommended a minimum of one week.[20] Subsequent studies similarly recommend at least a one-week preparatory period, while the maximum recommended time period was two weeks.[10,11,18,21-23] It has been suggested that using a time period longer than two weeks can lead to the participant forgetting what they read before the journal club session.[10]

When participants review articles prior to the journal club, article evaluation guidelines or a critical appraisal instrument should be used. This practice has been consistently reported in the literature as a feature of successful journal clubs.[4,9-11,15-18,20-25] However, Carpenter and colleagues found that most EM programs (71%) do not use structured critical appraisal instruments.[7] The use of critical appraisal checklists have been shown to increase learner satisfaction, improve the educational value of the journal club, and promote productive discussion, without increasing the overall workload.[20,21,26] These instruments can have many formulations, ranging from a list of questions to a structured worksheet[10,27] (Figure).

1. What type of research is reported?
2. Who are the authors and what are their qualifications?
3. What is the research question? Or, if one is not stated, create one
    a. What was the purpose of the research?
    b. Why is the research being conducted, and why is it considered significant or important?
    c. Were the research questions, objectives, or hypothesis (or hypotheses) clearly stated?
4. What is significant about the literature review?
    a. Does the literature review seem thorough and recent (within the past 5 years)?
    b. Does the content of the literature review relate directly to the research problem?
    c. Are there omissions?
5. Describe the study design. Is it appropriate?
    a. Who were the subjects, and how representative is the sample?
    b. Was any selection bias evident in the sample selection?
    c. How was the research conducted and data collected?
    d. Are the methods appropriate for the research question?
    e. How were ethical considerations handled?
    f. Could the study be replicated from the information provided?
6. Briefly summarize the main points or findings of the article.
7. Were the results significant?
    a. Are the results valid?
    b. How were the data analyzed?
    c. Are the data consistent with the methods?
    d. Do the selected statistical tests appear appropriate?
    e. Are the results presented in a clear and understandable way?
8. What are the strengths and weaknesses of the design, topic, and points made?
9. What is the value of the study or article, and to whom does it apply?
    a. Were study limitations discussed?
    b. What were the implications of this study to clinical practice?
    c. How does the study contribute to the body of knowledge?
    d. What additional questions does the study raise?

Figure. Example critical appraisal tool (adapted from Mazal and Truluck).[10]

Best Practice Recommendations:

1. **Develop clearly defined goals and objectives that are agreed upon by all journal club participants (Level 2a).**
2. **Faculty members or more experienced clinicians should provide mentorship to ensure appropriate article selection, maintenance of structure, and applicability to objectives (Level 2a).**
3. **Distribute articles to participants one to two weeks prior to the scheduled session and consider reminders to read the articles at predetermined intervals (Level 4).**
4. **Use a structured critical appraisal tool when evaluating articles for journal club (Level 2a).**

Topic Selection

The first consideration that should be made when selecting journal club topics are the overall objectives.[4] In fact, many authors make a distinction between a journal club and an evidence-based medicine session. Journal clubs are typically described as sessions focused on reviewing articles to inform clinical practice, while evidence-based medicine sessions focus on learning the skills to critically appraise the articles.[17]

This distinction in goals may influence the topic selection methods used for the session. For example, a journal club session with a primary objective of teaching principles of evidence-

based medicine might select very different articles to review than one with a primary goal of keeping participants informed on the most current literature. Alternatively, topic selection techniques focused on enhancing resident participation (e.g., having learners select the article to discuss) may result in different learner goals, with variations in the applicability to practice or the ability to teach critical appraisal skills. Moreover, the curriculum and the impact of the selected topic may be influenced by the experience of the learner. Harris and colleagues highlighted that "a [journal club] for students or interns may include the same ingredients, but in different proportions, with more emphasis on learning the 'rules' of critical appraisal and the topics of clinical epidemiology and biostatistics."[17] Additional considerations are included in Table 3.

Table 3. Considerations for journal club topic selection.

• New and upcoming literature
• Classic papers supporting current practice
• Articles generating clinical controversy
• Articles that are illustrative of specific methodologic techniques or biostatistical principles
• Manuscripts covered in blogs, podcasts, tweets, or other online sources
• Articles that align with other aspects of the curriculum being taught
• Articles reflecting original research rather than review articles or opinion pieces

As a result, some experts have suggested separating the curriculum that teaches skills in epidemiology from the curriculum that reviews the newest literature. One study found that this separation improved the ability of participants to acquire the skills and knowledge in each area.[17] The authors from this study further suggested that having a baseline clinical knowledge on a topic can be helpful as the learners will not need to familiarize themselves with the content, allowing them to focus predominantly on skill development.[17] Another study found that less-experienced learners had more difficulty with critical appraisal because they were focused on mastering the content rather than critical analysis.[28] To balance this, one study divided up the journal club sessions, so that some were focused on specific topics, while others were focused on critical appraisal and methodology.[29]

When selecting article topics, it can be valuable to begin with a specific clinical question. These may be based upon actual cases encountered by the learner, hypothetical cases, or new literature. The use of a particular case or challenge may increase learner interest and engagement. Several authors have described the importance of a clinical problem-based article selection, though formal comparative studies are limited.[4,20,30-33]

In a systematic review on journal clubs published by Honey and colleagues, nine of the 14 included articles had the participants select the topic.[21] Adult learning theories suggest that by having the learner drive the selection of the material there may be better engagement in the discussion process.[33-35] In fact, one study found that the active participation of the learners in the planning, preparation, and facilitation of the session was associated with higher attendance and better overall success.[9] Learners also benefit by learning the critical steps in translating a clinical question into a query that can be used to search evidence databases.[36,37] They can learn how to use formal search databases to access information and select the articles best suited to answer their question.[36,37]

It is important that the article search be performed in a structured manner to be effective. When performing a search for potential articles, learners first need to understand how to convert a clinical question into a query. They should receive structured training to be familiar with the variety of literature repositories (e.g., PubMed, Scopus, CINAHL). They should learn search strategies, such as using Boolean language and how to use MeSH terms. Training should include practice in searching article databases and feedback on their search strategy. Additionally, learners should receive instruction on which journals publish the highest quality literature in EM. Therefore, they often need to have direct mentorship in article selection techniques.[18,35] One study found that faculty mentorship for article selection significantly improved participant satisfaction.[38] Alternatively, faculty may select the articles for inclusion. This technique offers the advantage of ensuring high-quality article selection, while allowing the learners to focus on analyzing and applying the selected articles. However, this reduces the learners' opportunity to develop their skills in query generation, database search strategies, or article selection. Interestingly, one study used a committee of both residents and attending physicians to assist with topic selection for their journal clubs with good learner satisfaction.[29]

It is important to vary the types of studies included to ensure that the learner develops the skills to analyze multiple different types of articles (e.g., retrospective, prospective observational, randomized controlled trial, systematic review and meta-analysis);[35] however, the structure of this may vary depending upon the session goals. For example, if the session goal is to critically analyze the performance of chart review studies, then only retrospective chart reviews will be included, while if the focus is on a particular topic, then multiple article types may be valuable. This can allow the learners to compare and contrast the different article formats.[35] While the ideal number of papers to review has not been formally studied, it is important to ensure a balance of topic breadth with depth. Selecting more articles may increase the potential yield in a broader sense, by covering more material, at the expense of reducing the ability to perform in-depth analyses.[35] Two large

surveys both found that the majority of programs assessed between one and four articles at each session.[39,4]

Best Practice Recommendations:

1. **Determine whether the primary objective is critical appraisal or informing clinical practice and ensure that the articles selected align with this objective. While these are not mutually exclusive, one often predominates (Level 4).**
2. **Involve learners in the topic and article selection process to increase learner engagement and maximize the learner benefit (Level 3b).**
3. **When possible, have the article selection driven by a specific clinical question (Level 3a).**
4. **Article selection and topic selection should have active mentorship from a faculty member (Level 4).**

Implementation Strategies

While there are numerous studies assessing different aspects of journal clubs, there is no standard process for how to implement a journal club. Review of the existing literature demonstrated that the setting of a journal club varied significantly between studies, including conference rooms, faculty members' houses, restaurants, and the hospital. The timing also varied in the studies, with some meeting in the evening, while others met during work hours. This variation is likely dependent upon the physician type, due to the variations in schedules and work hours. For example, a study conducted in an internal medicine residency program, found meeting during the lunch hour to be the most common.[39] Similarly, a survey of surgical residency programs indicated they were split between morning (29%), midday (29%) and evening (42%),[40] while a study of anesthesiology resident physicians found that 53% preferred to meet before work and 40% preferred to meet after work, with 57% preferring the workplace.[41] Unfortunately, this is often not feasible with EM resident physician schedules. When studied within EM, successful journal clubs were most commonly held in the evening in a faculty member's home.[4,42] Jouriles performed a large survey of EM residency programs and discovered that 32% of programs scheduled journal club during didactic sessions, while the majority occurred outside of conference time.[6] In that study, journal club was found to be most successful when it was held in the evening, outside of conference, and at the home of a faculty member.[6]

Although there are variations in the time and place of hosting a journal club, one of the most significant factors associated with successful journal clubs was the availability of food as an incentive.[10,16,20,22,39,41] Regardless of the location or timing, the availability of food has been associated with increased longevity of the journal club (>2 years) and higher attendance.[4,38] Studies have found benefit regardless of the quantity of food, with some providing light refreshments while others provide full dinners.[10,16,20,22,39,41]

The optimal frequency of journal club meetings has not yet been established. Meeting too often may result in lower attendance, while meeting infrequently may decrease the retention of evidence-based medicine concepts. Most programs meet every two to four weeks for journal club sessions.[16,19-21,39-43] Survey data has found that monthly sessions are most common among surgery (64%),[40] orthopedic surgery (78%),[16] anesthesiology (70%),[41] family practice (81%),[43] and EM (86%) residency programs.[6] Among internal medicine programs, there was more variation with 42.7% meeting monthly, 28.2% meeting bi-weekly, and 20.2% meeting weekly.[39] Regardless of the specific frequency, it is important that the journal clubs occur in regular, predictable intervals and at the same time so that participants can anticipate and schedule accordingly. Several programs have demonstrated that set days and times promote attendance.[10,15,44] Sadeghi found that redesigning journal club with an emphasis on regularity by predefining the entire schedule for the year was associated with increased resident satisfaction and improved self-assessments of evidence-based medicine knowledge.[29]

Most journal club sessions range from one-to-two hours in length.[16,19,21,39,40] Among general surgical residency programs, 88% of journal clubs lasted one to two hours,[40] while 83% of internal medicine programs lasted one hour and 95% lasted less than two hours.[39] Among orthopedic surgery residency programs, 99% of journal clubs were between one-to-two hours in length.[16] There is no data on session lengths specifically among EM residency programs, though it would be reasonable to extrapolate the above data to this field.

Another important consideration is whether the journal club sessions should be mandatory. In a survey of anesthesiology residents, 63% of residents preferred voluntary attendance.[41] However, when evaluating successful journal clubs, mandatory attendance was one of the primary factors associated with success.[4] Over half of all programs in multiple specialties have a mandatory attendance for journal club; however, the mean attendance is typically 60% for many programs.[39,40,43] This may be due to a number of challenges, including clinical shifts, vacation, and external obligations. Deenadayalan proposed having regular journal club attendance be an expectation with the consideration of making it mandatory.[20]

While mandatory attendance will increase the number of learners, it is equally important to ensure that the sessions align with sound educational principles. First, the learners must feel that they are in a safe learning environment. The journal club must establish an environment that is conducive to learning, which includes learners being comfortable with their own limitations, as well as feeling comfortable discussing the specific limitations of a study.[21] A safe learning environment will facilitate discussion and place learning in context.[23,45] One study found that a less threatening, more egalitarian environment in journal club was of high value to learners to avoid the hierarchical nature inherent in residency and to facilitate the participation of all learners.[46] Specifically, junior learners did not feel as comfortable discussing their opinions due to fewer clinical experiences.[46] As a result, the authors suggested that there should be defined opportunities for more junior learners to contribute and efforts should be made to ensure all members feel included.[46]

Additionally, it is valuable to incorporate adult learning theories when designing journal club sessions (Table 4).[34] As addressed previously, sessions should be focused on active involvement of participants from article selection to analysis, with an emphasis on incorporation of prior experiences and applicability to clinical cases.[4,7,9,17,30]

Table 4. Four principles of adult learning theory.[34]

1.	Adults need to be involved in the planning and evaluation of their instruction.
2.	Experience provides the basis for the learning activities.
3.	Adults are most interested in learning subjects that have immediate relevance and impact to their job or personal life.
4.	Adult learning is problem-centered rather than content-oriented.

Studies have found that using multifaceted approaches to learning and integrating the education with clinical activities are associated with increased learner satisfaction and critical appraisal skills.[17,47] The journal club format often includes components of one-on-one mentoring, formal presentation, and large-group discussion.[17] Other approaches include a formal debate, written critique, discussion of research developments, small-group discussions, and competitions for best presentation.[4,6,22,48,49] The use of gamification approaches, such as a debate or competition, may further increase user engagement, motivation, and participation in journal clubs.[49-51]

Best Practice Recommendations:

1. **Sessions should be hosted in the evening and away from the hospital environment (Level 3b).**
2. **Food should be provided to participants (Level 3b).**
3. **Monthly meetings at regularly scheduled intervals are optimal for continued involvement of the residents and retention of evidence-based medicine concepts (Level 3a).**
4. **Journal club attendance should be mandated by program leadership (Level 3a).**
5. **Principles of adult learning theory should be upheld (Level 3b)**

Incorporation of Technology

Modern social media platforms (e.g., Twitter, Facebook, YouTube, blogs) provide the opportunity to readily create and participate in online journal clubs.[52-56] Online journal clubs may help to improve journal club participation by removing barriers, such as time, location, and limited, local membership.[57] Educators, content experts, investigators, and learners can all join in the discussion real-time (i.e., synchronous) or afterward (i.e., asynchronous) depending upon the platforms used.[56] For educators interested in leveraging social media to accelerate the speed of knowledge translation at and beyond their institution, there are numerous papers across specialties that describe how to effectively create and conduct sustainable online journal clubs.[53,55,56,58-60]

As technology has evolved, so has the online journal club experience. Early journal clubs consisted of static webpages with experts providing summaries of articles and highlighting the applicability to other research and clinical practice without the opportunity for discussion.[53,56,57] This transitioned to local email discussions allowing more interaction, but limited ability to readily organize and measure impact.[53,57] There are now multiple pathways for running an online journal club.

One of the most commonly used resources for online journal clubs is Twitter. This platform has been used as the starting platform for numerous online journal clubs, as well as individuals, specialty organizations, journals, institutions, and events by providing instantaneous discussions with a diverse group of participants.[23,52,55,56,59,61-66] Participating in an online journal club also helps new Twitter users to rapidly build their own unique, high-quality, personal learning network.[56]

Twitter has rapidly become the dominant source of medical blog traffic while providing a platform for journals to tweet links to their latest papers. This initiates the community peer-review process and may predict future

paper citations.[56] For many online journal clubs, Twitter discussions are curated, summarized, and then linked to the initial PubMed citation for the article.[23,52,56] This curated commentary may also be submitted and published as an article commentary or letter to the editor.[67] Disadvantages of Twitter include character limits and lack of an underlying organizational structure, making delayed asynchronous engagement more challenging.[52,54,64] Furthermore, many educators and learners do not use Twitter as consumers, or feel comfortable engaging in Twitter conversations as participants.[52] Ultimately, more in-depth and even private discussions may be conducted on linked blogs or other online platforms.[23,53,55,58]

The rapid expansion and affordability of high-quality online video teleconferencing platforms (e.g., Skype, Google Hangouts) has created the ability to rapidly share and record journal club discussions across the globe.[10,53] In 2013 the Academic Life in Emergency Medicine (ALiEM) team partnered with the *Annals of Emergency Medicine* on a year-long pilot of a series of online journal clubs discussing select articles from the journal.[52,58] This unique project extended across multiple, social media platforms, beginning with a live Google Hangout session with topic experts, followed by the creation of podcasts and blog posts from these discussions.[52,58] These online journal clubs were linked to and promoted by multiple medical blogs and websites, resulting in a significantly broader reach than attainable with a local journal club, as demonstrated by page views, Twitter activity, and comments.[52,58]

Other researchers have demonstrated that a hybrid model of live event and online discussions provides an adaptive and feasible educational delivery method for clinicians with limited educational time, with one study finding a positive improvement in the use of evidence-based recommendations by clinicians.[68] At many training programs, faculty and learners may be working clinically at multiple institutions limiting the attendance for in-person journal club sessions. Yang and colleagues described the successful use of video conferencing software to increase attendance at monthly journal clubs.[59]

Other platforms have been used successfully including the Wikipedia software to create the Wiki journal club (WikiJC) in 2011.[54] WikiJC begins each online journal club with a landmark article selected by the WikiJC editors. WikiJC entries can be written and edited by any registered person. Typically, the sections are authored by two people, with subsequent fact checking performed by the WikiJC editorial team. After this, the journal club discussion is disseminated through the website, email, and Twitter. WikiJC entries progress collaboratively from incomplete to a published status over an average of three-to-four weeks. With nearly 300 articles, WikiJC has become one of the most prolific online journal clubs to date.[23,54]

Suggested keys to success for a new online journal club include starting discussions on a single platform (e.g., Twitter) and then sharing the curated discussions on a blog or website; providing live discussions with the educator or author, followed by subsequent replies to learner comments across platforms; focusing on an initial small community of learners; ensuring that psychological safety is always ensured even after erroneous comments are posted; and tracking local participation and engagement.[23,52,53,58]

One study of general surgery residents found that an online journal club using a combination of email, Facebook, and Twitter was very well received by learners, noting that it was easy to participate in, helpful in keeping up with the latest literature, and valuable for developing critical appraisal skills.[67] Learners found it significantly preferable to traditional journal club, and the authors noted that the online journal club led to the successful publication of eight article commentaries.[67] Similar data were found by several other authors, noting improved learner satisfaction;[25,57,61] however, more data are needed on higher level learning outcomes.

Best Practice Recommendations:

1. **Consider using an online journal club format to increase participation and overcome the limitations of time, geography, and limited local membership (Level 4).**
2. **Before creating an online journal club, review successful, established online journal clubs and use previously established, effective strategies (Level 5).**
3. **Starting a new online journal club requires a significant time and resource commitment by a dedicated team. Ensure that this is feasible at your institution prior to launching an online journal club. Consider joining an existing online journal club rather than creating a new one if resources are limited (Level 5).**

LIMITATIONS

It is important to consider several limitations with respect to this article. While we used multiple methods to identify potential relevant articles, it is possible that some articles may not have been identified by the current review; however, we used an inclusive search strategy, reviewing all articles in PubMed that populated in response to the keywords "journal club." We also discussed this with topic experts, reviewed the bibliographies for all relevant articles, and reached out via multiple social media networks for further resources. Nonetheless, it is possible that some articles not published in

PubMed or referenced in the included articles may have been missed by this search strategy.

Additionally, we based article selection upon relevance to the specific themes selected. The topic of journal clubs is extensive and only specific components deemed to be most relevant to the clinician educator were selected for review in this publication. We also did not assess journal club effectiveness, as this has already been studied elsewhere.[17] Instead, the focus was on practical, evidence-based recommendations for creating and maintaining a journal club. Finally, while preference was given to data directly evaluating journal clubs in EM residency programs, the data were more limited for this arena. Therefore, when data specific to EM residency programs were not available, we used data from other medical residencies and fields as a surrogate.

CONCLUSION

This paper provides an evidence-based review of the literature on the design and structure of journal clubs in residency education. Strategies for preparation, topic selection, implementation, and integration of technology are discussed along with recommendations for best practices. After reading this paper, it is the authors' intention that readers will have new strategies and techniques for implementing and running a journal club at their home institution.

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Teaching Methods Utilized During Medical Resuscitations in an Academic Emergency Department

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Introduction: One important skill that an emergency medicine trainee must learn is the resuscitation of the critically ill patient. There is research describing clinical teaching strategies used in the emergency department (ED), but less is known about specific methods employed during actual medical resuscitations. Our objective was to identify and describe the teaching methods used during medical resuscitations.

Methods: This was a prospective study involving review of 22 videotaped, medical resuscitations. Two teams of investigators first each reviewed and scored the amount and types of teaching observed for the same two videos. Each team then watched and scored 10 different videos. We calculated a Cohen's kappa statistic for the first two videos. For the remaining 20 videos, we determined means and standard deviations , and we calculated independent two-tailed t-tests to compare means between different demographic and clinical situations.

Results: The Cohen's kappa statistic was K=0.89 with regard to number of teaching events and K=0.82 for types of teaching observed. Of the resuscitations reviewed, 12 were in coding patients. We identified 148 episodes of teaching, for an average of 7.4 per resuscitation. The amount of teaching did not vary with regard to whether the patient was coding or not (p=0.97), nor based on whether the primary learner was a junior or senior resident (p=0.59). Questioning, affirmatives and advice-giving were the most frequently observed teaching methods.

Conclusion: Teachers use concise teaching methods to instruct residents who lead medical resuscitations. Further research should focus on the effectiveness of these identified strategies. [West J Emerg Med. 2018;19(4)756–761.]

INTRODUCTION

The emergency department (ED) is a rich learning environment for learners, abounding with undifferentiated, complicated and critically ill patients. Clinical teaching in the ED not only provides learners with the opportunity to improve their fund of knowledge, but perhaps more importantly it impacts their clinical acumen, procedural skills and development as professional healers.[1-3] Despite the wealth of learning opportunities in the ED, traditional teaching methods may not be as effective in this clinical environment, especially during an acute resuscitation where care of the seriously ill or injured patients must be prioritized over all other tasks.[4,5] To

be effective in these high-stakes situations, successful teachers need to have an efficient and dynamic set of teaching tools.[5]

Multiple studies have been published on effective bedside teaching in the ED and other environments where time is limited.[4-8] Other research describes teaching residents during critical resuscitations; however, the majority of these are done in the setting of simulation. [9-11] Less is known about what teaching methods are used during actual medical resuscitations in the ED.

Prior to determining the most effective teaching strategies to use during medical resuscitations, it is necessary to establish what types of teaching methods are currently being used. One study by Grall et al. attempted to codify the types of teaching observed in an academic ED. They discovered that in addition to previously described teaching methods, such as questioning and limited teaching points, up to six previously undescribed strategies were used by teachers in this setting, including advice-giving and affirmatives (Table 1).[8] This study, however, was not limited to the environment of an acute medical resuscitation, and the type of teaching strategies used in this more dynamic situation may differ from those used in other situations in the ED. The purpose of this study was to further elucidate the type of strategies that are used to teach learners during medical resuscitations in an academic ED.

Population Health Research Capsule

What do we already know about this issue?
To teach in the highly dynamic environment of the emergency department (ED) requires efficient teaching tools that challenge the learner but also help to direct care.

What was the research question?
What teaching strategies are used to teach learners during medical resuscitations in the ED?

What was the major finding of the study?
Concise methods are used to teach during medical resuscitations, including questioning, affirmatives and advice-giving.

How does this improve population health?
This study provides the groundwork to further investigate the efficacy of teaching during resuscitations. Improving the teaching provided during these events could improve the care of the critically ill.

METHODS

We conducted a prospective, observational, primarily descriptive study involving review of video-recorded

Table 1. Teaching methods, previously reported and newly described, with definitions (adapted from Grall et al. emergency medicine teaching methods).

Method	Definition
Methods previously described in the literature	
Questioning	Challenges resident using questions; assesses resident's knowledge with questions
Limited teaching points	Focused teaching on 1-2 key concepts
Bedside teaching	Traditional bedside teaching in the patient's presence
Problem-oriented learning	Encourages learning from specific patient problems or management issues
Reflective modeling	Uses reflection on own practice to teach; explains own thought processes
Pattern recognition	Requests chief complaint and presumptive diagnosis before hearing case
Priming	Orients and focuses resident just prior to seeing patient
Feedback	Describes specific behaviors that were effective or need improvement
Newly described methods	
Advice giving	Gives advice on aspects of patient care
Patient updates	Resident gives update on patient information and attending provides reassurance
Affirmatives	Short affirmatives or nods to let learners know they are on the right track
Information sharing	Attending shares further information they have discovered independently
Role modeling	Demonstrates the role of an emergency physician with learner observing
Mini-lecture	Provides short lectures focused on one topic

medical resuscitations from May to September 2016 in the ED of Community Regional Medical Center (CRMC) in Fresno, California. This study was approved by the CRMC institutional review board, and a waiver for informed consent was obtained. A policy on the use of videotaped resuscitations exists at CRMC explaining its use for quality improvement, education and research. Learners, faculty and nurses have the opportunity to opt out of being videotaped.

CRMC is the only Level I trauma center and burn center for the Central Valley of California. The ED cares for 115,000 patients per year and is home to a four-year emergency medicine (EM) residency training program with 40 residents. A resident in the second post-graduate year (PGY-2) or higher and a faculty member are primarily assigned to cover the high acuity medical area of the ED. Residents are responsible for the assessment and care of the patients and present all patients to faculty. During the majority of medical resuscitations, both the resident and faculty are present during the initial assessment and treatment. Besides the resident and faculty running the resuscitation, other teachers and learners may be in the room including medical students, residents, and faculty who present from other areas of the ED during a resuscitation to assist or learn from the situation.

Critically ill patients arriving via ambulance are announced overhead as a medical resuscitation or as a code blue. An attempt is made to place all of these patients initially into a designated resuscitation room with video- recording capabilities. When the patient arrives, the system is activated and the resuscitation is recorded.

Beginning in May 2016, 22 consecutive, video-recorded medical resuscitations were collected. The six investigators, who on average have 11 years of experience as clinical educators, worked in two teams of three. All investigators have roles in the EM program that involve evaluation of residents and faculty.

We designed a structured observation form, using the 14 teaching methods described in the Graff et al. study. The form also had areas to collect demographics and situational information (Table 2). Prior to the initiation of the study, all investigators met to be trained on the use of this structured form and to be provided examples of each type of teaching strategy. Opportunity existed to discuss and clarify the different classifications and definitions of the teaching methods. Then each team of three, in separate locations, watched the same two test videos and scored their observations on the form. These data from the pilot observations were then used to determine interrater reliability.

Each team of three was then assigned 10 videotapes to observe for a total of 20 separate resuscitations. While watching the videos, the investigators considered not only the interaction between the faculty and the primary resident leading the resuscitation, but also among other learners and teachers in the room. Each video, thus, had several possible learner interactions, and each type of interaction was recorded separately. Team members completed the structured observation form individually and reviewed their results at the end of each video. Discrepant results were discussed, and relevant video segments were reviewed until consensus was reached.

Table 2. Coding categories and demographic data on observation form.

Coding categories
• Questioning
• Limited teaching points
• Teaching at bedside
• Problem-oriented learning
• Reflective modeling
• Pattern recognition
• Priming
• Feedback
• Advice giving
• Patient updates
• Affirmatives
• Information sharing
• Role modeling
• Mini-lecture
Demographic data collected
• Patient status (coding vs. non-coding, presenting presentation for non-coding)
• Assigned emergency severity score
• Teacher's level of training (faculty, fellow, senior resident)
• Learner's level of training (PGY1-4, medical student)
• Number of learners in the resuscitation room

PGY, post-graduate year.

Data from the two pilot observations were entered into an Excel 2013 spreadsheet (Microsoft, Redmond, WA), and we calculated a Cohen's kappa statistic to determine interrater reliability between the two groups of investigators with regard to the number and types of teaching documented. Data from the 20 observation forms were then entered into an Excel 2013 spreadsheet, where means and standard deviations were calculated when appropriate. We calculated independent, two-tailed t-tests to compare the means between different demographic (e.g., type of teacher and learner) and clinical situations (e.g., "coding patients," pulseless patients receiving active cardiopulmonary resuscitation [CPR] vs. "non-coding patients," unstable patients with a pulse not undergoing CPR).

RESULTS

The Cohen's kappa statistic comparing the two groups of investigators for the test video recordings was K=0.89 with regard to number of teaching events and K=0.82 for types of teaching documented, suggesting a high degree of interrater reliability between the two groups. We identified 148 teaching episodes during the 20 resuscitations for an average of 7.4 per case (range 1-10). Sixty-five of these teaching episodes were between faculty and senior residents (PGY-3 or -4), sixty-two between faculty and junior residents (PGY-2), four faculty to medical student, eight senior resident to junior resident, and nine resident to medical student.

Of the resuscitations reviewed, 12 were coding patients and the rest were non-coding patients requiring urgent resuscitation. All coding patients had an assigned Emergency Severity Score (ESI) of one. Five of the non-coding patients had an ESI of one and the remaining three had an ESI of 2. Five of the non-coding patients presented with altered level of consciousness, three of which required intubation. Two other patients presented after return of spontaneous circulation in the field and also required intubation. The remaining patient presented with hypotension and bradycardia.

The quantity of teaching did not vary significantly with regard to the clinical status of the patient, coding vs. non-coding (7.42 vs. 7.38, p=0.97); however, in non-coding patients the frequency of teaching was greater in the more critically ill patients (ESI=1) (9.6 vs. 4.3, p=0.002). The amount of teaching by faculty of the primary resident running the resuscitation did not significantly change based on whether the learner was a junior (PGY-2) or senior resident (PGY-3 or 4) (5.64 vs. 5.0, p=0.59).

The most common methods of teaching used between the faculty and primary resident during the resuscitations, both codes and non-codes, were questioning, affirmatives and advice-giving (Table 3). Questioning was the most-used technique both in coding and non-coding patients; however, advice-giving and bedside teaching were the next most-used methods in the setting of a coding patient, whereas affirmatives and limited teaching points were more common in situations involving non-coding patients (Table 4). The teaching methods most commonly used (questioning, affirmatives and limited teaching points) were the same when comparing the more critically ill non-coding patients (ESI=1) to the less critically ill (ESI=2).

Questioning was the most frequently used teaching method by faculty for both junior and senior residents and advice-giving was used equally among these learners. Faculty, however, were more likely to use limited teaching points with junior residents, whereas with senior residents they frequently relied on affirmatives (Table 5).

On average, two learners were present during each resuscitation (range 1-4). Interns and medical students in the room were present mainly as observers or performing procedures. The most common teaching methods used for these learners were limited teaching points, teaching at bedside, and mini-lecture (Table 5). Reflective modeling or pattern recognition were not observed during these resuscitations.

Table 3. Frequency of teaching methods during medical resuscitations n=148 (%).

Teaching method applied	n (%)
Questioning	51 (34)
Affirmatives	23 (16)
Advice giving	18 (12)
Limited teaching points	16 (11)
Teaching at bedside	13 (9)
Information sharing	10 (7)
Patient updates	6 (4)
Priming	3 (2)
Feedback	3 (2)
Role modeling	2 (1)
Mini-lecture	2 (1)
Problem-oriented learning	1 (1)
Reflective modeling	0(0)
Pattern recognition	0(0)

Table 4. Comparison of top three teaching methods used based on status of patient.

Status of patient	Most common methods (%)
Coding	Questioning (39) Advice giving (13) Bedside teaching (10)
Non-coding	Questioning (27) Affirmatives (27) Limited teaching points (15)

Table 5. Comparison of top three faculty teaching methods used based on level of learner.

Learner level	Most common methods (%)
Senior resident (PGY-3 or 4)	Questioning (35) Affirmatives (20) Advice giving (12)
Junior resident (PGY-2)	Questioning (40) Limited teaching points (15) Advice giving (11)
Interns and medical students	Limited teaching points (38) Teaching at bedside (24) Mini-lecture (10)

PGY, post-graduate year.

DISCUSSION

Grall and colleagues published an observational study of teaching in the ED involving patients of a range of different levels of acuity. They found that questioning, advice-giving and limited teaching points were the most frequently used teaching methods.[8] This study sought to establish which methods of teaching are most commonly used during resuscitation, in an effort to guide further evaluations of effectiveness.

Questioning is heavily used during medical resuscitations in both coding and non-coding patients. Questioning in coding patients tended to be more focused on directing care of the patient (e.g., "What medication should you give next?"), whereas in the non-coding patient there were more examples of questioning used to more deeply probe the knowledge of the learner (e.g., "What are the potential causes of bradycardia in this patient?")

In coding patients, the next two most-common teaching methods were advice-giving and bedside teaching. Advice-giving, first described by Grall and his colleagues, is a rapid way for the teacher to guide the resident in the next stages of care (e.g., "I would intubate the patient next') in the time-sensitive situation of a coding patient.[8] Bedside teaching in this situation was most commonly procedurally based (e.g., bedside ultrasound, placement of central line).

In non-coding patients, after questioning, affirmatives and limited teaching points were the next most frequent teaching methods used. Limited teaching points may be more likely to be used in the setting of the non-coding patient because there is more time to do directed teaching when compared with the more time-sensitive scenario of the coding patient.

Questioning, the most frequently used teaching method for both senior and junior residents, was identified by Heidenreich and Ramani to be both effective and efficient.[3,12,13] The intent of the questions varied from narrow and specific, seeking to yield information for further consideration or to assess the learner's knowledge base (e.g., "The patient has been down for how long?", "What dose of amiodarone would you give?") to broader questions used to stimulate the learner's critical thinking and problem-solving skills or to guide patient management (e.g.; "What other medications would you consider giving at this point?"; "What are the treatable causes of pulseless electrical activity?").

Advice-giving, first described as a teaching method by Grall and colleagues, was also used by attendings in this study to teach both junior and senior residents who had primary responsibility for the care of the patient being resuscitated. The teacher provides advice to the learner (e.g., "I would use the bedside ultrasound to assess for cardiac activity at this point"; "I would administer broad spectrum antibiotics"). Advice-giving may be an efficient method of teaching because it is immediately applicable and builds on prior knowledge of the learner.[8]

For senior residents, affirmatives were one of the top three teaching methods used. Affirmatives were also first described by Grall et al. Affirmatives can be verbal or non-verbal and serve to inform learners that the teacher agrees with their plan or cognitive process.[8] Affirmatives may be more frequently used with senior learners because the teacher is more confident of their knowledge base and skills and only feels the need to assure the resident that he or she is on task.

For junior residents, limited teaching points was one of the top three teaching methods used. Limited teaching points was previously described by Heidenreich and Bandiera as a valid teaching method.[12,14] Limited teaching points usually relates to a specific aspect of the patient's care (e.g., discussing the pros and cons of using etomidate vs. ketamine in a septic patient) and are concise and specific. They may be more commonly used for junior residents because the teacher feels there are knowledge gaps that need to be addressed in a rapid manner during the resuscitation.

Limited teaching points were also used for interns and medical students, but more in-depth teaching methods including teaching at bedside (usually procedurally based) and mini-lectures on a topic related to the patient's care ("Let's go over the 5 H's and T's of PEA") also were observed. The teaching of these learners was usually conducted by a faculty member or resident who was not primarily responsible for the resuscitation, but who had arrived to help. The peripheral role of interns and medical students during critical resuscitations at our institution might be the cause of the observed differences in how they are taught. This study helps to establish which types of teaching occur during medical resuscitations in both coding and non-coding patients. We identified several methods used by teachers in these time-sensitive cases that have been previously validated as both efficient and effective. This study, however, did not directly address the efficiency of these teaching methods.

LIMITATIONS

There are several potential limitations to our study. The Kappa statistic to determine inter-rater agreement between the two groups that watched the videos was only calculated for the two pilot videos that were observed by both groups. After the two pilot videos, the two groups watched different videos, so no Kappa statistic could be calculated for the 20 videos included in the study; however, given that there was good inter-rater reliability with the two test videos, it is inferred that this reliability would continue throughout the other observations.

Only the first 20 resuscitations recorded during the study period were reviewed. Other videos may have revealed different teaching methods, although this cohort is likely a good representation and supports much of the earlier work by Grall and his colleagues. It is also possible that occasionally teaching that occurred prior to the start of the resuscitation were missed because the record button on the video camera was not pressed early enough. In addition, there was likely teaching surrounding

the resuscitations that occurred between the resident and faculty that occurred later, off camera. It was not our goal to capture this interaction, however, as we sought to identify only teaching happening during the resuscitation effort itself.

Because all team members knew that the resuscitations were being recorded, this may have impacted the degree of teaching due to the Hawthorne effect. While we assessed the types of teaching during critical medical resuscitations and code situations, we did not assess the effectiveness of these teaching methods nor did we assess if these teaching methods improved resident learning outcomes; these are possible directions for future studies.

CONCLUSION

Teachers use a variety of concise teaching methods to instruct residents who lead medical resuscitations. More in-depth teaching strategies are used for more-junior learners in the room. Further research should focus on the effectiveness of these identified strategies.

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A Targeted Mindfulness Curriculum for Medical Students During Their Emergency Medicine Clerkship Experience

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Introduction: Despite high rates of burnout in senior medical students, many schools provide the majority of their wellness training during the first and second preclinical years. Students planning a career in emergency medicine (EM) may be at particularly high risk of burnout, given that EM has one of the highest burnout rates of all the specialties in the United States We developed an innovative, mindfulness-based curriculum designed to be integrated into a standard EM clerkship for senior medical students to help students manage stress and reduce their risk of burnout.

Methods: The curriculum included these components: (1) four, once-weekly, 60-minute classroom sessions; (2) prerequisite reading assignments; (3) individual daily meditation practice and journaling; and (4) the development of a personalized wellness plan with the help of a mentor. The design was based on self-directed learning theory and focused on building relatedness, competence, and autonomy to help cultivate mindfulness.

Results: Thirty students participated in the curriculum; 20 were included in the final analysis. Each student completed surveys prior to, immediately after, and six months after participation in the curriculum. We found significant changes in the self-reported behaviors and attitudes of the students immediately following participation in the curriculum, which were sustained up to six months later.

Conclusion: Although this was a pilot study, our pilot curriculum had a significantly sustained self-reported behavioral impact on our students. In the future, this intervention could easily be adapted for any four-week rotation during medical school to reduce burnout and increase physician wellness. [West J Emerg Med. 2018;19(4)762–766.]

INTRODUCTION

Recent studies have demonstrated the high prevalence of burnout in residents and medical students.[1,2] These unfortunate numbers have prompted medical educators to develop and implement new strategies to promote wellbeing and reduce stress. Of the different approaches, the most promising interventions focus on a concept known as mindfulness training. Originally developed in 1979 by Jon Kabat-Zinn, mindfulness-based stress reduction techniques have since been widely used and modified. Mindfulness programs for medical

students generally consist of semester-long, elective courses during the pre-clinical years.[3] Topics include gaining self-awareness, managing stress, and handling difficult emotions. Mindfulness is thought to decrease emotional reactivity through the act of paying attention to one's thoughts and feelings. Meditation acts as a focused method for practicing the different aspects of mindfulness.

Students planning a career in emergency medicine (EM) may benefit from mindfulness training, as EM has one of the highest rates of burnout.[4,5] Medical students who learn these skills may be uniquely positioned to succeed in residency and beyond. To the best of our knowledge, this is the first mindfulness-based curriculum designed for medical students participating in an EM clerkship.

METHODS

In order to integrate this curriculum into a four-week EM clerkship, we developed four, once-weekly, 60-minute classroom sessions supplemented by reading assignments, individual meditation practice and journaling, and a wellness plan with the help of a mentor (Table 1). The full curriculum is included in Appendix A.

Students had readings and videos to review prior to each classroom session, as well as a short, weekly written assignment. The classroom sessions included techniques to encourage participation and collaborative learning, including the following: 1) ice breakers to build community; 2) brainstorming about the students' current stressors to create relevance; 3) brief didactics about wellness and mindfulness to convey knowledge; 4) role-playing to foster value; and 5) practice exercises in mindfulness and meditation to develop competence. To build the value and skills required for sustained behavioral change, the students also regularly practiced meditation and tracked their progress via a daily practice journal that was reviewed weekly by a faculty mentor. The final assignment consisted of developing an individualized wellness plan using mindfulness-based techniques that the student could use following the completion of the curriculum.

A single faculty member (A.S.C.) led all of the classroom sessions, checked the daily practice journal, and worked with each student to develop his or her own individualized wellness plan. The faculty leader trained EM residents at the same institution (R.F., E.H., K.R.) to help facilitate group discussions and in-session activities. The faculty leader was not involved in determining the final grades for the students' clerkships and did not participate in writing any standardized letters of evaluation for the students' applications for residency programs.

Measured outcomes included surveys completed by the participants at baseline prior to starting the curriculum, immediately following the end of the four weeks, and again at six months. Each survey assessed for self-reported behaviors and attitudes regarding meditation and mindfulness and overall reactions to participation in the curriculum. Paired sample t-test analysis comparing baseline results against the results at four weeks and at six months was performed using standard software (SPSS©) with two-tailed statistical significance predetermined at $p<0.05$.

This pilot study was approved by the Maimonides Medical Center Institutional Review Board.

RESULTS

We enrolled 30 students during three consecutive EM clerkship rotations at a single, urban, academic institution. EM is not a required clerkship at our institution and we preferentially select students for our clerkship who are planning a career in EM during the summer months of June, July, and August. Each student completed surveys prior to, immediately following, and six months after completing the curriculum. We excluded 10 students from the final analysis for failure to complete all three surveys. Responses were defined on a Likert scale as the following: 1=not at all/never; 2=a little/occasionally; 3=a lot/once at week; 4=very much/every day.

We found significant changes in the self-reported behaviors and attitudes of the students immediately following participation in the curriculum compared to prior to the curriculum (Table 2). Students believed more strongly in the importance of wellness for students and residents ($p=0.01$). They felt more confident that they could explain to another person how to meditate ($p=0.0001$) and be mindful ($p=0.0001$); more confident in their own ability to meditate ($p=0.0001$) and be mindful ($p=0.0001$); reported meditating more often ($p=0.0001$) and practicing mindfulness more often ($p=0.0001$); and were more likely to recommend meditation ($p=0.0001$) and mindfulness ($p=0.0001$) to another person.

More importantly however, many of these changes remained sustained at six months later (Table 2). Six months following participation, the students still felt more confident that they could explain to another person how to meditate ($p=0.0001$) and be mindful ($p=0.0001$); more confident in their own ability to meditate ($p=0.012$) and be mindful ($p=0.0001$); reported meditating more often ($p=0.005$) and practicing mindfulness more often ($p=0.007$); and were more likely to recommend meditation ($p=0.008$) and mindfulness ($p=0.042$) to another person when compared to prior to their participation in the curriculum.

Interestingly, three-quarters of the students (15/20, 75%) reported using their individualized wellness plan at least occasionally even up to six months later. Most students reported talking about either meditation (17/20, 85%) or mindfulness (17/20, 85%) to at least one other person since participating in the curriculum.

Students overall had very positive reactions to their participation in the curriculum. The majority of students responded that the prerequisite assignments were interesting

Table 1. Content outline of mindfulness curriculum with prerequisite assignments, session objectives, classroom methods, and timeline for the final project.

	Session one: the basics	Session two: practicing mindfulness	Session three: mindfulness in daily life	Session four: reflections on mindfulness
Prerequisite reading/ videos	NY Times article Medscape Report Dan Harris video #1 60 Minutes video	Chapter 1: Why Zebras Don't Get Ulcers Power of Concentration Dan Harris video #2	9 Mindfulness Rituals 13 Things Mindful People Do Every Day	TED Talk Fallacy of Chasing Work-Life Balance Mindful Training
Objectives	Define foundational concepts relevant to wellness and mindfulness Identify personal stressors or stressful situations Practice meditation using breath technique	Summarize evidence supporting benefits of mindfulness Persuade a (role-play) patient to try meditation as a stress-reduction technique Practice meditation using the body scan	Discuss different strategies to incorporate mindfulness into daily activities Identify barriers to mindfulness Practice mindful eating	Reflect on changes associated with regular meditation Illustrate how mindfulness can improve personal life and patient care Select a preferred method of mindful meditation
Classroom methods	Formal Presentation Foundational concepts, including wellness, stress, burnout, meditation, mindfulness, and the MBSR program Group Discussion Identify commonly occurring situations in their personal and professional life that trigger stressful thoughts or feelings In-Session Activity "Museum Tour" to explore the different interpretations of wellness, burnout, and mindfulness 2-Minute Meditation Breath technique	Formal Presentation Evidence supporting effectiveness of meditation and mindfulness, including physiologic as well as mental health changes Group Discussion Share experiences with meditation practice over the past week, both positive and negative In-Session Activity Role-play scenarios in which the student promotes mindfulness as a stress reduction technique to a patient 2-Minute Meditation Body scan technique	Formal Presentation Methods to incorporate mindfulness into daily activities Group Discussion Share mindful experiences from both the clinical setting and in personal life In-Session Activity Think-pair-share to brainstorm barriers to practicing mindfulness in both clinical practice and in daily activities 2-Minute Meditation Mindful eating	Formal Presentation Relationship between reflection, mindfulness, and life-long learning Group Discussion Reflect on any changes that have occurred following a regular meditation practice In-Session Activity In teams, create a concept map to illustrate how mindfulness can enhance both personal wellness and patient care 2-Minute Meditation Meditation of choice
Weekly assignment (due on day of session)	Identify at least 3 specific stressors or stressful situations that the student has personally experienced.	Summarize the first week of meditation practice using either bullet points or prose.	Describe a case in which mindfulness was used during a clinical encounter, preferably during the previous week.	Short reflection any changes noted after implementing a regular schedule of meditation or on incorporating mindfulness in daily life
Individual wellness plan (approximate timeline)	—	First draft of plan	Refine draft using feedback from mentor	Complete and sign plan

and informative (17/20, 85%), the content covered in the classroom sessions was useful (20/20, 100%), and that the format of the classroom sessions was effective (19/20, 95%). Interestingly, more than half responded that regularly practicing meditation was important to them (13/20, 65%) and that they planned on using their individual wellness plan in the future (12/20, 60%). Many students (17/20, 85%) responded that they would recommend this course to others.

Table 2. Survey responses at baseline (prior to the curriculum), four weeks (immediately following the curriculum), and six months after completing the curriculum. Statistical significance ($p<0.05$) comparing values at baseline vs. four weeks and again comparing baseline versus six months has been denoted with an (*).

Question	Baseline	4 wk	6 mo
I believe in the importance of wellness for medical students and residents.	3.35	3.65*	3.45
I feel confident that I can explain to another person how to meditate.	1.85	2.95*	2.90*
I feel confident in my own ability to meditate.	2.00	2.80*	2.65*
On average, I meditate _____.	1.45	2.80*	2.15*
How likely are you to recommend meditation to another person?	2.10	2.80*	2.65*
I feel confident that I can explain to another person how to be mindful.	2.00	3.20*	2.85*
I feel confident in my own ability to be mindful.	2.35	3.10*	2.95*
On average, I practice mindfulness _____.	1.95	3.15*	2.65*
How likely are you to recommend mindfulness to another person?	2.30	3.35*	2.70*

DISCUSSION

Although some medical schools have implemented mindfulness training into their formal curriculum, most of these interventions occur during the pre-clinical years.[3] Studies have demonstrated that burnout and suicidality increase during the third and fourth years.[1,6] A recent systematic review highlighted the effectiveness of mindfulness interventions for reducing medical student stress, depression, fatigue, and burnout.[7] We felt that developing a mindfulness-based curriculum for students designed to be integrated into their clerkship rotations would be one means to address this need for wellness programs in the later years of medical school.

Many clerkships include weekly didactic sessions within which our curriculum can be easily integrated. The curriculum may be led by the clerkship director or another faculty member invested in student wellbeing. The required resources are minimal, and no special equipment is required. Our curriculum can be easily reproduced at different institutions and for different clerkships, not just EM.

We measured student reactions, attitudes, and self-reported learning and behaviors according to the first two levels of the Kirkpatrick Model, which describes the progressive effectiveness of educational interventions as reaction, learning, changes in behavior, and patient outcomes. Reactions to the curriculum were positive, with most students reporting that they would recommend this curriculum to others. Most importantly, however, the self-reported changes in attitudes, learning, and behavior remained sustained even up to six months later, which is perhaps the most remarkable and impactful significance of this intervention.

LIMITATIONS

Clear limitations of our study include a small sample size and implementation only at a single institution. We also acknowledge possible participation bias. We chose three summer months when students interested in EM rotate on our EM clerkships. It is unclear if these students were more motivated to participate in the curriculum given the timing. We attempted to mitigate this effect by ensuring that the faculty leader (A.S.C.) was not involved in the students' final grades, standardized letters of evaluation, or any other letters of recommendation. We also excluded 10 students from the final analysis, which may have represented a second source of participation bias. Unfortunately, we did not measure demographic factors or other variables that would have allowed us to determine if there was a systematic difference between the students who completed all three surveys and those who did not.

Another limitation was the lack of burnout assessment or other similar outcomes. After careful consideration, we decided that, given the pilot nature of our study, evaluating a change in burnout as a result of our curriculum would be outside of the scope of our investigation.

Finally, our main outcomes were measured using a non-validated survey instrument. However, the survey questions were reviewed internally by the study authors (A.S.C., R.F., E.H., K.R.), and we felt that the questions appropriately assessed self-reported behaviors and attitudes. The questions were also limited by their self-report nature; however, directly observing outcomes was outside the scope of this initial curriculum evaluation.

CONCLUSION

Although this was a pilot study, our innovative mindfulness-based curriculum had a significantly sustained impact on the attitudes and self-reported behaviors our students. Our intervention could easily be adapted for any four-week rotation during medical school.

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1 Evidence for Social Disparities in Emergency Department Hallway Bed Assignment

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Objective: Hallway beds in the emergency department (ED) lead to lower patient satisfaction, and may be associated with inferior care. Our objective was to determine whether socioeconomic factors influence which patients are assigned to hallway beds, independent of patients' clinical characteristics at triage.

Methods: We performed a retrospective analysis of 96,650 visits to a large academic ED's adult acute care area in 2013-2016. For each visit, we observed patient age, sex, race, and insurance status (i.e., Medicaid, Medicare, private insurance), as well as time and date of arrival, illness acuity level at triage, and final diagnosis. In a series of logistic regression models, we estimated the effects of patients' insurance status and race on the likelihood of their being assigned to a hallway bed, controlling for time and day of arrival, illness severity, and patient characteristics at time of triage. We also estimated a Cox proportional hazards model for the effect of hallway bed assignment on length of stay, controlling for triage acuity, age, sex, race, and time and day of arrival in the ED.

Results: Overall, 12.0% of adult acute care patients were assigned to hallway beds. At triage acuity levels 2-4 (98.6% of visits), Medicaid patients were more likely to be assigned to hallway beds, compared to patients with Medicare or private insurance. Patients assigned to hallway beds had significantly longer lengths-of-stay than roomed patients of the same acuity level ($p<0.05$). In logistic regression models controlling for age, sex, race, time and day of visit, and triage acuity, Medicaid status was associated with 44% greater odds of assignment to a hallway bed (odds ratio [OR][1.44], 95% confidence interval [CI] [1.37-1.52]), compared to privately insured patients. Black patients were more likely than white patients to be assigned to hallway beds (OR [1.14], 95% CI [1.06-1.22]), but race alone did not account for the effect of Medicaid status on hallway bed assignment, and exhibited complex interactions with insurance status.

Conclusion: Our findings provide evidence for socioeconomic disparities in the use of ED hallway beds, and suggest process improvement measures to remedy them.

2 Opt-out Emergency Department Screening of HIV and HCV in a Large Urban Academic Center

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Objectives: In 2011, Miami was found to have the highest rate of new HIV diagnoses in the country. Miami is now at the frontline of a crisis of HIV-related causes of death. Acute HCV infections are also on the rise in Miami. Intravenous drug use, homelessness, high-risk sexual behavior, stigma related to the diseases, and influx of immigrants from high prevalence countries may be some of the causes for these statistics. Jackson Memorial Hospital (JMH) is an urban tertiary care center that serves 2.7 million residents of Miami-Dade County and provides care to those most at-risk for HIV/HCV. The populations served are largely uninsured, and use the emergency department as a primary means of healthcare. As a result, they may not receive routine screening for HIV/HCV or have access to treatment. We are performing non-risk based, opt-out, integrated, blood-based ED HIV/HCV screening to better characterize risk factors and actively link HIV and/or HCV-infected patients to expedite their access to care and services.

Methods: Opt-out, HIV Ag/Ab and HCV Ag testing was performed on all patients who required blood analysis for assessment of their presenting chief complaint. Patients who had a documented screening test within one year were excluded. Results were disclosed to patients appropriately.

Results: A total of 10,447 patients were screened between June 2017 and October 2017. 221 (2%) were positive for HIV and 505 (4.8%) were positive for HCV. Out of these, 269 had positive HV RNA viral loads. Of those who tested positive for HIV, 21 (10.76%) were unaware of infection and 4 (2.05%) were acute infections. Coinfection was detected in 33 patients.

Conclusion: The percentages of HIV and HCV positive individuals in our patient population are higher than previously reported for Miami. The HIV prevalence at JMH was found to be more than twice the national average. Our HCV prevalence findings highlight the critical role EDs may serve in identifying patients with undiagnosed HCV infection. The demographic data for those positive for HIV and HCV correlate with those previously reported. Miami-Dade has high rates of intravenous drug use, high-risk sexual behavior, and homelessness, which are all known risk factors and likely contribute to the high prevalence of HIV and HCV that was identified. Thorough coordination and perseverance between multiple hospital departments, community resources, and local health departments to develop a customized treatment workflow for our patients is necessary to improve enrollment into treatment.

3 The Impact of the Affordable Care Act on Primary Care Treatability of Emergency Department Visits

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Background: The Affordable Care Act (ACA) attempted to address rising health care costs by providing better access to primary care providers for non-emergent complaints. Studies measuring emergency department (ED) utilization before and after the enactment of the ACA have yielded mixed results.

Objective: To analyze how changes in coverage status from 2011-2016 as a result of the ACA impacted ED utilization, and determine which populations were more or less likely to use the ED for non-emergent purposes.

Methods: We compared changes in the severity of ED visits and sociodemographic factors at an academic and community hospital to analyze longitudinal trends pre- and post-ACA. We used poverty level of the zip code of residence as a proxy for patient level socioeconomic status (SES). Patients were categorized as high (≤9.9% of households below poverty), intermediate (10.0-19.9%), or low (≥20.0%) SES. We measured ED severity according to the validated Ballard algorithm. Multi-level logistic regression was employed to determine whether the probability of having a non-emergent ED Visit changed after the ACA. We defined the pre-ACA period as January 1, 2011-December 31, 2013, and the post-ACA period as April 1, 2014-December 31, 2016. We excluded ED visits that occurred from January 1, 2014-March 31, 2014 due to uncertainties about coverage status as insurers adjusted to the new ACA regulations.

Results: Our results showed that a lower proportion of ED visits were non-emergent post-ACA compared to pre-ACA ($p<0.001$, 95% confidence interval [CI] [0.72-0.75]). Compared to insured patients, uninsured patients showed a 1.12 fold increase in odds of having a non-emergent visit to the ED ($p<0.001$, 95% CI [1.08-1.16]). Compared to white patients, black patients had a 1.39 fold increase in odds ($p<0.001$, 95% CI [1.34-1.44]) and Asian patients had a 1.14 fold increase in odds of having a non-emergent ED visit ($p<0.02$, 95% CI [1.03-1.27]). Compared to non-Hispanic patients, Hispanic patients showed a 1.77 fold increase in odds ($p< 0.001$, 95% CI [1.71-1.84]). Compared to patients in the high SES category, patients with an intermediate SES had a 1.16 fold increase in odds of visiting the ED for a non-emergent reason ($p<0.001$, 95% CI [1.12-1.19]).

Conclusion: Our results suggest a lower proportion of ED visits were non-emergent after implementation of the ACA. However, some patient populations remain at risk for ED overutilization for non-emergent needs.

4 Association Between Race/Ethnicity & Wait Time in Adults Presenting With Emergent vs Urgent Symptoms

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Objectives: Evidence suggests that increasing wait times in the emergency department (ED) leads to detrimental health outcomes. Specific race/ethnic groups were shown to have varying wait times, which could lead to health disparities. We seek to determine whether there is an association between race/ethnicity and wait time on the bases of emergent and urgent presentation in ED.

Methods: We performed analysis of adult participants of the 2012-2014 National Hospital Ambulatory Medical Care Survey (NHAMCS) who arrived at the ED presenting with selected emergent (chest pain/shortness of breath) or urgent (abdominal pain/back pain) symptoms. Independent associations were assessed using logistic regression models. Stratification by emergent and urgent symptoms of presentation was performed to examine potential effect modification.

Results: We studied 9396 patients, of which 60% were Non-Hispanic whites, 22% were non-Hispanic blacks, 15% were Hispanics and 3% were other races. Overall, 47% of non-Hispanic blacks waited for > 30 minutes compared to 38% of non-Hispanic whites. In the stratified adjusted analysis, among participants with emergent symptoms, non-Hispanic blacks had significantly higher odds of waiting > 30 minutes as compared to non-Hispanic whites (odds ratio [1.58], 95% confidence interval [1.10-2.27]). This association was not significant for the non-Hispanic blacks presenting with urgent symptoms. No differences were found for the other race categories.

Conclusion: Our findings suggest that there are disparities in waiting times according to race/ethnicity. Compared to non-Hispanic whites, non-Hispanic blacks are more likely to have longer waiting times when presenting with emergent symptoms at EDs across the United States.

5 Trends of Freestanding Emergency Department Visits in Florida

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Objectives: Little is known about the characteristics of freestanding emergency department (FSED) visits. Proponents of FSEDs cite potential benefits including lower cost, waiting time, reduced overcrowding in traditional EDs, and overall convenience. However, previous studies on emergency care access and expenditure have suggested that increased access to emergency care may lead to an increase utilization of emergency departments for lower acuity patients, resulting in higher overall health care expenditures. The objective of this study is to examine trends of FSED visits.

Methods: Publicly accessible statewide emergency department (ED) data during years 2014-2016 were collected. Total FSED visits per quarter were plotted. Trends in total visits, top diagnoses treated, and average charges of those conditions were noted.

Results: Total FSED visits in 2016 has more than doubled (203%) from total FSED visits in 2014. FSED visits have captured increasingly more of all ED (traditional ED and FSED)

visits statewide, comprising 3.3%, 4.5%, and 6.1% of total ED volume during 2014-2016, respectively. The most common treated condition of FSED visits is "Injury and Poisoning" (~25% of total FSED visits) compared to "Signs, Symptoms, and Ill Defined Conditions," which is ~22% of total traditional ED visits. Regarding all years examined, FSEDs had lower average costs for each of the ED's top three treated conditions: "Injury and Poisoning" $3,679 vs $4,745; "Signs, Symptoms, and Ill Defined Conditions" $5,822 vs $7,888; "Diseases of the Respiratory System" $2,821 vs $3,370. The price difference between the top three treated conditions has remained relatively stable in the years examined.

Conclusion: The emergence of newly built FSEDs has many implications for how they will impact traditional EDs and care of patients. Considering that the most common condition treated during visits to FSEDs in Florida is "Injury and Poisoning," such facilities should be equipped and staffed accordingly to handle this condition. The cost of FSED visits are consistently lower than traditional ED visits throughout the years examined; this is different from FSED visits in Texas where their costs have become comparable to traditional EDs. Continued monitoring of FSEDs is warranted particularly with factors affecting costs and it's ability to affect traditional EDs' volume.

6 One Last Shot: Self-Inflicted Firearm Violence in Trauma Centers in 2012-2013

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Objectives: Intentional self-harm (suicide) is a growing problem in the United States and is one of the top ten leading causes of death. Our objective is to compare the presentations and outcomes of victims of self-inflicted gunshot wounds (SIGSW) by handguns versus other types of firearms. Additionally, we compare the presentations and outcomes of victims with head/face injuries to other regions of the body.

Methods: We performed a retrospective analysis of data from the National Trauma Database of all patients who presented to registered trauma centers between 2012 and 2013. Categorical data included patient characteristics upon presentation and outcomes which were compared between patient's with handgun injury versus shotgun, hunting rifle, and military firearms using the Chi-Squared test. Continuous data were analyzed through the Mann-Whitney U test. Additionally analysis of head and face injuries versus other bodily injuries were compared between the handgun group versus shotgun, hunting rifle, and military firearms group using Chi-squared test.

Results: There were a total of 7828 SIGSWs from the NTDB data. Males accounted for 6600 (84.3%) patients and females accounted for 1228 (15.7%) patients. Of the total number of SIGSWs, 78% (6115) were white. Handguns accounted for 5139 patients and 1130 were due to shotguns, hunting rifles, and military firearms. There were 1405 SIGSWs due to all other types of guns not identified.

Patient's in the handgun group were statistically more likely to be older than 55 years, be hypotensive (systolic blood pressure < 90) upon arrival in the emergency department, have a lower GCS score, test positive for illegal drugs, use prescription drugs, sustain GSW to head, be admitted to the ICU, have a shorter length of stay, and expire in the emergency department.

When comparing those who had head and facial injuries (4799) to those who had injuries to other bodily regions (3028), those who sustained head and facial injuries where statistically more likely to be male, use handguns, be hypotensive, have a lower GCS score, test positive for alcohol but be less likely to test positive for illegal and prescription drugs, be admitted to the ICU, expire in the emergency department, and have an higher overall mortality.

Conclusions: In this retrospective cohort study, we were able to demonstrate several differences between patients with handguns that are involved in SIGSW versus those that use other types of firearms. It is hoped that this information could be used to better understand those who are particularly vulnerable to SIGSW. Future studies can use this information to develop educational and prevention programs.

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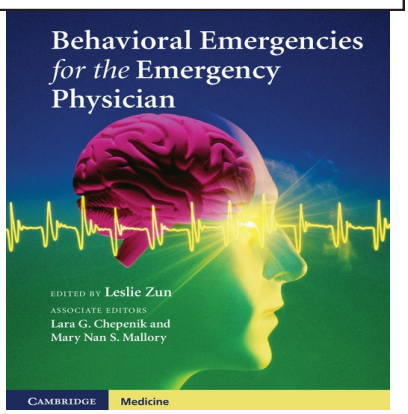

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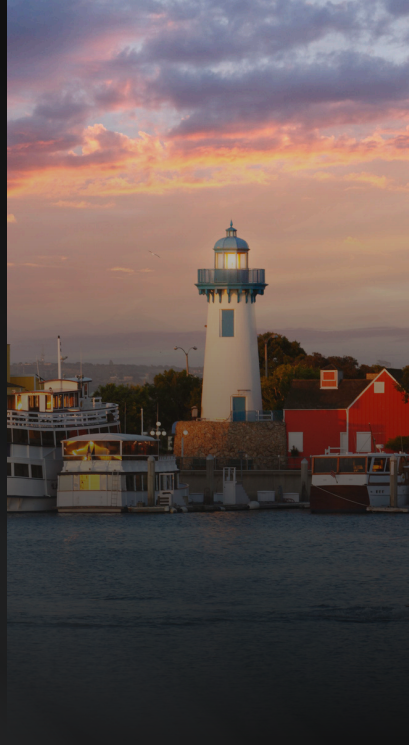

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