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Western Journal of Emergency Medicine:

Integrating Emergency Care with Population Health

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Western Journal of *Emergency Medicine*:

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JOURNAL FOCUS

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

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VITAL STATISTICS

Western Journal of Emergency Medicine (WestJEM): Integrating Emergency Care with Population Health (WestJEM) is the premier open-access Medline-indexed EM journal in the world. As the official journal of California ACEP, American College of Osteopathic Emergency Physicians (ACOEP) and the California chapter of American Academy of Emergency Medicine (AAEM), the journal focuses on how emergency care affects health and health disparities in communities and populations. Additionally, WestJEM focuses on how social conditions impact the composition of patients seeking care in emergency departments worldwide. WestJEM is distributed electronically to 23,278 emergency medicine scholars and 4,323 in print. This includes 78 academic department of emergency medicine subscribers and 6 AAEM State Chapters.

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2	Identify-Isolate-Inform: A Tool for Initial Detection and Management of Zika Virus Patients in the Emergency Department
3	The San Bernardino, California, Terror Attack: Two Emergency Departments' Response
4	Ten Tips for Engaging the Millennial Learner and Moving an Emergency Medicine Residency Curriculum into the 21st Century
5	Point-of-Care Multi-Organ Ultrasound Improves Diagnostic Accuracy in Adults Presenting to the Emergency Department with Acute Dyspnea
6	Acute Stroke: Current Evidence-based Recommendations for Prehospital Care
7	Managing Agitation Associated with Schizophrenia and Bipolar Disorder in the Emergency Setting
8	Mumps Virus: Modification of the Identify-Isolate-Inform Tool for Frontline Healthcare Providers
9	Randomized Controlled Trial of Electronic Care Plan Alerts and Resource Utilization by High Frequency Emergency Department Users with Opioid Use Disorder
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10		Point-of-Care Sonographic Findings in Acute Upper Airway Edema

The Time Is Now to Use Clinical Outcomes as Quality Indicators for Effective Leadership in Trauma

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To the Editor:

We read with interest the comprehensive review by Ford et al.,[1] which was published in August 2016 issue of the *Western Journal of Emergency Medicine*. The authors aimed to review the best available evidence regarding the effect of leadership and teamwork in trauma and resuscitation on patient care and how effective leadership can be measured.

Presence of a trauma team leader (TTL) in the trauma team is associated with positive patient outcomes in major trauma.[2] Consistent with other authors, Ford et al.[1] highlighted that strong leadership and teamwork can improve processes of care in trauma by improving the compliance with primary and secondary surveys. Nowadays, in major trauma centres the trauma team is lead by a designated TTL; nevertheless, what is the compliance rate with primary and secondary surveys in major trauma centres?

Compliance with the primary and secondary survey components of Advanced Trauma Life Support (ATLS) has been variable across different trauma centres. We conducted a retrospective data analysis of 93 adult trauma patients admitted to our centre, a Level I major trauma centre in England, to assess the compliance with secondary survey examinations recommended by ATLS guidelines.[3] The compliance with secondary survey was significantly poor ranging from 1% for examination of perineum to 62% for examination of chest and limbs. In our centre the management of all trauma cases is led by designated TTLs, most of whom have instructor role in various trauma leadership training programs. So, it remains unclear why knowledge and skills developed in leadership training programs do not necessarily translate to improved clinical outcomes, such as compliance rate with trauma surveys, or missed injuries.[3]

As highlighted by Ford et al,[1] evidence about most effective tool to measure effective leadership in trauma is lacking. The time is now to move away from non-clinical tools toward clinical outcomes to train leaders and to measure effective leadership in trauma. The current state of literature in trauma should value clinical outcomes as the most effective measures for effective leadership. Missed injuries are considered as an important issue in trauma patients and can lead to significant morbidity and even mortality; therefore, they should serve as a quality indicator in TTL performance and should remain the outcome of interest for future studies.

Who should lead the trauma team? Considering the ongoing evolution of care in trauma management and the training of nonsurgical specialties in trauma care, the composition of many trauma teams has changed. The necessity of routine surgical leadership in the resuscitative component of trauma care has been questioned by some authors due to lack of objective evidence in favour of mandatory surgical leadership of trauma teams.[4-6] In view of a controversy about who should lead the trauma team, we conducted a systematic review of the literature and meta-analysis of reported outcomes associated with surgeon versus non-surgeon TTLs in management of trauma patients.[7] Our analysis of 2,519 adult major trauma patients showed that there was no difference in survival (odds ratio [OR]: 0.82, 95% confidence interval [CI] [0.61-1.10], P=0.19) and length of stay when trauma team was led by surgeon or non-surgeon TTLs; however, fewer injuries were missed when the trauma team was led by a surgeon (OR: 0.48, 95% CI [0.25-0.92], P=0.03). However, the best available evidence was mainly from a limited number of retrospective cohort studies and high quality randomised controlled trials are required to provide more robust evidence.

In conclusion, we know from available evidence that effective leadership is associated with positive patient outcomes in major trauma; however, the current non-clinical leadership tools do not necessarily translate to improved clinical outcomes. Clinical outcomes, such as missed injuries, should be the main focus in leadership training programs, should serve as a quality indicator in TTL performance, and should remain the outcome of interest for future studies.

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Reply: "The Time Is Now to Use Clinical Outcomes as Quality Indicators for Effective Leadership in Trauma"

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Thank you for the opportunity to respond to the letter from Drs. Shahab Hajibandeh and Shahin Hajibandeh. Their letter introduces some excellent points into this review and discussion of the role of leadership in trauma resuscitations. Identifying a leader prior to patient arrival is critical to proper team functioning and is associated with more complete primary and secondary surveys. However, non-compliance with ATLS does not necessarily equate to poor leadership skills. It is well established that some aspects of ATLS are invasive, uncomfortable and unnecessary. In fact, ATLS has been incrementally modified to reflect this reality.

The letter authors assert that clinical measures and outcomes are the future of training and studying leadership in trauma. However, while we believe that clinical outcomes are important to assess, they cannot be the only measure of leadership. We do not know if leadership behaviors have a direct impact on patient outcomes, or if they do, if other factors such as technical skill, medical knowledge, system resources or illness severity confound or mediate this proposed relationship. A physician with great leadership skills may lead the whole resuscitation in the wrong direction, to the detriment of patient care. Understanding which area of performance by a physician is flawed is important in order to correct these areas. Leadership must be directly measured in addition to clinical outcomes so that these different components can be examined individually. We identified the Leader Behavior Description Questionnaire (LBDQ) as the best validated measure of leadership based on prior literature. Furthermore, further research is needed to determine if the LBDQ or other measures of leadership correlate with improved processes of care and/or better patient outcomes.

The letter authors also bring into question who should be the identified resuscitation leader. Prior work by Leeper (2013, Journal of Trauma and Acute Care Surgery) has indicated that trauma surgeons may miss fewer minor injuries than emergency physicians, particularly in patients who have other severe injuries; however, this is a single-center study limited by a retrospective design. We believe that whether an emergency physician or a trauma surgeon is best suited to lead the initial resuscitation is not yet settled by the evidence. The ideal leader may be institution dependent and depend on the volume of significant trauma a particular center receives. In our own institution, we work collaboratively between the department of surgery and the emergency department, with the senior emergency resident serving as leader under the direct supervision of both the emergency attending and the attending trauma surgeon. We agree that regardless of who is leading the trauma resuscitation, the identified leader should have the best possible training in leadership and teamwork in order to improve processes of care. Anecdotally, there is often no formal leadership component to residency and fellowship training in the United States, and which leadership skills and behaviors are most important to teach is yet to be elucidated.

We thank the letter authors for the time they put into reading our manuscript and preparing their letter. We look forward to future studies by the Hajibandehs and other authors to clarify this exciting area.

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A Patient-Centered Emergency Department Management Strategy for Sickle-Cell Disease Super-Utilizers

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Introduction: A subpopulation of sickle-cell disease patients, termed super-utilizers, presents frequently to emergency departments (EDs) for vaso-occlusive events and may consume disproportionate resources without broader health benefit. To address the healthcare needs of this vulnerable patient population, we piloted a multidisciplinary intervention seeking to create and use individualized patient care plans that alter utilization through coordinated care. Our goals were to assess feasibility primarily, and to assess resource use secondarily.

Methods: We evaluated the effects of a single-site interventional study targeted at a population of adult sickle-cell disease super-utilizers using a pre- and post-implementation design. The pre-intervention period was 06/01/13 to 12/31/13 (seven months) and the post-intervention period was 01/01/14 to 02/28/15 (14 months). Our approach included patient-specific best practice advisories (BPA); an ED management protocol; and formation of a "medical home" for these patients.

Results: For 10 subjects targeted initially we developed and implemented coordinated care plans; after deployment, we observed a tendency toward reduction in ED and inpatient utilization across all measured indices. Between the annualized pre- and post-implementation periods we found the following: ED visits decreased by 16.5 visits/pt-yr (95% confidence interval [CI] [-1.32-34.2]); ED length of state (LOS) decreased by 115.3 hours/pt-yr (95% CI [-82.9-313.5]); in-patient admissions decreased by 4.20 admissions/pt-yr (95% CI [-1.73-10.1]); in-patient LOS decreased by 35.8 hours/pt-yr (95% CI [-74.9-146.7]); and visits where the patient left before treatment were reduced by an annualized total of 13.7 visits. We observed no patient mortality in our 10 subjects, and no patient required admission to the intensive care unit 72 hours following discharge.

Conclusion: This effort suggests that a targeted approach is both feasible and potentially effective, laying a foundation for broader study. [West J Emerg Med. 2017;18(3)335-339.]

INTRODUCTION

The most common manifestation of sickle-cell disease in the emergency department (ED) is painful vaso-occlusive events.[1-3] Many sickle-cell disease patients manage pain at home; some seek ED care for complications, infection, or most commonly a need for enhanced analgesia. Importantly, a small subpopulation of sickle-cell disease patients, termed super-utilizers, presents to EDs much more frequently than other patients with sickle-cell disease or variants.[4] Approximately 20% of the sickle-cell disease patients account for more than half of ED visits by patients with this disease.[5,6] This latter group may have more severe disease, less social support, consume more healthcare resources, and/or have an opportunity to better manage their care.[4,7,8]

A lack of coordinated care increases the frequency of unscheduled requests for medical care needs, particularly in EDs.[1,3] Creating a management protocol along with enhanced support reduces ED and hospital utilization by sickle-cell disease patients.[9] To date, no prior studies have evaluated a multidisciplinary approach that incorporates an ED protocol targeted specifically at super-utilizers.

We sought to test the development and introduction of a patient-centered management strategy targeting super-utilizer sickle-cell disease patients who presented to the ED with uncomplicated painful presentations. We wished to assess feasibility and preliminary impact on care measures.

METHODS

Study Design

We evaluated the effects of a single-site interventional study targeting a subset of adult sickle-cell disease patients, i.e. super-utilizers, using a pre- and post-implementation design. The pre-intervention period was 06/01/13 to 12/31/13 (seven months) and the post-intervention period was 01/01/14 to 02/28/15 (14 months). Our approach included patient-specific best practice advisories (BPA); an ED management protocol (Figure) with team-approved standing orders; and referral to a "medical home." The institutional review board (IRB201500216) approved the retrospective analysis of medical records with a waiver of informed consent as no intervention was outside of common practice, though often variable. Therefore, this study did not use blinding.

Study Setting and Population

Our study site was University of Florida, a Level I trauma and academic center in Gainesville, Florida, with an ED census of approximately 70,000 annual visits. We defined sickle-cell disease super-utilizers as adults (≥18 years of age) diagnosed with sickle-cell disease who presented to the ED 12 or more times in an average 12-month period.[6]

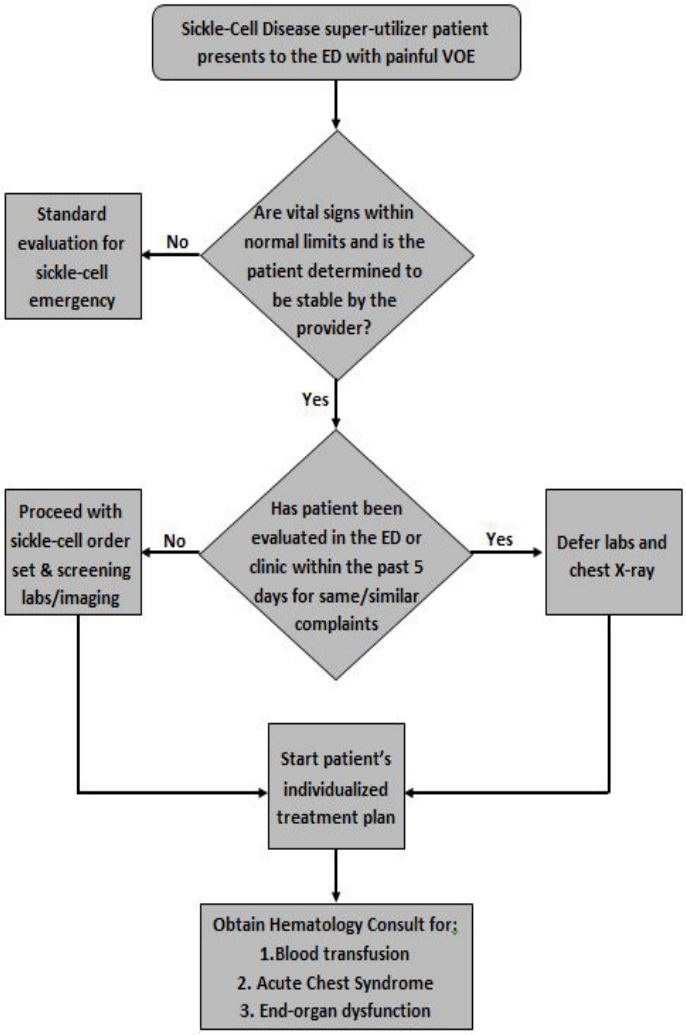

Figure. The sickle-cell disease super-utilizer protocol was designed to expedite analgesic administration and reduce redundant laboratory tests and imaging for patients meeting inclusion criteria. If patients are determined to be clinically stable by the provider with appropriate vital signs, the patient's treatment plan developed by the multidisciplinary team can be implemented, thereby expediting and standardizing care. If the patient has been evaluated by laboratory examination or radiographs in the ED or clinic within five days of their current ED visit, the provider can defer work-up at that time and implement the patient's treatment plan, serving to reduce redundant work-up and further expedite and standardize care. If a hematologic emergency is suspected, a comprehensive evaluation is warranted based on provider discretion.
ED, emergency department; *VOE*, vaso-occlusive event.

Study Protocol

Intervention Development

Our interdisciplinary sickle-cell committee was formed in April 2013 and included community advocates and leaders from the local chapter of the Sickle Cell Disease Association, along with representatives from emergency

medicine, internal medicine, hematology, pharmacy, ED and inpatient nursing, social work, psychology, and addiction psychiatry. The themes emerging during committee meetings were patient and provider frustration concerning lack of continuity of care, inconsistent treatment regimens, and reasons for elevated ED utilization. The team met monthly, inviting patients on occasion, and designed individualized care plans for super-utilizing patients.

Best Practice Advisories

We entered patient-specific care plans created by the multidisciplinary care team into the electronic medical record as a BPA so that all providers and staff would have immediate "pushed" access to the plan upon opening the patient's chart. This BPA directed the provider to current recommendations from the interdisciplinary committee on pain management including patient-controlled analgesia settings, prior sickle-cell emergencies (e.g., acute chest syndrome, priapism), behavioral issues, and transfusion history. We revised plans regularly with input from the multidisciplinary team and continuous communication with hematology.

ED Protocol

The ED protocol for super-utilizers (Figure) helped guide decision-making, reduced redundant resource utilization, and standardized and expedited care. The multidisciplinary team created standing orders for pain control, imaging, and supportive care, which were implemented during the pre- and post-intervention periods to expedite care. We educated every ED resident and ED nurse via physician and nurse champions. A process improvement team formed and met monthly.

Medical Home

Study patients were referred to the "Care One Clinic," a multidisciplinary hospital-based clinic for vulnerable patients with high-frequency ED visits. Upon enrollment, patients were seen by a primary care doctor, social worker and pharmacist, and had access to an embedded addiction and pain specialist and clinical psychologist. Pill counts, random drug screening, and self-documented pain scores were monitored closely. Missed appointments or aberrant behavior risked the cessation of analgesic prescriptions or institution of more frequent and stringent monitoring.

Measures

We measured use of a plan, along with annualized frequency of ED visits; ED length of stay (LOS), measured from arrival to departure; frequency of admission; inpatient LOS; and left before treatment frequency. We also assessed 72-hour death from any cause and intensive care unit (ICU) admission after discharge as crude initial safety estimates.

Data Analysis

We collected an aggregate de-identified dataset from the Decision Support Services data repository during the IRB-approved study period. We analyzed data using SAS Enterprise Guide version 9.4 (SAS Institute). We annualized study variables (i.e., multiple by 12 months/"n" months study period) for comparison. We primarily targeted descriptive measures given the feasibility and preliminary nature of the work, using 95% confidence intervals (CI) to assess those differences.

RESULTS

Ten patients (five women) had an ED-based care plan developed. We confirmed use of BPAs and the ED protocol in all patients during ED visits. Overall, we found a tendency towards a decrease in all indices of emergency resource utilization. No patient mortality or ICU admissions 72 hours following discharge were observed.

ED visits

We observed an (annualized) mean of 38.4 visits per patient per year ("pt-yr") (standard deviation [SD]=23.9) in the pre-implementation period and 21.9 visits/pt-yr (SD=12.7) in the post-implementation period, representing a decrease of 16.5 visits/pt-yr (95% CI [-1.32, 34.2]) after implementation.

ED LOS

The super-utilizers were seen in the ED for a mean of 305.3 hours/pt-yr (SD=247.4) in the pre-implementation period and 190.0 hours/pt-yr (SD=160.9) in the post-implementation period, representing a decrease of 115.3 hours/pt-yr (95% CI [-82.9-313.5] after implementation.

In-patient admissions

We observed a mean 12.2 admissions/pt-yr (SD=3.23) in the pre-implementation period and 7.97 admissions/pt-yr (SD=7.78) in the post-implementation period, representing a decrease of 4.20 admissions/pt-yr (95% CI [-1.73-10.1) after implementation.

In-patient LOS

Those super-utilizers admitted had an in-patient mean LOS of 142.2 hours/pt-yr (SD=147.7) in the pre-implementation period and 106.3 hours/pt-yr (SD=127.5) in the post-implementation period, representing a decrease of 35.9 hours/pt-yr (95% CI [-74.9-146.7]) after implementation.

Left Before Treatment

The total annualized number of patient visits in which the patient left without being seen or left against medical advice (LWBS/AMA) was 20.6 in pre-implementation, 6.85 in post-implementation, representing a reduction of 13.7 visits.

DISCUSSION

Sickle-cell disease patients who more frequently present to the ED are often more severely ill as indicated by laboratory values, report greater pain, and have more complications from their condition than the standard sickle-cell disease healthcare user.[4,7] Repeated admissions for pain control correlate with higher mortality rates.[8] The chronicity and rapidity of these pain episodes reduce sickle-cell disease patients' quality of life.[4,6,9] Because sickle-cell disease predominantly affects minority populations, the manifestations of the disease exacerbate the challenges faced by communities with high proportions of minority residents.[10] This motivated us to develop a protocol of care in an effort to improve the medical care provided to the sickle-cell disease population at our institution. While research on standard sickle-cell disease patient care exists, little is known about very high care utilizers, the population we targeted. Koch reported an intensive management strategy centered on opening a designated sickle-cell disease day hospital, which led to reductions in healthcare use in their high-utilizer and super-utilizer groups.[6] We studied exclusively super-utilizers using a multidisciplinary, ED-based strategy and found similar effects. This suggests that implementing similar protocols at other academic and community institutions is both possible and potentially effective in achieving reductions in resource utilization. Further, we observed that none of our patients required ICU care 72 hours following a discharge, nor did we observe any patient mortality.

Previously published studies highlight the viability of patient-centered management strategies.[6,9] Our patient-centered multidisciplinary care team and the inclusion of advocates for sickle-cell disease patients fostered relationships between the hospital and community. Reduction in LWBS/AMA rates suggests an expectation of improved care as a result of the individualized care plans.

LIMITATIONS

Our trial was primarily a feasibility effort and not designed or powered to detect specific differences; while we saw lower resource use across all who had a plan enacted, the small sample does not allow us to quantify a durable magnitude effect but does offer promise for future work in other settings. We cannot perform a granular assessment of safety due to our small sample, though our current short-term signal was not negative. We did not measure patient satisfaction, though anecdotally the acceptance and unstructured feedback were high among providers and patients. Overall costs measurement was not a focus, but the broad reduction in admission and other resource utilization will very likely translate into a cost savings with this approach.

The study was not blinded, i.e., the providers were aware of the interventions and the institution's new standard of care, which may have improved results. The Hawthorne effect could also be influencing the patient outcomes we observed, which does limit interpretation of the results.

CONCLUSION

An individualized care plan created by a multidisciplinary care team can be created and used in a population of sickle-cell disease super-ED users linked to a tendency to reduce healthcare utilization. The scalability and cost effectiveness of this approach is fertile ground for new research in this under-explored topic.

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State Emergency Department Opioid Guidelines: Current Status

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Introduction: The purpose of this study was to evaluate and categorize current state-sponsored opioid guidelines for the practice of emergency medicine (EM).

Methods: We conducted a comprehensive search of EM-specific opioid prescribing guidelines and/or policies in each state to determine current state involvement in EM opioid prescribing, as well as to evaluate some of the specifics of each guideline or policy. The search was conducted using an online query and a follow-up email request to each state chapter of ACEP.

Results: We found that 17 states had emergency department-specific guidelines. We further organized the guidelines into four categories: limiting prescriptions for opioids with 67 total recommendations; preventing/diverting abuse with 56 total recommendations; addiction-related guidelines with 29 total recommendations; and a community resources section with 24 total recommendations. Our results showed that current state guidelines focus on providers limiting opioid pain prescriptions and vetting patients for possible abuse/diversion.

Conclusion: This study highlights the 17 states that have addressed opioid prescribing guidelines and categorizes their efforts to date. It is hoped that this study will provide the basis for similar efforts in other states. [West J Emerg Med. 2017;18(3)340-344.]

INTRODUCTION

Opioid prescriptions and use are of major concern for both the health profession and the general public. The Centers for Disease Control and Prevention reports that 259 million prescriptions for opioid-pain medications were written in 2012, as well as 16,235 opioid-related deaths in the U.S. in 2013.[1] Headlines featuring opioids fill both general news outlets and medical literature, painting two stories that seem to be at odds with each other and placing the emergency physician (EP) in a nearly untenable position. The need to recognize and manage pain must be balanced with the knowledge that excess opioid prescriptions are leading to a near epidemic in both medication seeking and abuse.[2] This epidemic and its effect on communities across America has been receiving increased attention by the public, being highlighted by multiple media outlets and has recently become a significant topic during the current election cycle.[3]

While this issue confronts all medical providers, emergency medicine (EM) practitioners are at the nexus of the growing use of prescription pain medication and the devastating consequences of opioids, with nearly 43% of emergency department (ED) visits being related to pain.[4] According to one study, there were nearly 750,000 ED visits for opioid overdose alone from 1993-2010, while another reported a 14% increase in the number of opioid prescriptions written in the ED from 1993 – 2005.[5-6]

Use of guidelines has been shown to decrease use of opioid pain medication in minor and chronic complaints in

acute care settings.[7] To help guide the difficult balancing act of adequately and compassionately treating pain while minimizing diversion/abuse of opioid prescriptions from the ED, the American College of Emergency Physicians (ACEP) has established both policy statements and clinical policies regarding the treatment of acute pain and prescribing of opioid pain medications. Other societies, such as the American Academy of Emergency Medicine (AAEM), offer guidelines to aid in the responsible prescribing of opioids for EPs. Just as the majority of state guidelines have significant overlap, we found the various society guidelines to be similar. As part of ACEP's policy statement "Ensuring Emergency Department Patient Access to Adequate and Appropriate Pain Treatment (2012)," ACEP leaves it to the individual state chapters to establish guidelines and/or protocols for the treatment of pain in the ED.[8] Establishment of these guidelines and protocols can assist EM providers in treating pain in a safe and reasonable manner.

Population Health Research Capsule

What do we already know about this issue?
The opioid epidemic has had devastating effects. As emergency physicians we are on the front line, forced to address acute and chronic pain in a conscientious manner.

What was the research question?
Are state guidelines available to help facilitate emergency physicians' appropriate use of opioids?

What was the major finding of the study?
Only a few states offer opioid robust guidelines that aid the care of patients in the emergency department.

How does this improve population health?
With robust established guidelines, emergency physicians will be better equipped to use and prescribe opioids appropriately and efficiently.

METHODS

We conducted a directed but simple search of EM-specific opioid-prescribing guidelines and/or policies in each state to determine current state involvement in EM opioid prescribing, as well as to evaluate some of the specifics of each guideline or policy. The search was conducted using an online query and a follow-up email request to each state chapter of ACEP. To perform the online search we used the term "ED opioid guidelines" and "emergency department opioid guidelines" for each state (e.g. "Ohio ED opioid guidelines) and evaluated the links that the search returned using the Google search engine. The District of Columbia, Puerto Rico, and national Government Services were omitted from this search as we focused on state-specific guidelines. To standardize the search we limited analysis to the first four pages of results, noting that 91% of online searchers do not click past the first page of search results.[9] Within these parameters, we identified any guideline that pertained to the ED, whether produced by the state itself or a society/chapter. In addition, we directly contacted each state ACEP chapter executive director by email requesting this same information and sent a second, follow-up email two weeks later. Of the states that had both online search hits and an email response, we did not find significant conflicting information. Only results that specifically pertained to the ED, EM providers or that addressed the treatment of acute pain were considered relevant to this study. We organized all results into a spreadsheet, grouped by type of guideline.

RESULTS

We found that 17 states had ED-specific guidelines based on our online search and email inquiry. A total of 20 states responded to the email query; of those, 11 had clear guidelines (AZ, CA, DE, HI, NY, OH, OK, OR, PA, RI, WA), an additional four had policy statements or more vague recommendations (KY, NC, TX, WV), and five had no recommendations (CO, MI, NE, NJ, VA). We further organized these into four categories, sorting each category by the most frequently recommended guidelines. For initial categorization, Washington State's prescribing guidelines were used as the authors were familiar with this guideline and felt it to be a good representation of a comprehensive guideline at this time. We added additional categories that were common across multiple states. The table is a summary of the overall results, displaying which guidelines were recommended by each state. In the Limiting Prescriptions for Opioids section (67 total recommendations), prescribing short-acting formulations and using only short courses were the most recommended guideline. The Preventing/Diverting Abuse (59 total recommendations) sections had frequent recommendations for avoiding replacement of lost prescriptions, utilization of prescription-drug monitoring programs, and requirements for government-issued ID to receive an opioid prescription. Addiction-related guidelines (34 total recommendations) encouraged screening tools and avoidance of methadone distribution to patients. Finally, the Community Resources section (24 total recommendations) had suggestions for care coordination programs, educational information for patients, and maintaining a list of available clinics in the community.

Table. The 17 U.S. states with emergency department (ED) opioid prescribing guidelines. (The remaining 33 states did not have ED-specific opioid prescribing guidelines listed online or received from their ACEP chapters at the time this research was conducted.)

	AZ	AR	CA	DE	FL	HI	MD	ME	MN	NY	OH	OK	OR	PA	RI	UT	WA	Total
Limiting Rx for opioids																		
Only prescribe a short course	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	16
Use short-acting formulations	X	X	X	X		X	X			X	X	X	X	X	X	X	X	14
Parenteral is discouraged for acute exacerbation of chronic pain	X	X	X	X		X		X			X	X	X		X		X	11
Start with lowest effective dose	X					X	X			X		X		X	X	X		8
Meperidine is discouraged	X	X		X							X		X				X	6
Address chronic pain with non-opioids			X						X	X		X		X				5
Avoid opioids with benzodiazepines						X			X	X		X						4
Preventing abuse/diversion																		
Lost Rx- do NOT replace		X	X	X		X	X	X		X	X	X	X	X	X		X	13
Use Rx drug monitoring programs	X		X			X	X	X	X		X	X	X	X	X		X	12
ED Rx should require government ID	X	X	X					X			X		X		X		X	8
Patient should not receive Rx from multiple providers				X			X	X					X	X	X		X	7
Dispense only the amount needed until pharmacy or PCP office opens	X	X										X		X	X		X	6
ED should photograph pain patients without government ID	X	X						X			X						X	5
Utilize ED information exchange programs																	X	1
Addiction related																		
Should not provide methadone for patients in treatment programs	X	X	X	X		X	X				X		X				X	9
Assess for misuse/addiction with a screening tool	X		X				X	X	X	X		X	X				X	9
Perform urine drug screen if suspicion	X							X	X		X							4
ED should receive pain agreements		X				X											X	3
Encourage/Assist patients in seeking detox														X	X			2
Community																		
ED should use a care coordination program	X	X		X		X		X	X								X	7
Provide patient education information						X	X			X		X	X	X				6
Maintain list of clinics	X	X									X		X				X	5
Reference ACEP Clinical Policy on state site					X							X	X		X			4

Rx, prescription; *ED,* emergency department; *ID,* identification.

Limiting Prescribing of Opioids

This category provided EPs with advice on limiting the number, strength and duration of action of opioids being prescribed. All states combined had 67 different guidelines referring to limiting the prescribing of opioids.

Preventing/Diverting Abuse

The second category included state attempts to limit diversion or abuse of opioids by ED patients. All states combined had 59 different guidelines referring to preventing and diverting abuse of opioids.

Addiction-Related

The third category includes various items related to known, suspected or occult misuse or addiction, including both abuse screening and management for known substance abusers. There were 34 guidelines in this category across all of the states.

Community Resources

Lastly, ED integration with existing community resources was addressed by all the states with 24 guidelines combined between them. Washington State has been a leader in establishing state guidelines on opiates, and had the most guidelines of any state, numbering 16.[10] Arizona and Oregon were next, with 14 each (Table). Arkansas and Ohio rounded out the top five states, with 12 each.

DISCUSSION

The number of prescribed opioids and deaths related to their use has moved to the forefront of mainstream media, and found their way into both state and federal political discussions. It is important to note that while ED opioid prescribing has risen, the bulk of the opioid problem is due to long-acting or extended-release formulations used in treatment of chronic pain.[6,11] These agents are rarely prescribed in the ED, likely because the majority of painful conditions seen in the ED are acute in nature.[12]

ACEP and AAEM, as well as many other organizations, have been aggressive in the formation of policy and recommendations in regard to EP opioid prescribing and have encouraged individual states to do the same. These investigators found that although several organizations have made recommendations, many states have yet to implement any guidelines. The reasons for this are unknown, nor is it known whether local state ACEP chapters helped to contribute to the overall ACEP guidelines. The authors believe that ACEP likely encouraged individual states to create their own guidelines in an effort to help solidify a universal proper approach, give ED practitioners a second resource, and to help continue to increase awareness of the opioid problem.

The idea behind the simple search parameters was that this theoretically should be something easily accessible and discoverable by practitioners who are seeking the resource. The lack of easily identifiable guidelines via online search was concerning. For a topic that is becoming as mainstream as opioid prescribing, the authors felt that if the most generic search could not find the guidelines then they would not be used in clinical practice.

Review of the guidelines showed that most states were able to craft guideline language that, while discouraging prescription of opioids in the ED, maintained EP professional judgment and autonomy to best address the very real need of their patients in pain. However, a minority of states had ED-specific guidelines, and our research demonstrated that only 17 states had created such guidelines. While most states developed guidelines affecting all providers, these authors found they established relatively few guidelines that would impact EM providers in any meaningful way due to their focus on chronic pain therapy. These chronic-pain prescribing guidelines have been shown to reduce opioid prescriptions, and with proper planning and execution, acute pain guidelines may be able to accomplish the same.[13]

Future research should focus on comparing states that have ED-specific opioid guidelines to those states that have broad guidelines or lack guidelines completely and how these differences possibly impact the rising opioid epidemic. We are not aware of any literature on the exact impact of awareness, prescribing method changes or adherence to guidelines in states that have only national guidelines versus those with state-specific guidelines. Further investigating the comparative impact of opioid prescribing patterns between primary care, inpatient care, and emergency care could help further define the need for ED-specific prescribing patterns.

LIMITATIONS

There are several limitations of this study. First, there could be states with guidelines that were not easily found via online search or were not provided to us upon request to the ACEP chapters. It is possible that our online search parameters were inadequate or not specific enough to discover the state guidelines. Finally, we only looked at state ACEP guidelines and did not include any states that may have opioid prescribing guidelines from other EM organizations (i.e., AAEM).

CONCLUSION

This study highlights the various ways in which states have approached opioid prescribing guidelines and categorizes their efforts to date. It is hoped that this study will provide a rational basis for similar efforts in other states or on the federal level.

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Cross-Sectional Study of Risky Substance Use by Injured Emergency Department Patients

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Introduction: Survey data regarding the prevalence of risky substance use in the emergency department (ED) is not consistent. The objective of this study was to identify the prevalence of risky substance use among injured ED patients based on the Alcohol, Smoking and Substance Involvement Screening Test (ASSIST v3.0). A secondary objective was to report on the feasibility of administering the ASSIST to this population, based on the time to conduct screening.

Methods: This cross-sectional study used screening data from a randomized controlled trial. Injured ED patients completed the ASSIST on a tablet computer, and an ASSIST score was computed that indicated the need for a brief or intensive treatment intervention (risky use) for alcohol and other substances. For a subsample, data on time to complete each step of screening was recorded.

Results: Between July 2010 and March 2013, 5,695 patients completed the ASSIST. Most (92%) reported lifetime use of at least one substance and 51% reported current risky use of at least one substance. Mean time to complete the ASSIST was 5.4 minutes and screening was considered feasible even when paused for clinical care to proceed.

Conclusion: Estimates of risky substance use based on the ASSIST in our large sample of injured ED patients were higher than previously reported in other studies of ED patients, possibly due to the current focus on an injured population. In addition, it was feasible to administer the ASSIST to patients in the course of their clinical care. [West J Emerg Med. 2017;18(3)345-348.]

INTRODUCTION

The emergency department (ED) is an opportune setting for identifying patients with substance use problems. ED patients have higher rates of alcohol and drug use than the general population,[1] with injured patients in particular reporting increased rates of alcohol misuse.[2] Screening in the ED is recommended for alcohol use,[3-5] and screening for other substances is an area of current research interest.[6,7] Survey data regarding the prevalence of risky substance use has been assessed in two single-site studies in inner-city EDs, which found substantial differences in the prevalence of risky substance use (15%[8] vs. 34%[9]). These differences, however, may reflect differences in the measures used to determine risky substance use rather than the rates themselves.

The Alcohol, Smoking and Substance Involvement Screening Test (ASSIST v3.0) was developed by the World Health Organization (WHO) to assess substance use in general medical settings and classify use as low, moderate, or high risk.[10] It has been used successfully to screen patients in the ED for substance use interventions.[11,12] Because there are outside directives to provide screening in the ED for many substances included in the ASSIST, such as alcohol, tobacco, and opioids, demonstrating the feasibility of screening with the ASSIST in the ED setting is important to show that it

can be done efficiently with a validated measure despite the difficulties inherent to screening in this setting. The objective of the current study was to describe the prevalence of substance use based on the ASSIST among injured ED patients. A further goal was to describe the feasibility of screening ED populations using the ASSIST given the inherent limitations on studying such patients contemporaneously.

METHODS

This observational, cross-sectional study was nested within a randomized controlled trial registered at ClinicalTrials.gov (NCT01326169).[12] Trained research assistants (RAs) screened patients in two EDs in a northeastern U.S. city. One was a Level I trauma center with 105,000 patient visits/year, of which 29% are admitted, with an average patient age of 52, 11% Hispanic/Latino, and 75% white, 14% black, and 11% other race; and the second was an academic community hospital with 55,000 patient visits/year, of which 28% are admitted, with an average patient age of 46, 20% Hispanic/Latino, and 65% white, 16% black, and 19% other race. During shifts that involved all days and times, RAs approached patients following a predetermined, randomly ordered list of treatment rooms. More recruitment shifts occurred at the Level I trauma center (61%), weekends were oversampled due to high patient volume (32% of shifts), and few shifts were scheduled between 11:30 p.m. and 7:30 a.m. (1%) due to difficulty staffing them. The RAs screened the patients' medical records to identify patients eligible for verbal consent for additional screening. Inclusion criteria were presenting to the ED for an injury, age ≥18 years, English-speaking, medically stable, not admitted to the hospital, and not combative, intoxicated, or in police custody. Additional eligibility criteria pertinent to the trial were ascertained: confirmation that they identified as injured, not homeless, and had access to a telephone. Eligible participants completed the ASSIST on a tablet computer. The ASSIST has been adapted for administration via tablet computer in a prior ED-based study.[13] The current analysis includes all participants who completed the ASSIST as part of screening for the parent trial.

For a convenience sample of 15 day and evening recruiting shifts a second RA partnered with the screening RA to record the length of time for screening with the ASSIST. The institutional review board for both hospitals approved the study and patients received no financial incentives for completing the ASSIST. Our reporting of the conduct, data analysis and interpretation of the results of this cross-sectional study is consistent with the "Strengthening the Report of Observational Studies in Epidemiology" statement.[14]

Measures

The ASSIST has been found to have acceptable validity for assessing psychoactive substance use.[10] A current specific substance involvement score is calculated for each substance by summing responses to six questions about prior three-month use, psychological dependence, harmful use, and lifetime and recent problems related to its use. Responses of "don't know" or "refuse to answer" were given a value of 0. For all substances but alcohol, a score of 4 – 26 indicates moderate-risk use/abuse and an associated recommendation for a brief intervention; for alcohol, the corresponding range is a score of 11 – 26. For all substances, a score of 27 – 39 indicates high-risk use/dependence and an associated recommendation of a more intensive treatment intervention.[10] A final question asks if injection drugs have been used; a positive response indicates high-risk substance use. Time data was collected using a stopwatch and recorded.

Statistical Analyses

We calculated the mean and standard deviation for each substance's specific involvement score using SAS 9.3 (Cary, NC). The mean, standard deviation, minimum, and maximum were calculated for each component of the time analysis using Microsoft Excel (Redmond, WA).

RESULTS

Between July 2010 and March 2013, 9,788 patients were approached for screening; 5,695 completed the ASSIST. Reasons for not completing the ASSIST (see Supplemental Figure) were not meeting eligibility criteria (n=2,405) or refusing consent (n=1,688). More patients (72%) were approached for screening at the Level I trauma center than the academic community hospital, reflecting the greater volume of patients seen at the Level I trauma center. Two participants had insufficient data to calculate an ASSIST score for any substance. Substance use was common in this population, with only 434 (8%) reporting no lifetime use of any psychoactive substance (Table). Overall, 51% of participants reported moderate- or high-risk use of at least one substance. Among patients reporting risky substance use, 80% were indicated for brief intervention and 20% for more intensive treatment. Findings differed slightly by site; fewer participants at the Level I trauma center reported low-risk use (48% vs 51% at the community hospital) and more reported moderate-risk use (42% vs 40% at the community hospital) or high-risk use (10% vs 9% at the community hospital) ($p<0.01$).

Time data for screening was collected for 191 participants (see Supplemental Table). The average time to complete the ASSIST was 5.4 minutes (standard deviation 4.0 minutes). Of the participants who completed the ASSIST, 13 (18.6%) had to pause completing the ASSIST to allow for their clinical care to proceed. The average time of the pause for these 13 patients was 26.4 minutes (standard deviation 35.6 minutes), with a minimum of one minute and a maximum of 115 minutes.

DISCUSSION

Alcohol and other substance use has consistently been documented among injured ED patients.[8,9,15,16] Findings from this study using the ASSIST indicate that not only is substance

Table. Distribution of risky substance use among injured patients screened in the emergency department (N=5,695).

Substance	High-risk use	Moderate-risk use	Low-risk use	No lifetime use
Tobacco	6.17 (5.54,6.79)	34.28 (33.04,35.51)	25.37 (24.23,26.50)	34.19 (32.96,35.42)
Alcohol	3.48 (3.01,3.96)	14.32 (13.41,15.23)	70.21 (69.03,71.40)	11.98 (11.14,12.83)
Cannabis	2.21 (1.83,2.59)	19.29 (18.27,20.32)	31.08 (29.87,32.28)	47.42 (46.12,48.72)
Cocaine	0.78 (0.55,1.00)	3.23 (2.77,3.69)	14.13 (13.23,15.04)	81.86 (80.86,82.87)
Opioids	0.60 (0.40,0.80)	2.25 (1.87,2.64)	4.25 (3.72,4.77)	92.90 (92.23,93.57)
Amphetamines	0.28 (0.14,0.42)	2.61 (2.19,3.02)	10.17 (9.38,10.95)	86.94 (86.07,87.82)
Hallucinogens	0.09 (0.01,0.17)	1.55 (1.23,1.88)	12.55 (11.69,13.41)	85.81 (84.9,86.72)
Sedatives	0.06 (0,0.12)	1.03 (0.76,1.30)	3.18 (2.71,3.66)	95.73 (95.19,96.28)
Inhalants	0	0.32 (0.17,0.46)	2.59 (2.18,3.00)	97.09 (96.66,97.53)

All values are % (95% confidence interval).

use common among injured ED patients, but half (51%) of all patients receive ASSIST scores indicating the need for a treatment intervention. Blow et al. (2011) screened 14,557 adults presenting to an urban ED with medical complaints or injuries using the Substance Abuse Outcomes Module (SAOM) and found that 34% of patients reported risky substance use. Among injured patients, 38% needed intervention or treatment, demonstrating more risky substance use among injured patients. Hankin et al. (2013) screened 19,055 urban ED patients with either medical complaints or injuries using a modified version of the ASSIST and found that 28% of patients reported binge alcohol use or other drug use and, of those, 56% (15% of all patients screened) reported risky substance use. This is a much lower prevalence than found in the current analysis or by Blow et al. (2011). However, they modified screening by only administering the ASSIST to participants reporting prior 12-month use of tobacco, illicit drugs, or binge alcohol use and asking about the prior 30 days rather than the prior three months, both of which could have resulted in false negatives.[8] Thus, their study is not representative of the ASSIST as a comprehensive substance-use screening tool in the ED as it was designed. We used the ASSIST as designed and validated by the WHO in a similar ED setting and found a much higher prevalence of risky substance use indicating the need for a treatment intervention, more similar to findings based on screening with the SAOM. These findings highlight the prevalence of substance misuse in an ED injured population and the importance of screening for, developing and offering substance misuse treatment resources to ED patients.

Finally, the time data for the administration of the ASSIST in the ED is very encouraging. Participants completed the ASSIST on the low end of the expected range of 5-10 minutes,[17] despite being administered in a busy clinical setting. Less than one-fifth of patients paused their screening due to clinical care and even in the case of a long pause, as might happen when a patient needs imaging or other ED medical intervention, the patient was able to resume and complete the ASSIST. This demonstrates that the ASSIST may be a useful tool for both research and clinical programs conducting screening for risky substance use in the ED.

LIMITATIONS

Limitations of the current study include the refusal rate (23% of those eligible) and the lack of other substance use measures to facilitate comparison to other studies. In addition, very few shifts covered overnight hours between 11:30 pm and 8:00 am. Also, patients who were critically injured or intoxicated for the duration of the RA's shift could not be screened and patients reporting homelessness or lack of access to a telephone did not complete the ASSIST. Overall, nearly 22% of patients could not be screened due to not meeting study criteria and many of them were likely risky substance users such as those who were intoxicated. Findings are based on self-report and so may be subject to recall and social desirability biases. These all might suggest that the true prevalence of risky substance use is higher than previously estimated in this population. Finally, the ASSIST was completed on tablet computers, which may have positively impacted the completion time and ability to pause for interruptions but may not be available in all EDs.

Strengths of this study include the completion of the ASSIST as developed by the WHO by all injured patients who provided consent. It also included both a Level I trauma center and a smaller academic community hospital, demonstrating that trauma centers may have a slightly higher prevalence of risky substance use but both locations see a large volume of patients who may be indicated for a treatment intervention.

CONCLUSION

Our findings show that the rate of substance use among injured ED patients is high and screening for substance use in the ED with the ASSIST is feasible and produces similar, albeit somewhat higher, results compared to other screening tools.

This study demonstrates the feasibility of using the ASSIST in the ED setting, which may allow EDs to collect local substance-use data for multiple substances that could help determine what community referral resources and hospital-based programs are needed. The higher proportions of risky substance use found in this study may be due to differences in injured patients, i.e., that substance use is more heavily implicated in injured versus non-injured ED patient populations.

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Outcomes by Mode of Transport of ST Elevation MI Patients in the United Arab Emirates

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Introduction: The purpose of this multicenter study was to assess differences in demographics, medical history, treatment times, and follow-up status among patients with ST-elevation myocardial infarction (STEMI), who were transported to the hospital by emergency medical services (EMS) or by private vehicle, or were transferred from other medical facilities.

Methods: This multicenter study involved the collection of both retrospective and prospective data from 455 patients admitted to four hospitals in Abu Dhabi. We collected electronic medical records from EMS and hospitals, and conducted interviews with patients in person or via telephone. Chi-square tests and Kruskal–Wallis tests were used to examine differences in variables by mode of transportation.

Results: Results indicated significant differences in modes of transportation when considering symptom-onset-to-balloon time ($p < 0.001$), door-to-balloon time ($p < 0.001$), and health status at six-month and one-year follow-up ($p < 0.001$). Median times (interquartile range) for patients transported by EMS, private vehicle, or transferred from an outside facility were as follows: symptom-onset-to-balloon time in hours, 3.1 (1.8-4.3), 3.2 (2.1–5.3), and 4.5 (3.0–7.5), respectively; door-to-balloon time in minutes, 70 (48–78), 81 (64–105), and 62 (46–77), respectively. In all cases, EMS transportation was associated with a shorter time to treatment than other modes of transportation. However, the EMS group experienced greater rates of in-hospital events, including cardiac arrest and mortality, than the private transport group.

Conclusion: Our results contribute data supporting EMS transportation for patients with acute coronary syndrome. Although a lack of follow-up data made it difficult to draw conclusions about long-term outcomes, our findings clearly indicate that EMS transportation can speed time to treatment, including time to balloon inflation, potentially reducing readmission and adverse events. We conclude that future efforts should focus on encouraging the use of EMS and improving transfer practices. Such efforts could improve outcomes for patients presenting with STEMI. [West J Emerg Med. 2017;18(3)349-355.]

INTRODUCTION

Acute coronary syndrome (ACS) is a leading cause of morbidity and mortality worldwide,[1] with approximately half of these deaths occurring in the prehospital setting.[2] For patients presenting with ST-elevation myocardial infarction (STEMI), percutaneous coronary intervention (PCI) is recommended.[3] The short- and long-term mortality of STEMI patients can be reduced with PCI and coronary artery bypass grafting (CABG),[4] with studies suggesting that primary PCI reduces mortality and major adverse cardiovascular events, when compared with thrombolytic therapy.[5,6] The updated 2015 guidelines of the American College of Cardiology/ American Heart Association (ACC/AHA) and the 2013 guidelines from the European Society of Cardiology recommend a door-to-balloon (D2B) time of less than 90 minutes.[6,7] When this goal is met, PCI for STEMI reduces mortality and morbidity.[8]

Advanced prehospital management by emergency medical services (EMS) plays a crucial role in facilitating access to care and reducing mortality rates for STEMI patients.[7-11] Studies have shown that transport by EMS is associated with quicker treatment, including shorter symptom-onset-to-arrival time and door-to-reperfusion time, when compared to private transport.[12,13] Several studies have found that among patients who underwent emergency angiography, D2B times were shorter in EMS-transported patients.[13-15]

With EMS transport, treatment decisions can be made more quickly and effectively, as EMS can perform a prehospital electrocardiogram (ECG) and alert the hospital that the patient is en route, thereby minimizing door-to-reperfusion times.[16-20] Prehospital ECG may also detect signs of transient ischemia and arrhythmias, which may no longer be present when the patient receives the first in-hospital ECG.[21,22]

The purpose of this multicenter study was to assess differences in patient demographics, medical history, symptoms, treatment times, and follow-up status among patients transported via EMS vs. those using private transport or those who were transferred from other medical facilities.

Population Health Research Capsule

What do we already know about this issue?
In the Middle East, EMS is underutilized and despite improvements in cardiac care, patient education about signs and symptoms of ACS, and the importance of EMS use is inadequate

What was the research question?
Does the mode of transport for care of patients with ACS affect clinical outcomes?

What was the major finding of the study?
EMS use was associated with shorter treatment times and potentially reduced adverse outcomes in the hospital events and readmission.

How does this improve population health?
This study highlights the benefits of using EMS in ACS care and could raise awareness and potentially increase EMS use in the Middle East.

METHODS

Sample and Study Setting

This study was set in the Emirate of Abu Dhabi, United Arab Emirates (UAE), where both government and private hospitals provide cardiac catheterization services. Government hospitals are operated by the Abu Dhabi Health Services Company, while the EMS is operated by the Abu Dhabi Police Emergency and Public Safety Department and staffed by paramedics and EMT's. For patients with suspected ACS, 12-lead ECG is performed and interpreted by paramedics. This interpretation involves paramedics activating the receiving hospital catheterization lab through a central activation number. Patients who are transferred by EMS from non-PCI centers receive advanced life-support care, including cardiac care (e.g. arrhythmia management), but the responsibility for catheterization lab activation lies within the inter-hospital transfer pathway, and not the EMS.

Procedures

This was a retrospective review of EMS and hospital data. Data obtained through chart review were supplemented with prospectively collected follow-up data. The study was conducted over a period of 18 months, with follow-up interviews at 30 days, six months, and one year after initial discharge. We recorded mode of transport (EMS, private, or transferred from other medical facility) and in-hospital events for each patient, using electronic medical records from both EMS and hospitals. Data included sex, age, past medical history (including history of 11 related conditions, such as hypertension, angina, diabetes mellitus types 1 and 2, and stroke), time of arrival, pain on arrival, door-to-ECG time, door-to-catheterization lab arrival time, D2B time, symptom-onset-to-balloon-inflation time (total ischemic time), hospital events (including eight related events such as bypass surgery, reinfarction, and mortality), 30-day follow-up status, six-month follow-up status, and one-year follow-up status.

Statistical Analysis

Sample descriptive statistics are reported elsewhere.[23] We calculated inferential statistics to determine whether significant differences existed between EMS-transported and privately transported patients with respect to the variables of interest. The Kruskal–Wallis rank test was used to estimate differences in continuous variables (door-to-first ECG, door-to-catheterization lab arrival, D2B time, and symptom-onset-to-balloon time) between modes of transportation. All other variables were categorical and were compared with chi-squared tests of independence. We performed all analyses using SPSS Version 22.0 (IBM Corporation, Armonk, NY, USA). All p values ≤ 0.05 were considered significant.

RESULTS

Demographics and History

We enrolled 455 consecutive patients with STEMI treated at four public hospitals in Abu Dhabi. A minority of patients (n = 53, 12%) arrived via EMS, and the remainder via private transport (n = 274, 60%) or were transferred from other facilities (n = 128, 28%). The majority of patients were male (94%), and half (52%) were active smokers. The average age was 51 ± 11 years, with 13% of patients younger than 40 years.

We observed no significant differences with respect to in-hospital events and discharge outcomes according to age (p = 0.121). No significant differences were noted in variables of health history according to mode of transportation, indicating that previous conditions did not affect the choice of transportation method.

Patients who arrived via private transportation were significantly more likely (p = 0.005) to arrive after hours (between 5 p.m. and 8 a.m. or on weekends). Other modes of transportation were approximately equal with respect to after-hours arrival.

For all modes of transportation, a high percentage (97%) of patients reported experiencing pain on arrival. We observed no significant differences in pain on arrival as a predictor of mode of transport among the groups (p = 0.16).

Time to Treatment

Door-to-ECG time was available for all patients, with the median time being four minutes (interquartile range [IQR] two to seven minutes). At the time of this study, a 12-lead ECG was repeated for all patients in triage, prior to transport to the catheterization lab. The median door-to-ECG time was significantly higher for patients who used private transportation and EMS (both five minutes; IQR 2-8 and 2-6, respectively) than for transfer patients (four minutes) (p = 0.005). A door-to-ECG time of 10 minutes or less was achieved in 89% (n = 405) of patients. It is important to note that patients were also transferred from smaller clinic-type centers, requiring confirmation of STEMI, thereby justifying the rationale for adding door-to-ECG as a variable.

Door-to-catheterization lab arrival time data were available for 99% (n = 450) of patients. We found that privately transported patients had the longest door-to-catheterization lab arrival time (median = 74 minutes); this duration was significantly higher than that noted for EMS or transfer patients (p < 0.001). There was no significant difference observed for door-to-catheterization lab arrival times between EMS-transported and transfer patients (median = 45 minutes [28, 69] and 36 minutes [23, 55], respectively) (p= 0.462).

D2B time data were available for 96% (n = 438) of patients, with 76% (n = 334) of patients having a D2B time of 90 minutes or less. Privately transported patients had the longest D2B time (median = 81 minutes [64, 105]), which was statistically significant when compared to other modes of transportation (p < 0.001). We observed no significant difference between EMS and transfer patient D2B times (median = 70 minutes [48,89] and 62 minutes [46,77], respectively). Results related to treatment times are summarized in Table 1.

There were significant differences between modes of transport with respect to symptom-onset-to-balloon times (p < 0.001). Patients transferred from other medical facilities had the highest symptom-onset-to-balloon time (median = 4.5 hours [IQR 3.0–7.5]). Patients transported by EMS (median = 3.1 hours [IQR 1.8–4.3]) and privately (median = 3.2 hours [IQR 2.1–5.3]) had significantly shorter symptom-onset-to-balloon times (Table 2).

In-Hospital Events and Follow-Up

Data for in-hospital events were available for 97% of patients. For the entire cohort, the rates of in-hospital events were as follows: cardiac arrest, 8.0% (n = 37); intra-aortic balloon pump, 5.6% (n = 26); CABG, 3.7% (n = 17); death, 3.2% (n = 15); in-stent thrombus, 1.1% (n = 5); stroke, 0.6% (n = 3); reinfarction, 0.2% (n = 1); bleeding, 0.2% (n = 1).

We observed a significant difference between the three modes of transportation with regards to the percentage of patients who required bypass surgery during their hospital stay (p = 0.017). Of the 17 patients who required bypass surgery, 11.3% arrived via EMS, 2.6% arrived by private transport, and 3.1% were transferred (Table 3).

We did not observe any significant differences with respect to transportation when considering any of the seven other in-hospital events studied. Patient follow-up status was categorized as follows: (1) no data or missing record; (2) home at follow-up; (3) readmitted to the catheterization lab since last follow-up; and (4) new disease event (includes reinfarction, stroke, and angina) or death since last follow-up. These statistics should not be confused with discharge-to-home status after the initial STEMI event; such discharge data are not available for the present study. There were no significant differences in health status at 30-day follow-up, with 75.4% of patients at home.

Table 1. Statistics from door-to-ECG, door-to-catheterization lab, and door-to-balloon time in a study examining how mode of transportation affected clinical outcomes in STEMI patients.

Variable	Mode	N[a]	Median (IQR[b])	p
Door-to-ECG				
	EMS	53	5 (2, 6)	0.005
	Private	274	5 (2, 8)	
	Transfer	128	4(2, 6)	
Door-to-catheterization lab arrival				
	EMS	51	45 (28, 69)	< 0.001
	Private	274	74 (55, 96)	
	Transfer	125	36 (23, 55)	
D2B				
	EMS	49	70 (48, 89)	< 0.001
	Private	265	81 (64, 105)	
	Transfer	124	62 (46, 77)	

D2B, door-to-balloon; *ECG*, electrocardiogram; *EMS*, emergency medical services; *IQR*, interquartile range; *STEMI*, ST-elevation myocardial infarction.
[a]Data were not available for all patients.[b] Interquartile range (first quartile, third quartile).

Table 2. Symptom-onset-to-balloon time according to mode of transportation to the emergency department.

Mode	N[a]	Median	IQR[b]	Min	Max	p
EMS	49	3.1	1.8, 4.3	1.1	24	< 0.001
Private	268	3.2	2.1, 5.3	0.9	16.3	
Transfer	128	4.5	3.0, 7.5	1.5	19.0	

EMS, emergency medical services; *IQR*, interquartile range.
[a]Data were not available for all patients.[b] Interquartile range (first quartile, third quartile).

Table 3. Cross-tabulation for mode of transport and in-hospital events (n = 455).

Event	EMS[a]	Private	Transfer	Total	p
CABG	6 (11.3%)	7 (2.6%)	4 (3.1%)	17 (3.7%)	0.017
IABP	5 (9.4%)	16 (5.8%)	4 (3.1%)	26 (5.7%)	0.296
REINF	0 (0%)	1 (0.4%)	0 (0%)	1 (0.2%)	0.875
Bleed	0 (0 %)	1 (0.4%)	0 (0%)	1 (0.2%)	0.875
Stent throm	1 (1.9%)	3 (1.1%)	1 (0.8%)	5 (1.1%)	0.915
Stroke	1 (1.9%)	2 (0.7%)	0 (0%)	3 (0.7%)	0.536
Arrest	7 (13.2%)	23 (8.4%)	7 (5.5%)	37 (8.1%)	0.281
Death	4 (7.5%)	7 (2.6%)	4 (3.1%)	15 (3.3%)	0.282

EMS, emergency medical services; *CABG*, coronary artery bypass grafting; *IABP*, intra-aortic balloon pump; *REINF*, reinfarction; *Bleed*, any kind of bleed; *Stent Throm*, formation of an in-stent thrombus; *Arrest*, cardiac arrest.
[a]Column values indicate the number of individuals from each corresponding mode of transport to experience a given in-hospital event, with the percentage indicating the proportion these individuals represent within each mode of transport.

Differences in at-home status between the modes of transportation were significant ($p < 0.001$). Of the 390 patients available for follow-up at six months (85.7% of the original sample), 268 (58.9%) were at home and 21 (4.6%) had been readmitted since the 30-day follow-up. Of the patients originally transported via EMS, 18 (34.0% of EMS sample) were at home at the six-month follow-up, compared to 180 of those privately transported (65.7% of private transport sample) and 70 of those originally transferred (54.7%). These differences were significant ($p < 0.001$).

At the one-year follow-up, such observations remained consistent, but with fewer follow-up records available. Of the patients originally transported via EMS, 20.8% were at home (79.2% of records unavailable), compared with 52.2% of those privately transported (41.2% of records unavailable) and 34.3% of those originally transferred (62.5% of records unavailable). These differences were significant ($p < 0.001$).

At the one-year follow-up of patients originally transported privately, 13 had been readmitted between six months and one year after the initial treatment; one transfer patient and no EMS-transported patients exhibited similar readmission. This difference could, however, reflect the decreased availability of data for the EMS and transfer groups. Results from 30-day and one-year follow-ups are summarized in Table 4. All follow-up data are provided for completeness, despite a considerable loss to follow-up at one year.

DISCUSSION

In this prospective, multicenter study of patients presenting with STEMI to a large network of public hospitals in Abu Dhabi, we observed that time-sensitive processes of care differed significantly according to the mode of transportation to the ED. Overall, total ischemic time (symptom-onset-to-balloon) was shortest among patients arriving by EMS, and longest among those transferred from other facilities.

While in-hospital processes (door-to-ECG, catheterization lab, and balloon times) were shortest among those transferred from outside facilities, these were offset by longer prehospital transfer times. Patients transported by EMS experienced a total ischemic time that was 1.4 hours (84 minutes) shorter than those transferred from elsewhere. Additionally, D2B and door-to-catheterization lab arrival times were 11 and 20 minutes shorter, respectively, among EMS-transported patients than privately transported patients; these differences were statistically significant.

These results are consistent with previous research showing that EMS transport is associated with shorter symptom-onset-to-hospital arrival and D2B times.[12,13] Although there was also a statistically significant difference in door-to-ECG times when comparing transferred patients to non-transferred (EMS and private), this difference amounted to only one minute. These findings highlight the need to improve prehospital transport networks for patients with STEMI, in addition to efforts that aim to streamline the in-hospital processes of care.

This finding is especially interesting in the context of the 2015 updated guidelines from the ACC/AHA, which recommend transferring STEMI patients promptly to achieve a D2B time of less than 90 minutes from arrival at the initial facility.[6] Although all groups in this study had median D2B times within this recommended range, the 84-minute difference when considering time-to-balloon inflation from symptom onset shows that the mode of transportation is an important variable for timely STEMI care. This is most important among patients who must be transferred from non-PCI capable facilities.

It is worth noting that the rates of in-hospital events, including cardiac arrest and mortality, were higher among the EMS group than among the privately transported group. This finding is, perhaps, partly accounted for by the relatively sicker population that EMS is likely to engage; younger, healthier patients with the ability to transport themselves privately may constitute a higher percentage of privately transported patients. Hence, the older and sicker EMS group may have been at a greater initial risk for poorer outcomes.

Table 4. Cross-tabulation for mode of transport and 30-day and one-year status (n = 455).

	30-day			1-year		
	EMS	Private	Transfer	EMS	Private	Transfer
Death	0 (0 %)	0 (0%)	1 (0.8%)	0 (0 %)	5 (1.8%)	3 (2.3%)
Readmission	1 (1.9%)	19 (6.9%)	15 (11.1%)	0(0%)	6 (2.2%)	0 (0%)
Reinfarction	0 (0 %)	12 (2.4%)	0 (0 %)	0(0%)	6 (2.2%)	0 (0%)
Lost to follow-up	16 (30.2%)	60 (21.9%)	8 (6.2%)	42 (79.2)	105 (38.3%)	74 (57.8%)

EMS, emergency medical services.

Statuses (e.g., stroke) not listed were not relevant to any patients at follow-up. [a]Column values indicate the number of patients exhibiting the relevant status at a given follow-up duration. All percentages reflect original, not follow-up, sample sizes.

Owing to the nature of the data collected, however, this hypothesis cannot be confirmed; future research is required to understand the difference in outcomes observed in this study. Similarly, the follow-up results provide little room for clear interpretation, owing to the large percentage of loss to follow-up.

It is important to promote the use of EMS, particularly for ACS, among the general public, especially given recent findings indicating an underuse of EMS among ACS patients in the Arabian Gulf region.[24,25] Other findings made in this study with respect to specific trends of EMS use may be relevant in the promotion of EMS. Privately transported patients were more likely to arrive after hours (i.e., at night and on weekends). Existing research suggests that cardiac patients may be reluctant to bother EMS providers, and tend to wait to seek treatment until they are certain that their symptoms warrant medical attention. Such observations could explain our findings with respect to after-hours EMS use; indeed, reluctance to engage EMS providers is likely to be exacerbated outside of normal business hours.[26]

Another possible explanation of this finding is an increased tendency to visit EDs during times when primary care physicians are unavailable, suggesting a lack of access to after-hours care for non-emergent medical concerns.[27] However, given that all patients in this study had STEMI and that there was no significant difference in the proportion of patients who reported pain on arrival, this possibility is unlikely for our sample. Therefore, improving public utilization of after-hours EMS could reduce time to reperfusion among ACS patients.

Additionally, facilities without interventional cardiology services urgently need to improve policies for the transfer of STEMI patients. Al Habib et al. recently emphasized the fact that, in the Arabian Gulf region, many of the vehicles used to transfer patients from primary care clinics to hospitals lack the equipment and personnel necessary to provide adequate prehospital ACS care.[24]

In the UAE, the setting of the present study, medical services are more developed than in many areas of the region, suggesting that these issues may also need to be addressed outside the urban area. Without organized systems to provide prehospital ACS care, the existence of PCI-capable facilities may not lead to associated improvements in ACS outcomes. In particular, in countries where EMS services are new or newly developing, public awareness and perception of EMS resources may lag behind actual service availability.

Researchers elsewhere noted that, when transferring patients to PCI centers for treatment, the time required to begin the transfer can significantly delay the overall time to treatment.[28] Our findings clearly show that transfer practices to government-operated hospitals in Abu Dhabi should be improved to ensure adequate care for STEMI patients. Increased resource availability and training of professionals qualified for prehospital ACS treatment and diagnosis could lead to reduced treatment times and improved outcomes. Better transfer practices, including faster recognition and transfer policies, are urgently needed.

LIMITATIONS

Our data are subject to limitations, which should be accounted for when interpreting the findings. Notably, many patients in the original sample were unavailable for follow-up, making it difficult to draw conclusions regarding the long-term impact of the differences observed. Additionally, when considering transfer patients, we did not record the source or reason for transfer. These factors could affect both transportation decisions and treatment times. Medical professionals should consider such factors when making transfer and transportation decisions. Further, EMS use for coronary symptoms should be encouraged among the general public to improve the quality of clinical outcomes for patients presenting with STEMI.

CONCLUSION

We observed significantly lower time from symptom onset to hospital arrival and PCI balloon inflation among patients transported by EMS when compared with those transported privately or transferred from another facility. These findings support previous research showing that EMS care of ACS patients facilitates a more efficient delivery of care. Future efforts to promote the use of prehospital ECG are still needed.

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Impact of Health Policy Changes on Emergency Medicine in Maryland Stratified by Socioeconomic Status

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Introduction: On January 1, 2014, the financing and delivery of healthcare in the state of Maryland (MD) profoundly changed. The insurance provisions of the Patient Protection and Affordable Care Act (ACA) began implementation and a major revision of MD's Medicare waiver ushered in a Global Budget Revenue (GBR) structure for hospital reimbursement. Our objective was to analyze the impact of these policy changes on emergency department (ED) utilization, hospitalization practices, insurance profiles, and professional revenue. We stratified our analysis by the socioeconomic status (SES) of the ED patient population.

Methods: We collected monthly mean data including patient volume, hospitalization percentages, payer mix, and professional revenue from January 2013 through December 2015 from a convenience sample of 11 EDs in Maryland. Using regression models, we compared each of the variables 18 months after the policy changes and a six-month washout period to the year prior to ACA/GBR implementation. We included the median income of each ED's patient population as an explanatory variable and stratified our results by SES.

Results: Our 11 EDs saw an annualized volume of 399,310 patient visits during the study period. This ranged from a mean of 41 daily visits in the lowest volume rural ED to 171 in the highest volume suburban ED. After ACA/GBR, ED volumes were unchanged (95% confidence interval [CI] [-1.58-1.24], p=.817). Hospitalization percentages decreased significantly by 1.9% from 17.2% to 15.3% (95% CI [-2.47%-1.38%], p<.001). The percentage of uninsured patients decreased from 20.4% to 11.9%.This 8.5% change was significant (95% CI [-9.20%-7.80%], p<.001). The professional revenue per relative value unit increased significantly by $3.97 (95% CI [3.20-4.74], p<.001). When stratified by the median patient income of each ED, changes in each outcome were significantly more pronounced in EDs of lower SES.

Conclusion: Health policy changes at the federal and state levels have resulted in significant changes to emergency medicine practice and finances in MD. Admission and observation percentages have been reduced, fewer patients are uninsured, and professional revenue has increased. All changes are significantly more pronounced in EDs with patients of lower SES. [West J Emerg Med. 2017;18(3)356-365.]

INTRODUCTION

Background

On January 1, 2014, the financing and delivery of healthcare in the state of Maryland changed profoundly. Four important provisions of the Affordable Care Act (ACA) were implemented on that day: guaranteed issue of health insurance to all citizens regardless of pre-existing medical conditions; the expansion of access to Medicaid coverage to individuals earning up to 138% of the federal poverty level; the provision of income-based tax credits and subsidies for the purchase of health insurance; and the requirement for all U.S. citizens to obtain qualified health insurance coverage.[1] Ten days later, a major revision to the Maryland Medicare waiver was announced, with the explicit goal of transforming the state's healthcare delivery system from a volume-based fee-for-service model to a value-based population health model. The new waiver ushered in a global budget revenue (GBR) structure for hospital reimbursement.[2] These two major policy changes substantially and uniquely affected emergency department (ED) finances and clinical operations in Maryland.

The ACA has two overarching objectives. The first is to increase access to healthcare through the establishment of health insurance exchanges and Medicaid programs. The second is to reform the healthcare delivery system so as to decrease the growth rate in spending and improve the quality of care. The first objective has an immediate effect as people matriculate into health insurance exchanges. The second goal is complex and involves mechanisms such as incentivizing reduction in Medicare readmissions, hospital-acquired conditions, and payment structures emphasizing value over volume.[3]

The state of Maryland is geographically diverse, with urban, suburban, and rural populations. Between 2011 and 2013, median household incomes ranged from $32,997 in rural Somerset County to $107,452 in suburban Howard County.[4]

The Maryland Medicare waiver is the result of legislation passed in 1977, which exempts the state from the Inpatient and Outpatient Prospective Payment Systems. It also allows the state's Health Services Cost Review Commission (HSCRC) to set hospital rates that Medicare and all other insurance companies must pay.[5] Important goals of the all-payer concept are to distribute the burden of uncompensated care throughout the state, provide robust support for graduate medical education, and control costs. The waiver was contingent upon keeping the cost per Medicare admission below the national average. The waiver revision was necessary because at that time the total hospital costs per Medicare beneficiary had grown significantly in Maryland. In 2014, the revised waiver created an all-payer global budget model that caps total hospital revenue growth at rates related to the gross state product and converted hospital reimbursement from a volume-based model to a value-based model. Under GBR the hospital's margin is the difference between the global budget cap and actual expenses. Each admission no longer improves the hospital's bottom line. To increase margins, hospitals have to manage the health of the populations they serve in the lowest cost settings and minimize expenditures associated with hospital stays. To maintain the waiver, Maryland must reduce the rate of growth of hospital costs per Medicare beneficiary below the national average. Consistent with the ACA, other metrics of success include reductions in the incidence of hospital-acquired conditions and the number of Medicare readmissions.[5] Health policy experts at the Centers for Medicare and Medicaid Services (CMS) and in Maryland anticipate that the success of the new Maryland waiver will serve as a national model for other states interested in an all-payer system.[2,6,7]

Population Health Research Capsule

What do we already know about this issue?
The insurance provisions of the Affordable Care Act were implemented in 2014. Maryland revised its Medicare waiver in 2014 creating a Global Budget Revenue model for acute care hospitals.

What was the research question?
How did these federal and state policy changes affect emergency department volumes, payer mix, hospitalizations, and finances?

What was the major finding of the study?
Volumes were unchanged; rates of uninsured patients decreased; hospitalization percentages decreased; revenue increased.

How does this improve population health?
Increased percentages of emergency patients have insurance and receive care in outpatient settings. These findings were greater in practices serving patients of lower socioeconomic status.

Importance

Emergency physicians (EP) have a critical role in healthcare utilization, as they make or participate in decisions regarding the disposition of more than half of all patients admitted to acute care hospitals.[8] Because of this integral role in hospital patient care and resource utilization, it is clear that major policy changes affecting hospitals have substantial impact on ED practice.

Goals of This Investigation

Our primary objective was to study the impact of the ACA and GBR on ED utilization, insurance profiles, professional reimbursement, and hospitalization practices in Maryland. We stratified our analysis by the socioeconomic status (SES) of each ED population involved in this analysis to better understand the differential impact of these changes. We hypothesized that the impact of policy changes would be more pronounced in EDs located in lower SES communities.

METHODS

Study Design

We performed a retrospective pre/post-intervention study with a washout period.

Study Population

We examined a convenience sample of 11 EDs in Maryland, representing a cross-section of locations, sizes, and median incomes. Our study sites ranged from low-volume rural EDs to urban academic EDs. The rural sites are three EDs located on the Eastern Shore of MD. One of the three is a freestanding facility. The urban EDs are located in Baltimore City. One is a large academic institution. Two are lower volume inner-city EDs. One of the study sites is a large county ED located in a Washington, DC, suburb. Our suburban study sites are located in northern and central MD. One is a freestanding facility. Using regression models and before-and-after comparisons, we analyzed the impact of new health financing policies on Maryland's EDs.

Data Source and Management

We collected monthly volume and admissions data from the health information systems of the 11 EDs. Revenue and payer-mix data were obtained from monthly billing company reports. We analyzed data from January 2013 to December 2015 (encompassing the 12 months preceding the January 1, 2014 ACA/GBR implementation and the subsequent 24 months). For our analysis, we considered the six-month period from January 1, 2014 through June 30, 2014 a washout period. Our study compared the 18 months from July 1, 2014, through December 31, 2015, to calendar year 2013. Collected information included visit volume, hospitalization defined as the combined admission/observation rate, revenue per relative value unit (RPRVU), and payer mix (percent uninsured, percent Medicaid, percent private insurance, percent Medicare).

We defined visit volume as the total number of registered ED visits in each study site. This number was collected monthly from each ED's information system and divided by the number of days in the month and reported as mean visits per day. We calculated the hospitalization rate by taking the sum of the number of ED patients admitted to the hospital or placed in an observation status and dividing that total by the number of ED visits for the month.

The RPRVU reflects professional revenue. In the study practices, the professional coding is done by trained coders who assign evaluation and management levels and procedure codes based on provider documentation. The RVUs are calculated from the codes based on the Center for Medicare and Medicaid's RVU weighting for each code. The RPRVU is a calculation based on total charges for a given month multiplied by the estimated collection percentage for each practice and divided by the total number of RVUs. The estimated collection percentage reflects historical experience with that practice.

We performed the payer-mix calculations by taking the total number of visits associated with each insurance category per month and dividing that number by the total number of visits for the month.

In our freestanding EDs, the hospitalization volume was calculated from the number of patients transferred to area hospitals for inpatient care. We calculated the median income of each ED's catchment area, using 2010 census data for ZIP code income. The study was considered non-human subjects research, which does not require institutional review board approval at our institution.

Data Analysis

We used multiple regression models to determine the effect of ACA/GBR implementation on hospital financial and operational performance. Outcome measures were regressed on a binary indicator variable that indicated whether or not ACA/GBR had been implemented. We controlled for differences between hospitals by including a set of dummy variables for each of them. The regression equation used for each outcome has the form –

$$\text{Outcome}=\beta_0+\beta_1\ \text{ACA}+\beta\ \text{Facility}$$

-- where Outcome is the outcome of interest (e.g., RPRVU, admission rate, un-insurance rate, etc.), β_0 is the intercept, β_1 is the estimated effect for the ACA implementation, ACA is an indicator variable that is 1 in months January 2014 and after, and 0 before, β is a vector of coefficients for each ED, and Facility is a vector of facility indicator variables.

To ensure that the results we obtained were not simply the continuation of pre-existing trends, we regressed the outcome variables on the baseline year of data, calendar year 2013, for each of the outcomes of interest. We then compared the outcomes in 2014 to what the value would have been had the 2013 trends continued. In most cases the 2013 trends were small, so differences were not significant.

To examine the potential differential impact of ACA/GBR implementation, we explored whether the SES of the patient population was an effect modifier. For this analysis, we used the estimated median income of each ED's catchment area. For each site, we recorded the 10 ZIP codes with the highest percentages of patients and the percent of patients from each of those ZIP codes. We computed a weighted average of the

median income from the 2010 U.S. census of each of those ZIP codes to produce a measure of the median income for the patient population for each ED. We included the median income of the ED population as an explanatory variable and interacted it with ACA/GBR implementation to seek differences in ED outcomes based on the income of the catchment area. When SES is included, the regression equation becomes –

Outcome=β_0+β_1 ACA+β_2 ACA Median Income+ β Facility -- where Median Income is the weighted average of the median income of the catchment area and β_2 is the interaction effect.

RESULTS

The 11 EDs saw an annualized volume of 399,310 visits during 2013 through 2015, ranging from a mean of 41 daily visits in the lowest-volume rural ED to 171 in the highest-volume suburban ED.

With regard to number of ED visits over the study period before and after the policy changes, our regression analysis found no significant relationship between ACA/GBR implementation and ED volume (Figure 1, Table 1s). The average volume per hospital went down by .17 patients per day per site (95% confidence interval [CI] [-1.58, 1.24], p=.817). However, before the policy change there had been a small volume decrease that flattened out after. As a result, the relative increase in ED volume of 16.6 (15.184, 17.954) patients reached statistical significance on a trend-adjusted basis. (Table 2s).

In an analysis of the impact of ACA/GBR implementation on the percentage of patients hospitalized, we found that rates decreased significantly after July 1, 2014 (95% CI: (-1.80%, -0.80%), p<.001) (Figure 2, Table 3s). When controlling for the pre-implementation trend, the decrease is still statistically significant (95% CI [-2.47%, -1.38%], p<.001). The admission rate was 1.9 percentage points lower than in the previous year. The mean hospitalization rate dropped from 17.2% to 15.3%, an 11% relative reduction.

Our analysis of the percentage of uninsured ED patients before and after the implementation of the ACA/GBR is given in Figure 3 and Table 4s. The rate of uninsured patients decreased by a statistically significant 8.5 percentage points (95% CI [-9.20%, -7.80%], p<.001). Before implementation of the ACA, the average ED month had 20.4% uninsured patients. After implementation, the rate was 11.9%, a relative reduction of 42%. The percentage of patients covered by Medicaid increased by 8.5% (95% CI [7.7%, 9.2%], p<.001), the percentage covered by Medicare increased by 0.9% (95% CI [0.6%, 1.2%], p<.001), and the percentage with private insurance decreased by 1.9% (95% CI [-2.5%, -1.2%], p<.001).

Regression analysis of the professional RPRVU over the study period shows a mean increase of $3.97 (95% CI [3.20, 4.74], p<.001) after implementation of the ACA/GBR as seen in Figure 4 and Table 5s. This increase represents a statistically significant 10.7% change.

An alternative explanation for the fact that we see changes in outcomes after January 1, 2014, is that there is a preexisting trend that simply continues throughout the entire observation period. Looking specifically at the baseline period, the 12 months prior to implementation of the policy changes, we found no statistically significant trends in either revenue per RVU (95% CI [-0.14, 0.22], p=0.65), the percent uninsured (95% CI [-0.01, 0.20], p=0.07), or percent admitted (95% CI [-.002, 0.12], p=.06). Regardless, we ran the regressions again, correcting for these possible underlying trends, shown in Table 2s. Although not statistically significant, in the case of uninsured rate and admission rates, the trend that we see is in the opposite direction of the effect observed after January 1, 2014. If anything, our estimates of the effects are underestimating the true underlying effect. We did see one significant trend in 2013: ED volume was decreasing. This trend flattened during the study period.

Turning to the moderating effect of SES on our results, we found that the interaction of median catchment area income and ACA/GBR implementation was statistically significant in each model. The median annual incomes of the catchment areas of the 11 EDs ranged from a low of $22,900 to a high of $70,000 (Table). The changes in each outcome are more pronounced for ED populations with lower median incomes. Figure 5 shows the expected change in outcome for an ED of a given income level. A 57% decrease in the uninsured rate is expected at an ED with a catchment area median income of $25,000, but only a 22% decrease at one with a median income of $70,000. The lower the income of the catchment area, the greater the expected increase in RPRVU. We estimated a 10% increase in RPRVU for a hospital with a catchment area median income of $25,000 but predicted no change at an ED with a median income of $70,000. Admission rates decreased the most at poorer hospitals as well, ranging from a decrease of 22% to no significant change.

Table. Emergency department (ED) and median income weighted by ED catchment Zip codes.

Hospital	Income
Hospital A	$23,616
Hospital B	$70,041
Hospital C	$56,337
Hospital D	$45,808
Hospital E	$31,192
Hospital F	$40,242
Hospital G	$56,716
Hospital H	$22,909
Hospital I	$58,028
Hospital J	$45,556
Hospital K	$26,307

DISCUSSION

Our study reports on the impact of the ACA and GBR policy changes implemented simultaneously at the state and federal levels, on EDs in Maryland. We found that ED volumes experienced a small, significant increase only on a trend-adjusted basis. Hospitalizations significantly decreased and the percentage of patients with insurance significantly increased, as did professional revenue.

A stated goal of both the ACA and GBR was to reduce the number of ED visits.[9-11] During the first 18 months of the new policies, we found minimal change in the volumes of patients using emergency services in Maryland. In contrast, after insurance coverage was expanded in Oregon and Massachusetts, ED use increased, particularly during the first-year transition from no insurance to Medicaid coverage.[12,13] Because of GBR, unique to Maryland, it is possible that newly insured patients are receiving more care in settings such as urgent care centers, outpatient clinics, physicians' offices, and patient-centered medical homes.[14,15]

The structure of the new policies in the federal healthcare exchanges is another reason that the ACA may result in lower utilization of healthcare services, including the ED. High deductibles and co-payments are features of the plans with the lowest premiums. The lowest-cost bronze plans have annual deductibles that exceed $5,000 for individuals and $10,000 for families. In contrast, deductibles in employer-provided insurance plans average $1,135. These high out-of-pocket costs might have had a suppressive effect on ED utilization particularly among

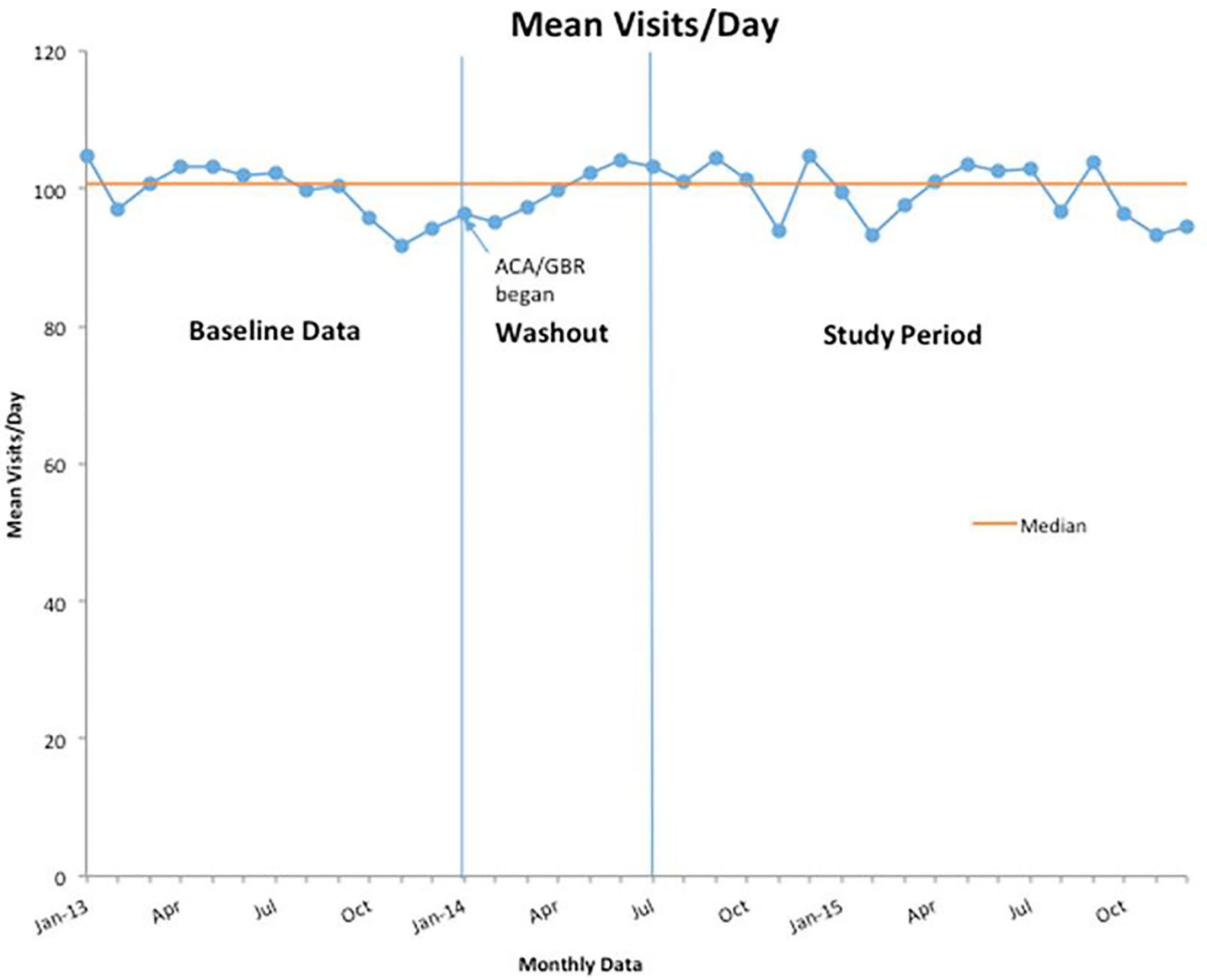

Figure 1. Run chart of monthly mean emergency department visits per day from baseline year through study period. *ACA,* Affordable Care Act; *GBR,* global budget revenue.

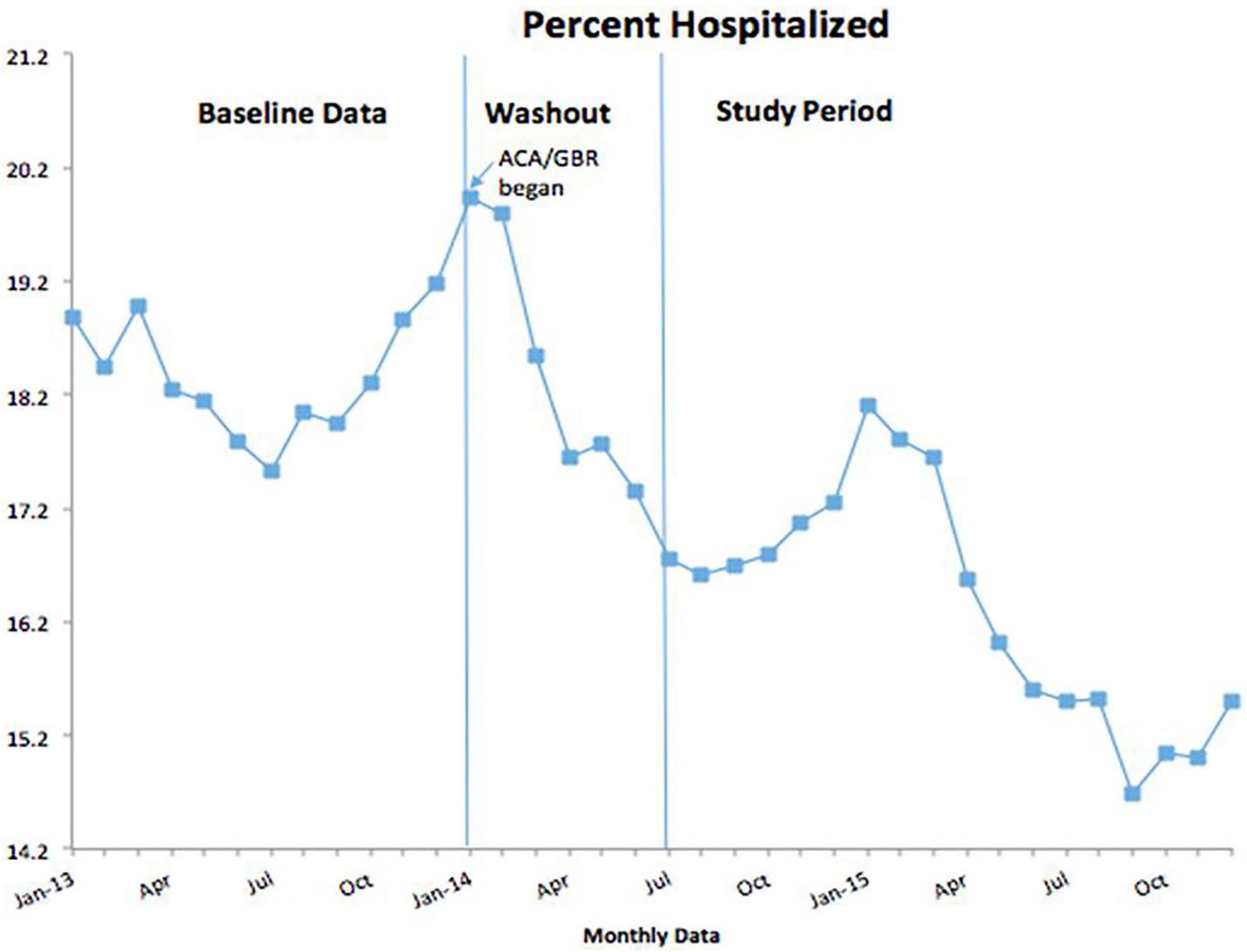

Figure 2. Run chart of the percentage of patients hospitalized from baseline year through study period.
ACA, Affordable Care Act; *GBR,* global budget revenue.

patients transitioning from plans with lower first-dollar costs.[16]

Examining the impact of policy changes on hospitalization practices, we found that EPs in Maryland decreased their use of inpatient resources by an absolute 1.3% and a relative decrease of 8.2%. An analysis of one large multi-state nonprofit hospital system, which compared hospital admissions before and after implementation of the ACA coverage expansions in 2014, showed a relative decrease of 2.4% in hospital admissions across the system.[17] However, striking differences by payer were evident. Medicaid admissions increased by 7.4% in Medicaid expansion states and by 1.4% in non-expansion states. This suggests that the significant decline in inpatient utilization by ED patients in Maryland, a Medicaid expansion state, is more heavily influenced by GBR than ACA.[18] When examining the data in relation to SES, we noted a significantly greater impact on less-affluent patient populations (Figure 5).

Maryland EP groups have been important partners with hospitals in striving for success under GBR. This partnership is critically important, because EPs have a direct impact on half of all hospital admissions.[8] The design and implementation of care plans for high utilizers of ED services are showing promising results with respect to decreasing hospital admissions, observations, and resource utilization.[19,20]

Another important approach is the application of evidence-based risk-stratification tools designed to decrease variations in EP practices, a source of potentially avoidable utilization (PAU).[21,22] These tools include the Pneumonia Severity Index and its associated Pneumonia Outcomes Research Trial (PORT) score.[23] The work of Peterson and colleagues on the identification of high-risk characteristics of patients with soft-tissue infections anticipates the development of a risk stratification tool.[24] An EP group in Maryland has taken the lead in implementing the

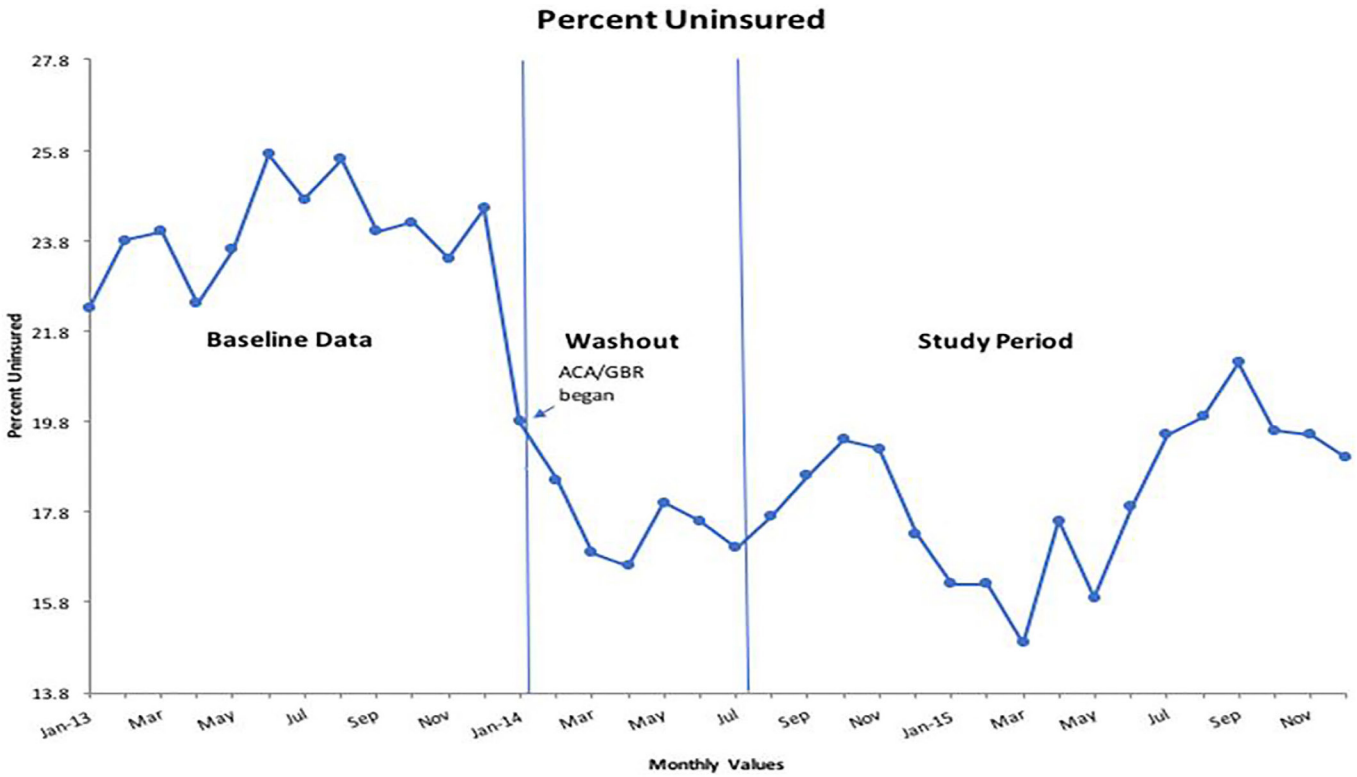

Figure 3. Run chart of the percentage of uninsured patients from baseline year through study period.
ACA, Affordable Care Act; *GBR,* global budget revenue.

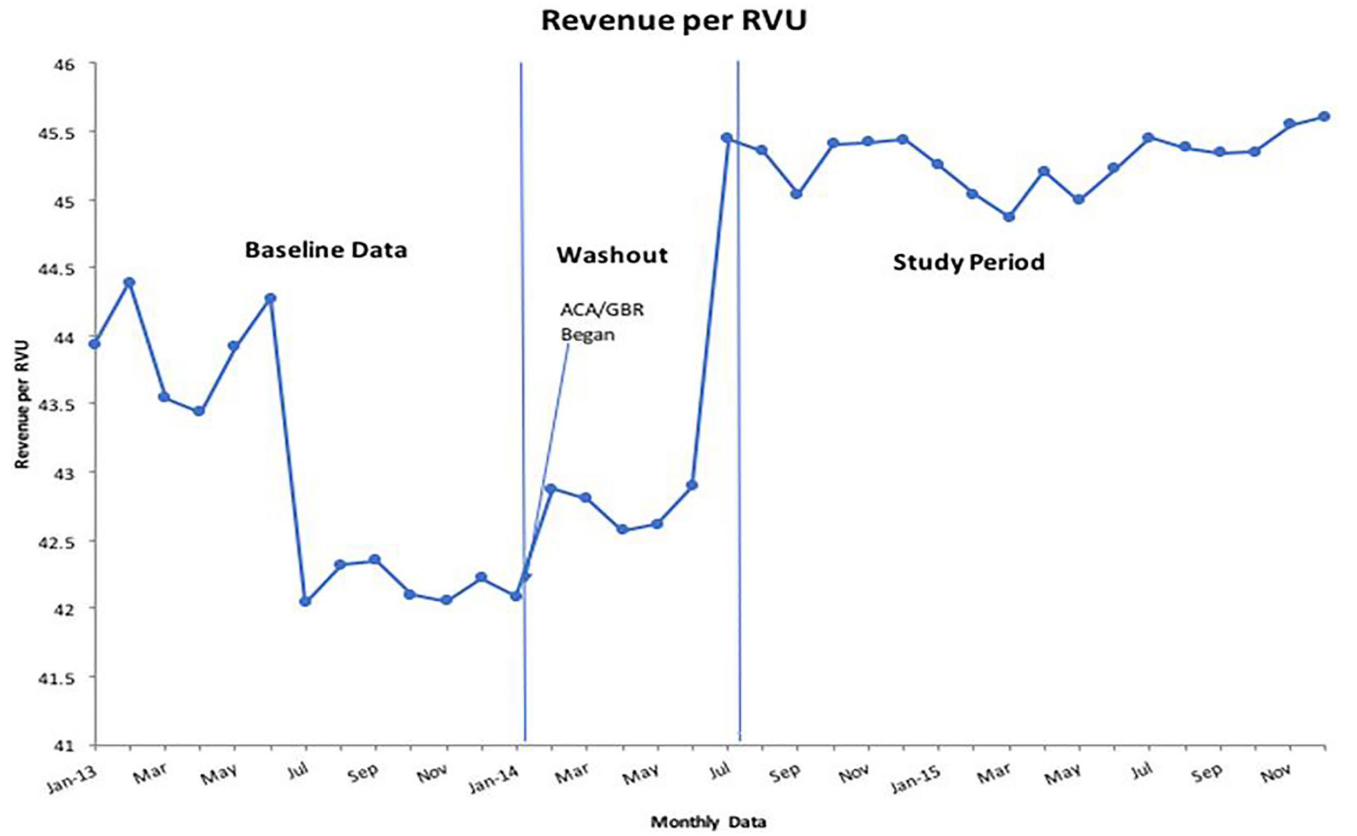

Figure 4. Run chart of the revenue per relative value unit from baseline year through study period.
RVU, Relative Value Unit

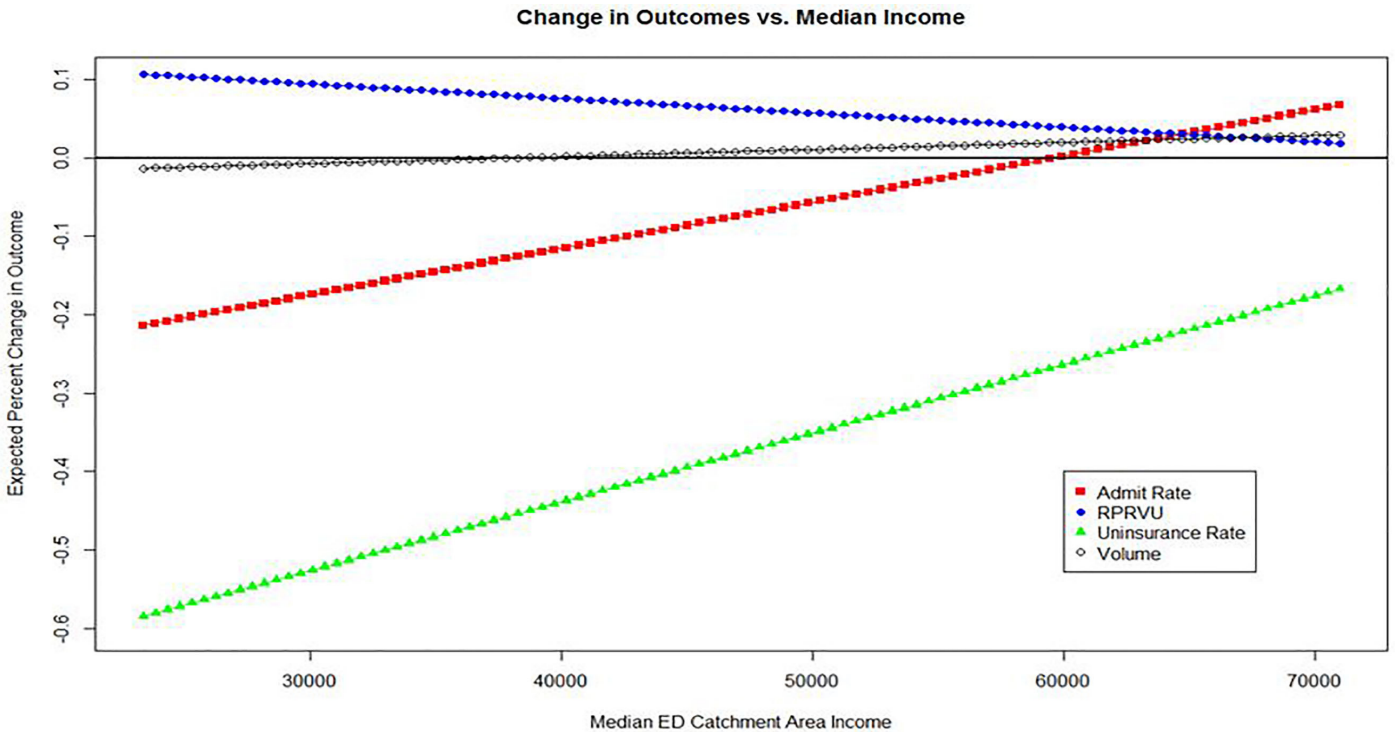

Figure 5. Expected percent changes in outcome vs. median ED income.
ED, Emergency department; *RPVU,* revenue per relative value unit.

HEART score, a protocol that uses the validated prediction rule for low-risk chest pain patients. This score has proven to be a powerful tool for decreasing variation in physician practice and minimizing PAU.[25-27] Similarly, Maryland EPs have incorporated the Choosing Wisely guidelines compiled by the American College of Emergency Physicians into their practices.[28] Emphasis has also been placed on adherence to guidelines for the workup of patients in whom pulmonary emboli are suspected, using a framework that incorporates pulmonary embolism rule-out criteria (PERC) and the stratification of patients into low-, medium-, and high-risk categories.[29-31] We surmise that the increased use of observation status for short-stay patients is the result of EPs' attempts to decrease admission/readmission rates, in accordance with CMS payment policies; this trend has been observed elsewhere in the country.[32]

With respect to the greater impact of policy changes on less affluent communities, hospitals and health systems have been incentivized by the GBR structure to meaningfully improve access to outpatient resources and follow-up care. Examples include the establishment of a wound and soft-tissue clinic that can be used for follow-up appointments by all ED patients with skin pathology, regardless of their insurance status. Enhanced mechanisms that expedite patient follow-up with primary care, cardiology, orthopedics, and mental health practices or clinics have been developed. These include the ability of ED personnel to schedule specific expedited appointments around the clock without having to page or call the referral office or provider. The increase in the number of patients with insurance coverage improves the financial viability of these new endeavors. Newly insured patients now have access to resources once available only to more affluent populations.

We found a statistically significant improvement in the insurance profile of ED patients in Maryland. Most of the change can be attributed to the transition of previously uninsured patients to Medicaid coverage. There was a spectrum of outcomes, with the greatest changes in EDs with the lowest SES and the least significant changes in the most affluent communities. Similarly, the RPRVU increased significantly more in the low SES practices. These financial improvements are directly attributable to the ACA. It is important to note that GBR is strictly a hospital initiative at this time and does not include physician revenue. Revenue improvements have been particularly important in Maryland, where physician reimbursement from insurance companies has been notably below national averages.[33] These increases will lead to better physician coverage in these EDs and lower reliance on hospital subsidies. This directly decreases disparities in coverage and care between EDs of higher and lower SES.

LIMITATIONS

Our study is based on a convenience sample of Maryland EDs. According to the 2014 Health Services Cost Review Commission report on ED visits in Maryland, the patient volume of the 11 departments in this study constitutes 16% of the total ED visits in the state. The EDs in this study constitute a cross-section of urban, suburban, and rural locations practicing academic and community medicine. The median income of the communities ranged from just under $23,000 to just over $70,000. Nevertheless, this sample might not be completely representative of the experience of all EDs in the entire state. Similarly, the median income of a community may not represent the SES of those using emergency services.

Maryland is geographically one of the smallest states in the country. Located in the mid-Atlantic, the state has a population of nearly six million residents. The largest city, Baltimore, has 620,000 residents. It is not clear that the impact of health policy in Maryland is generalizable to other states, particularly those with substantially larger cities and different demographics.

Because the ACA and GBR were implemented simultaneously, it is difficult to separate the impact of the federal program from the state program. Our study was not designed to specifically attribute the changes in ED practice to one policy or the other. We did not study clinical outcomes in this analysis and cannot relate increased insurance coverage or decreased hospitalization to the quality of care provided.

Our analysis is an early look at the ramifications of significant policy changes. Initiatives of this magnitude might require longer time frames to achieve policy goals. It is certainly possible that ED volumes and hospitalization percentages will change as hospitals and health systems continue to transition to population health. It will be important to continue to analyze the system as patients' use patterns change based on their access to insurance and resources.

We looked at a select number of outcome measures in our analysis. Other important effects of ACA/GBR are also worthy of analysis to attain a more complete understanding of the impact on Maryland ED patients. We strongly believe that continued research is indicated.

CONCLUSION

The simultaneous implementation of health policy changes at the federal and state levels in Maryland is changing the practice of emergency medicine. Fewer patients are now admitted to hospitals or observation units. The percentage of uninsured patients has decreased associated with increased professional revenue. All changes are significantly greater in practices serving populations of lower SES. Further research on the impact of these changes on clinical operations and patient outcomes is warranted.

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Prevalence of Homelessness in the Emergency Department Setting

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Introduction: According to the National Alliance to End Homelessness, the national rate of homelessness has been cited as 17.7 homeless people/10,000 people in the general population, and 24.8 homeless veterans/10,000 veterans in the general population. However, it is unknown what the prevalence of homelessness is in the emergency department (ED) setting. We set out to determine the prevalence of homelessness or at risk for homelessness in the ED setting.

Methods: Using a five-question screening tool derived from the U.S. Department of Housing and Urban Development, Health and Human Services and the Veterans Administration definition for homelessness, we surveyed all patients meeting inclusion/exclusion criteria on scheduled shifts in one of three EDs in Northeastern Pennsylvania. To participate, subjects had to be a registered patient in the ED, be 18 years or older, speak English, have the capacity to answer survey questions, not be critically ill, be willing to participate, and not have taken the survey before. We selected two survey periods to represent seasonal variations.

Results: We included 4,395 subjects in the analysis. The mean age of those who screened positive for homelessness or at risk for homelessness was 43.1 (SD 16.6). Overall, 136 (3.1%) participants screened positive for at risk for homelessness and 309 (7.0%) screened positive for homelessness. A total of 103 subjects (9.8%) screened positive for homelessness or at risk for homelessness on weekends and 312 (10.3%) on weekdays (p=0.64). The proportion of those screening positive for homelessness or at risk for homelessness varied by site: 145 (7.5%) at the trauma center, 151(9.1%) at the suburban site, and 149 (18.7%) at the center city site, p<0.001.There was no statistical significance to the difference between the trauma center and the suburban site (p=.088), but there was statistical significance between both the suburban and the trauma center when compared to the center city site (both p<0.0001). The proportion of those screening positive for homelessness in the summer months (156, 7.5%) was similar to those in the winter months (153, 6.6%), p=0.23.,

Conclusion: In our study, the overall prevalence of homelessness or at risk for homelessness was 10.1 percent. This prevalence did not seem to vary between weekdays and weekends. Additionally, summer months had a prevalence that was as concerning as winter months. The prevalence does, however, seem to vary by institutional characteristics even in the same geographic region. Understanding the patterns of prevalence of homelessness is a step toward considering possible interventions to assist this vulnerable population. [West J Emerg Med. 2017;18(3)366-372.]

INTRODUCTION

Nearly 1.5 million Americans spend at least one night in an emergency shelter or transitional housing each year, and on any given night in the U,S. over 500,000 people are homeless.[1] Homeless people have substantially higher rates of emergency department (ED) and hospital use compared to the general population.[2, 3] Homeless people suffer from serious medical conditions and when hospitalized have longer lengths of stay than patients who are not homeless, which results in excess medical costs.[3] Lack of a common definition of homelessness and our healthcare system's inability for early identification and documentation of homeless patients are barriers to adequately assessing the extent of the problem and subsequent proper care.[4,5]

Homeless patients in the ED may not be easily identifiable on chart review because the patient might often list the address of a shelter, a friend or family member's house, or a fictitious address as their primary residence.[6] The prevalence of homelessness typically cited is usually generated from queries of national databases that rely on self-reporting of homelessness, or data from local shelters to identify the burden of homelessness, which may not adequately assess the issue.[6-8] For example, studies from different time periods that used the National Hospital Ambulatory Care Surveys (NHAMCS-ED) reported only .4%- .6% of the "patient residence" data entries were listed as "homeless."[6,9] One study in the emergency medicine (EM) setting found that EM trainees often relied on visual pattern recognition to identify homeless patients, introducing a type of bias and creating an unreliable way to identify this population.[10]

The optimum way to determine the prevalence of homelessness in the ED setting has not been determined, and thus the magnitude of this problem has not been clearly defined. This is also complicated by resistance by the homeless to self-identify.[11] The existing literature on this topic has proffered and advocated for universal screening as a route to address the medical and social needs of patients who are homeless.[9] We set out to determine the prevalence of homelessness in the ED setting and to explore whether the prevalence varied between seasons (summer and winter) and between weekdays and weekends.

Population Health Research Capsule

What do we already know about this issue?
Homeless people have substantially higher rates of ED and hospital use compared to the general population. However, it is unknown what the prevalence of homelessness is in the ED setting.

What was the research question?
We set out to determine the prevalence of homelessness or at risk for homelessness in the ED setting.

What was the major finding of the study?
The prevalence of homelessness or at risk for homelessness was 10.1% and it did not vary between weekdays/weekends or season.

How does this improve population health?
Understanding the patterns of prevalence of homelessness is a step toward considering possible interventions to assist this vulnerable population.

METHODS

After the institutional review board expedited review and approval, a prospective survey was administered in three EDs in northeastern Pennsylvania. The contributing network hospitals were an inner city hospital with an annual census of over 20,000 visits per year (Site A), a Level I suburban trauma center with an annual census of 100,000 visits per year (Site B), and a suburban hospital with an annual census of 45,000 visits per year (Site C). Site characteristics (payer mix and admission rates) are listed in Table 1.

To participate, subjects had to be a registered patient in the ED, be 18 years or older, speak English, have the capacity to answer survey questions, not be critically ill, be willing to participate, and not have taken the survey before. A five-question screening tool was derived from the U.S. Department of Housing and Urban Development (HUD), Health and

Table 1. Site characteristics (% payer mix and admission) in study examining prevalence of homelessness in the emergency department setting.

Site	Site A (%)	Site B (%)	Site C (%)
Auto	1.18	2.4	1.43
Blues	8.06	22.08	20.85
Commercial	4.86	11.81	11.50
Medicaid	57.07	14.68	22.61
Medicare	13.42	42.04	36.20
Other	.23	.34	.34
Self-pay	14.41	4.69	5.7
Worker's comp	.78	1.89	1.33
Admission rates	6.02	32.29	20.60

Blues, Blue Cross and Blue Shield insurance; *Auto,* automobile; *Worker's comp*; worker's compensation.

Human Services (HHS) and the Veterans Administration (VA) definition for homelessness.[12-14] In order to be used as a discriminatory point on the screening tool for homelessness, the qualification had to be present in at least two of the three definitions. The screening tool consisted of five "Yes" or "No" questions. The first question was a self-identifying question for "at risk" for homelessness, and the remainder of the questions (2-5) were used to screen for homelessness. Specifically subjects were asked, "In the last 60 days have you—":

1. Been concerned about losing your housing
2. Changed residences more than twice*+
3. Lived with a friend or family member you do not normally reside with due to financial hardship^+
4. Been evicted or served an eviction notice*+
5. Slept outside, in an abandoned building, your car, in an emergency shelter, or in a motel due to financial hardship. *^+

(* derived from HUD, ^ derived from HHS, + derived from VA definition[s])

To improve validity, we tested the tool at site A using a convenience sample of patients over a period of four weeks (N=28). In response to feedback from these encounters, minor word changes to allow for better comprehension and reordering of the questions occurred. These results were not included in the study data. Thereafter, the study began and all eligible patients presenting to the ED were approached for study participation on systematically scheduled shifts in each of the three network EDs.

Shifts (either A.M. or P.M.) were the same hours at all three sites and were selected to proportionately represent site location, and evenly represent time of day, and day of the week. Site A had one pod (an area of defined beds cared for by an assigned physician), Site B had four pods, and Site 3 had three pods. Therein, sites with higher volume census have more pods and thus had more data hours for collection represented in the sample. By convenience, survey time periods were chosen to ensure representation of both summer and winter months (May 27-August 6, 2015, and December 3, 2015-February 29, 2016) and to capture seasonal variation. Surveys were administered by study team members (residents and students) who were not blinded to the study goal of determining homelessness prevalence. The primary outcome was the prevalence of homelessness or at risk for homelessness in the ED setting.

Analysis

The survey responses were coded positive for homelessness if subjects responded "yes" to the questions related to changing a residence more than twice, living with a friend of family member, having been evicted or served an eviction notice, or having slept outside or in an abandoned building, car or motel due to financial hardship. Respondents were considered "at risk" for homelessness if they positively responded to the question related to concern about losing housing. Participants who responded positively to the "at risk" question and positively to any of the "homeless" questions were considered homeless, not "at risk."

We summarized the categorical parameters of clinical enrollment site, season (winter versus summer), and time of week (weekday versus weekend) as a proportion of the subject group. Comparisons of the distribution of homelessness or at risk of homelessness by other study variables were made using chi-square. We used logistic regression to assess the association between survey questions and 1) clinical enrollment site, 2) weekday-versus-weekend survey administration, and 3) seasonality. For all models, clinical enrollment "Site B" was used as the referent, since it had the largest enrollment of the three contributing sites. Logistic models incorporated respondent sex and age to help control for potential confounding. We performed all analyses using Stata software v.14.1 (Stata Corporation, College Station, TX).

RESULTS

A total of 7,232 patients were approached for study enrollment. Of these, 2,738 (37.9%) did not participate. The leading reasons for non-participation were that the patient 1) did not meet age requirement (n=847, 31%); 2) did not have capacity (n=654, 24%); 3) refused or not interested (n=350, 13%); 4) did not speak English (n=340, 12%); or 5) was critically ill (n=275, 10%). A total of 4,494 patient evaluations were completed between May 27, 2015, and February 29,2016, on 150 separate screening dates. Of these, we

Table 2. Prevalence of homelessness and "at risk for homelessness" by study site.

Clinical site	At risk n (%)	Homeless n (%)	Total at risk or homeless n (%)	OR (95% CI)	p-value
Site A (n=793)	35 (4.4%)	114 (14.4%)	149 (18.8%)	2.9 (2.2-3.7)	<0.001
Site B (n=1,939)	52 (2.7%)	93 (4.8%)	145 (7.5%)	1.0 (referent)	--
Site C (n=1,663)	49 (2.9%)	102 (6.1%)	151 (9.1%)	1.2 (1.0-1.6)	0.08
Overall	136 (3.1%)	309 (7.0%)	445 (10.1%)		

excluded 99 evaluations due to a respondent reporting taking the survey at an earlier date. The remaining 4,395 evaluations were included in the analysis. A majority of the respondents were female (58.2% n=2,557) and the average participant age was 50.8 years (SD=20.5). After excluding the patients who did not meet eligibility, those who participated in the survey were more likely to be female (63.7% versus 60.1%, p=0.002), older (55.6 versus 50.8 years, p<0.001) and enrolled at Sites A and B, compared to Site C (69.5% and 65.3% versus 45.7%, respectively, p<0.001).

The 4,395 participant evaluations occurred at three different clinical enrollment sites. The plurality of the surveys (n=1,939, 44.1%) were completed at Site B (trauma center) while Site C (suburban hospital) had 1,663 (37.8%) and Site A (inner city hospital) had the fewest (n=793, 18.0%) (Table 2). Participant characteristics differed between enrollment sites. On average, Site A had younger participants, with a mean age of 39.1 (SD=15.6) years, compared to 54.7 (SD=20.8) years for Site B (p<0.001) and 51.8 (SD=20.1) years for Site C (p<0.001). Modest differences in gender distribution were also noted between facilities with 62.8% of Site A respondents being female, compared to 55.4% and 59.2% for Site B (p<0.001) and Site C (p=0.09), respectively. Overall, 10.1% (n=445) of the survey respondents were homeless or at risk of homelessness. The prevalence of homelessness or being at risk differed between clinical enrollment sites. With Site B being the referent population, respondents at Site A were 2.9 times more likely to report being at risk or being homeless (OR=2.9; 95%, confidence interval [CI] [2.2-3.7]).

Responses for the individual screening questions are presented in Table 3. Overall 5.8% (n=255) of participants reported "being concerned about losing their home," while 5% (n=221) reported living with a family member or friend. Fewer respondents reported a change in residence (n=75, 1.7%), being evicted or being served eviction papers (n=66, 1.5%) or sleeping outside or in an abandoned building (n=81, 1.8%).

After controlling for age and gender, we observed significant differences in response between enrollment sites, with participants at Site A (inner city) consistently reporting affirmative responses to each of the five survey questions. With Site B (trauma center) as a referent, participants from Site A were 2.7 times more likely to report changing their address

Table 3. Distribution of survey responses by clinical enrollment site.

		Survey response			
		Yes	No		
Survey question	Clinical enrollment site	n(%)	n(%)	OR (95% CI)*	p-value
Change in residence	Site A	29 (3.7)	764 (96.3)	2.7 (1.54-4.8)	0.001
	Site B	22 (1.1)	1,917 (98.9)		
	Site C	24 (1.4)	1,639 (98.6)	1.2 (0.7-4.9)	0.48
	Total	75 (1.7)	4,320 (98.3)		
Been concerned about losing house	Site A	81 (10.2)	712 (89.8)	2.3 (1.7-3.2)	<0.001
	Site B	82 (4.2)	1,857 (95.8)	referent	--
	Site C	92 (5.5)	1,571 (94.5)	1.3 (0.9-1.8)	0.09
	Total	255 (5.8)	4,140 (94.2)		
Lived with a family member	Site A	87 (11.0)	706 (89.0)	2.8 (2.0-4.0)	<0.001
	Site B	59 (3.0)	1,880 (97.0)	referent	--
	Site C	75 (4.5)	1,588 (95.5)	1.4 (1.0-2.0)	0.06
	Total	221 (5.0)	4,174 (95.0)		
Been evicted or served eviction	Site A	26 (3.3)	767 (96.7)	3.0 (1.6-5.7)	0.001
	Site B	17 (0.9)	1,922 (99.1)	referent	--
	Site C	23 (1.4)	1,640 (98.6)	1.5 (0.8-2.8)	0.2
	Total	66 (1.5)	4,329 (98.5)		
Slept outside or in abandoned building	Site A	38 (4.8)	755 (95.2)	3.1 (1.8-5.4)	<0.001
	Site B	23 (1.2)	1,916 (98.8)	referent	--
	Site C	20 (1.2)	1,643 (98.8)	1.0 (0.5-1.8)	0.9
	Total	81 (1.8)	4,314 (98.2)		

*All odds ratio estimates adjusted for participant age and gender.

Table 4. Distribution of survey questions by time of survey administration (weekday or weekend).

Survey question	Coding	Survey administration timing			OR (95% CI)*	p-value
		Weekday	Weekend	Total		
	No	2,990 (98.4)	1,330 (98.1)	4,320 (98.3)		
	Yes	49 (1.6)	26 (1.9)	75 (1.7)	1.3 (0.8-2.0)	0.37
Been concerned about losing house	No	2,863 (94.2)	1,277 (94.2)	4,140 (94.2)		
	Yes	176 (5.8)	79 (5.8)	255 (5.8)	1.0 (0.8-1.4)	0.76
Lived with a family member	No	2,886 (95.0)	1,288 (95.0)	4,174 (95.0)		
	Yes	153 (5.0)	68 (5.0)	221 (5.0)	1.0 (0.8-1.4)	0.88
Been evicted or served eviction	No	2,993 (98.5)	1,336 (98.5)	4,329 (98.5)		
	Yes	46 (1.5)	20 (1.5)	66 (1.5)	1.0 (0.6-1.7)	0.97
Slept outside or in abandoned building	No	2,980 (98.1)	1,334 (98.4)	4,314 (98.2)		
	Yes	59 (1.9)	22 (1.6)	81 (1.8)	0.9 (0.5-1.4)	0.6

*All odds ratio estimates adjusted for participant age, gender and survey administration location.

Table 5. Distribution of survey questions by season.

Survey question	Coding	Season of survey administration			OR (95% CI)*	P-value
		Winter	Summer	Total		
Change in Residence	No	2,288 (98.6)	2,032 (98.0)	4,320 (98.3)		
	Yes	33 (1.4)	26 (2.0)	75 (1.7)	1.2 (0.8-2.0)	0.35
Been concerned about losing house	No	2,201 (94.8)	1,939 (93.5)	4,140 (94.2)		
	Yes	120 (5.2)	135 (6.5)	255 (5.8)	1.2 (0.9-1.5)	0.28
Lived with a family member	No	2,211 (95.3)	1,963 (94.6)	4,174 (95.0)		
	Yes	110 (4.7)	111 (5.4)	221 (5.0)	1.0 (0.7-1.3)	0.84
Been evicted or served eviction	No	2,286 (98.5)	2,043 (98.5)	4,329 (98.5)		
	Yes	35 (1.5)	31 (1.5)	66 (1.5)	0.9 (0.5-1.4)	0.54
Slept outside or in abandoned building	No	2,286 (98.5)	2,028 (97.8)	4,314 (98.2)		
	Yes	35 (1.5)	46 (2.2)	81 (1.8)	1.2 (0.8-1.9)	0.36

*All odds ratio estimates adjusted for participant age, gender and survey administration location.

(OR=2.7; 95% CI [1.5-4.8]), 2.3 times more likely to report being concerned about losing their home (OR=2.3; 95% CI [1.7-3.2]), 2.8 times more likely to report living with a family member or friend (OR=2.8; 95% CI [2.0-4.0]), 3.0 times more likely to report being evicted (OR=3.0; 95% CI [1.6-5.7]), and 3.1 times more likely to report having slept outside or in an abandoned building (OR=3.1; 95% CI [1.8-5.4]).

The timing of survey administration is presented in Tables 4 and 5. Overall, 69.1% of the surveys were administered on weekdays. We observed no significant differences in the distribution of survey responses between weekday and weekend administration. Overall, 52.8% of surveys (n=2321) were administered in the winter and 47.2% (n=2074) in the summer. Of the 5.8% of the sample who reported being concerned about losing their housing, no significant difference was observed by the season of survey administration with 6.5% of respondents reporting concern in the summer and 5.2% reporting concern in the winter months (OR= 1.2; 95% CI [0.9-1.5]).

DISCUSSION

Lack of a standardized definition for homelessness across medical specialties and settings has been a barrier to the recognition and care of impacted patients.[5] Proper identification of this vulnerable population needs to begin somewhere, and accurate screening in the ED could become an important setting for early interventions.[10] In our study we found the prevalence range of at risk of homelessness or homelessness to vary from 7.5% to 18.8% based on site variability with the urban site having the highest prevalence. This range seemed higher than authors anticipated in context

of the prior studies based on NHAMCS-ED data and in context that the national rate of homelessness has been cited as 17.7 homeless people per 10,000 people in the general population, and 24.8 homeless veterans per 10,000 veterans in the general population.[6-9, 15]

Although the prevalence of homeless patients was higher at the inner city ED (Site A), the trauma center (Site B) and the suburban (Site C) sites both had a higher homelessness prevalence than authors might have perceived, dispelling our own stereotype that homeless patients only present to inner-city facilities. The difference between the positive homeless responses and the season of the year also dispels any potential misunderstanding that homelessness is only an issue during the colder winter months when patients have no warm-shelter provisions. This is also consistent with a study done in England, which found no evidence to suggest that homeless people are more likely to attend the ED in cold weather and actually found a small positive correlation between rate of attendances and daily temperature, somewhat consistent with what our data shows.[16]

Additional implications can be drawn from the lack of statistically significant difference between homeless responses on weekdays or weekends. While there is an abundance of literature about homelessness in the ED, prior work has been more focused on our role as providers, the relationship of homelessness and frequent utilization of resources, excess cost of care for the homeless, and addressing the medical and social needs of the homeless, while our study is unique in its goal of determining prevalence in different ED settings (both urban and suburban). [2-4, 6, 8, 10] As our results demonstrate, homelessness is a concern for healthcare providers year round, regardless of the season, site or day of week. These results provide insight into the prevalence of homelessness in the ED, and contribute to future decisions about the allocation of resources to assist in the care of this population.

In our study, subjects with positive screening for homelessness or "at risk for homelessness" were offered a street medicine consultation. This consult team provides care for the homeless population using an interdisciplinary mobile team approach (physician assistants, doctors, nurses, financial aid planners, etc). They are available for outpatient and inpatient consultations at all three sites and are funded by grants, private donors and institutional support. Of note, consultants anecdotally reported getting engaged earlier in the patients' care if they were admitted (Day zero), and consults placed based on positive screenings during the study time period were all deemed appropriate by the consulting service.

Future research is needed on what benefits detection of homelessness using this screening protocol provides. A cost analysis is vital, especially since our specialty is already overburdened with screening requirements (substance use, domestic violence, fall risk, etc.). Factored into the cost of screening must be actual patient outcomes, the potential money saved in the healthcare system, and at homeless shelters and the many other factors impacted by homelessness. The benefits of implementing this type of universal screening for homelessness in the ED setting must be considered in context of the potential cost savings.

LIMITATIONS

These findings may not be geographically generalizable to other ED populations, although the survey was administered in both urban and suburban settings. Additionally, our coverage area has about 120 permanent emergency shelter beds for males and 22 for women for about 250,000 people in the region. There is no national database to describe how these shelter-bed resources compare to other geographic region, and it is unknown what impact that may have had on our results. The eligibility requirements (particularly the requirement of speaking English) may have caused selection bias. Other sampling issues must be considered when interpreting our results (total subjects eligible, schedules that were applied, the study period selected, the disproportionate responses from each of the sites and the potential impact on the accuracy of the data). Participant's race was not collected as a part of the survey and its impact as a confounder to site variability is not known.

The survey was based on predetermined definitions of homelessness, but it has not been evaluated or strictly validated. Homeless people constitute a rare and elusive population, and effectively quantifying this population is made more difficult by the absence of an agreed-upon definition across time and place. This lack of definition results in a bias or unreliability in counting.[17] Virtually all definitions require enumerators to make a decision as to whether the person is homeless according to operationalized measurement definition. [8]

CONCLUSION

In our study, the overall prevalence of homelessness or at risk for homelessness was over 10%. This prevalence did not seem to vary between weekdays and weekends or by season as summer months had a prevalence that was as concerning as winter months. The prevalence does, however, seem to vary by institutional characteristics even in the same geographic region. Understanding the patterns of prevalence of homelessness is a step toward considering possible interventions to assist this vulnerable population.

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Randomized Trial of Adding Parenteral Acetaminophen to Prochlorperazine and Diphenhydramine to Treat Headache in the Emergency Department

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Introduction: Headaches represent over three million emergency department (ED) visits per year, comprising 2.4% of all ED visits. There are many proposed methods and clinical guidelines of treating acute headache presentations. However, data on intravenous acetaminophen usage in these settings are lacking. In this study, we sought to determine the efficacy of intravenous (IV) acetaminophen as an adjunct to a standard therapy for the treatment of patients who present to the ED with a chief complaint of "headache."

Methods: We conducted a single site, randomized, double-blind, placebo-controlled trial investigating the clinical efficacy of IV acetaminophen as an adjunct to a standard therapy with prochlorperazine and diphenhydramine for the treatment of patients who present to the ED with a chief complaint of "headache" or variants thereof. (See below for variants). The primary outcome measure of the efficacy of parenteral acetaminophen as an adjunct treatment for headache in addition to a standard therapy was a threshold two-point reduction in visual analog scale (VAS) pain scores on a 1-10 level at 90 minutes. Secondary outcomes measures included assessment of decreased requirement of "rescue" pain medicines, defined as any analgesic medications outside of diphenhydramine, prochlorperazine and acetaminophen, with particular interest to potential opioid-sparing effects with parenteral acetaminophen. Additional secondary outcome measure included time to disposition from arrival in the ED.

Results: For the acetaminophen group the initial mean pain score was 8.67, for the placebo group 8.61. At 90 minutes pain score was 2.23 for the acetaminophen group and 3.99 for placebo ($p<0.01$, 95% confidence interval (CI) [0.8%-16%]. Of 45 patients in each group, we observed at least a threshold two-point decrease in pain score 36/45 (80%) with acetaminophen vs. 25/45 (55%) with placebo ($p<0.01$) 95% CI [5%-41%], number needed to treat (NNT) = 4). Secondary outcome measure did not demonstrate a difference in length of stay (161 minutes for acetaminophen arm and 159 minutes for placebo). However, 17/45 (38%) of patients who received IV acetaminophen required rescue analgesia, opposed to 24/45 (53%) of patients in the placebo group ($p=0.13$) 95% CI [-5%-34%].

Conclusion: IV acetaminophen when used with prochlorperazine and diphenhydramine to treat acute headaches in the ED resulted in statistically significant pain reduction compared with prochlorperazine and diphenhydramine alone as measured by both threshold of lowering VAS pain score by at least two points (NNT = 4) and overall decline in VAS pain score. Further study is required to validate these results. [West J Emerg Med. 2017;18(3)373-381.]

INTRODUCTION

Headaches represent over three million emergency department (ED) visits per year comprising 2.4% of all ED visits.[1] Headache is among the three most common complaints of patient presentations to EDs across the country with 1,626 visits per 100,000 in the 18-44 age group.[1] Hospitalization costs totaling over $408 million were reported as of 2008.[2] Treatment of acute headache remains complex, often requiring an individualized regimen. There are many proposed methods and clinical guidelines of treating acute headache presentations; however, data on intravenous (IV) acetaminophen usage in these settings is lacking,[2,3] IV acetaminophen had demonstrated success in the post-operative period found by retrospective medical use evaluation surveys at sparing opioids as a part of a multi-modal approach to analgesia.[4]. It has also displayed effectiveness in the treatment of acute renal colic when compared to morphine directly.[5] While current recommendations for acute headache treatment do not routinely include opioids, many patients regularly use or require some form of opioid analgesia, complicating current approaches. Assessing the usage of IV acetaminophen in the setting of acute headache, as an adjunct to standard therapy and as part of a multi-modal approach, may display increased efficacy in terms of pain reduction and opioid-sparing effects.

Population Health Research Capsule

What do we already know about this issue?
IV acetaminophen has showed promise in post-operative pain control trials with demonstrated narcotic-sparing effects. It has not yet shown much success for other pain presentations.

What was the research question?
Can the addition of IV acetaminophen to a "standard" headache cocktail help improve pain control, diminish length of stay, and decrease amount of "rescue'"medications?

What was the major finding of the study?
IV acetaminophen added to prochlorperazine and diphenhydramine to treat acute headaches in the ED resulted in significant pain reduction when compared with prochlorperazine and diphenhydramine alone, decreasing VAS pain scores by at least 2 points (NNT =4), with overall decline in VAS pain score.

How does this improve population health?
Non-narcotic treatment of acute pain in the ED is recommended. We evaluated the effectiveness of alternative regimen for a common complaint.

METHODS

We conducted a single site, randomized, double-blind, placebo-controlled trial investigating the clinical efficacy of IV acetaminophen as an adjunct to a standard therapy for the treatment of patients who present to the ED with a chief complaint of "headache" or variants thereof. (See below for variants.) Independent of the clinician's ultimate disposition of the patient, data collection was performed to ascertain the primary outcome measure of the efficacy of parenteral acetaminophen as an adjunct treatment for headache in addition to a standard therapy, with primary end point being threshold two-point reduction in visual analog scale (VAS) pain scores on a 1-10 level at 90 minutes. An estimated 100 patients were needed for the study (50 patients in each group) to achieve adequate power when considering the primary outcome measure. The primary outcome measure would be anticipated to reflect a statistically significant difference in mean pain scores between acetaminophen and placebo greater or equal to two with standard statistical thresholds of $p < 0.05$ and beta (power) > 0.8. Secondary outcomes measures included assessment of decreased requirement of "rescue" pain medicines defined as any analgesic medications outside of the aforementioned protocol with particular interest to potential opioid-sparing effects with parenteral acetaminophen. Additional secondary outcome measures included decreased time to disposition from arrival in the ED.

We obtained institutional review board approval and informed consent documentation prior to beginning patient enrollment. We included a convenience sample of patients age 18-65 years presenting with chief complaint of headache, migraine headache, tension headache, cluster headache or headache not otherwise specified, reporting pain as >4 using a standard 10-point VAS. We excluded patients who consumed a cumulative dose of acetaminophen >2,600 mg within the preceding 24 hours (per manufacturer recommendations), physical or mental disability hindering adequate response to assessment of pain, mental disability limiting ability to give consent, hemodynamic instability or medical condition requiring acute lifesaving intervention, documented or suspected pregnancy or active breastfeeding, any known contraindication to acetaminophen use (liver failure, cirrhosis, hypersensitivity, allergic reactions), brain mass/glioma, intra-cranial hemorrhage, skull fracture and any contraindication or reported allergy to the use of prochlorperazine and/or diphenhydramine.

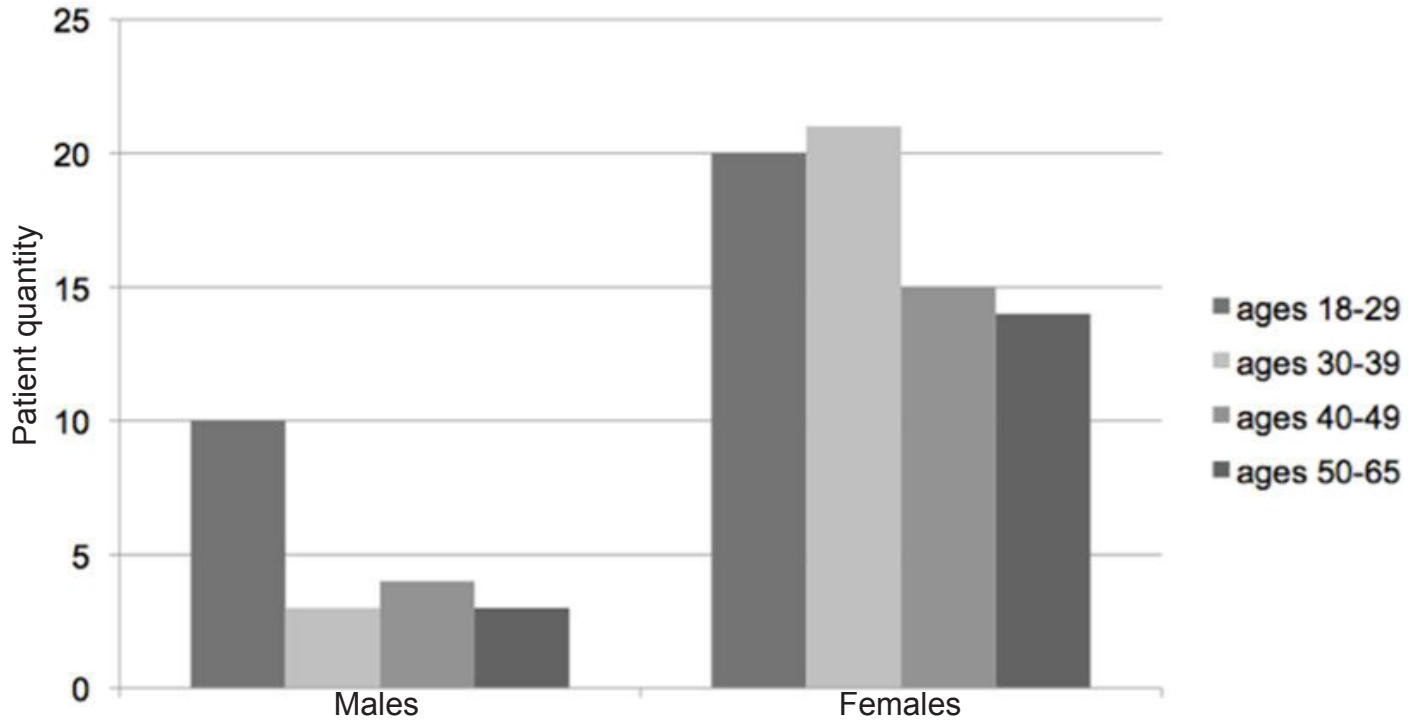

Figure 1. Demographics of patients in age range categories.

Patients presenting to the ED with chief complaint of headache or variant thereof were evaluated by the treating emergency physician, who discussed the study in detail with the patient, reviewed inclusion and exclusion criteria, and obtained informed consent for enrollment. An order set was used in the electronic medical record to initiate a pre-selected order cluster including prochlorperazine 10mg IV bolus, diphenhydramine 25mg IV bolus, 1,000 ml 0.9% normal saline bolus, and "study drug." The "study drug" was either 100ml 0.9% sodium chloride in a minibag, or 1,000 mg IV acetaminophen transferred from the manufacturer's vial into a 100 cc minibag, both labeled "study drug." All patients received prochlorperazine, diphenhydramine, and 1,000 ml 0.9% normal saline immediately from the ED medication-dispensing machine, and then subsequently the "study drug" upon arrival from pharmacy via tube system to ensure blinding. Both IV acetaminophen and placebo were administered via IV infusion over a 15-minute interval as is required by the manufacturer's dosing administration instructions. The study was double blinded to both physician and patient. Therefore, patients were randomized by the pharmacist to either treatment arm "A" or "B," where "A" represented acetaminophen, and "B" represented placebo. The pharmacists used a numeric identifier in a logbook to track whether patients received the study drug or placebo.

ED nursing staff completed a stratification form that noted the patient age, chief complaint, pain assessment intervals at time of arrival, time of "study drug" administration, reassessment at 30-minute intervals thereafter, and additional reassessment if a "rescue" medication was later used. In the event of adverse reaction to the IV infusion of the "study drug," the infusion would be stopped and pharmacy contacted if required to "break" the double blinding to determine which medication was administered.

One hundred patients were enrolled in the study from November 2014-June 2015. We excluded four enrolled patients from data analysis secondary to age; two were excluded for repeat enrollment (only the initial enrollment was included) and three were excluded secondary to missing data. One patient who was found to have a brain mass was also excluded.

Table. Individual race, as per hospital federal reporting regulations, of participants in a study of the effectiveness of adding parenteral acetaminophen in treatment of acute headache.

Demographics	n
Black or African Americans	46
White, Hispanic, or Caucasian	43
Asian/Pacific Islander	0
American Indian or Alaskan Native	1

RESULTS

Forty-five patients received placebo and 45 IV

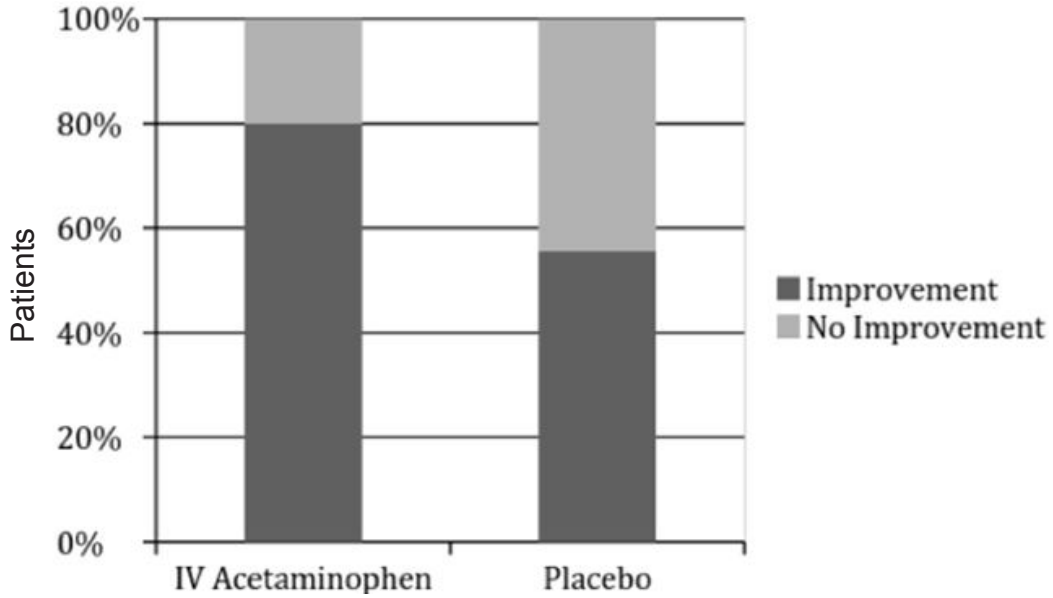

Figure 2. Improvement of visual analog scale pain score reporting ≥ 2 decrease from presentation at the 90-minute mark. *IV,* intravenous

acetaminophen. Both groups received 50 mg IV diphenhydramine, 10 mg IV prochlorperazine, and 1,000 ml 0.9% NS bolus. At no time was the study blinding broken secondary to patient side effects. Our patients' racial demographics are reported in table.

We enrolled 70 men and 20 women with a mean age of 31 and 38 respectively. Age groups of study participants were further divided with notable findings of the majority of males being within ages 18-29, and females being ages 18-39 (Figure 1).

Pain scores were analyzed at 0, 30, 60, and 90 minutes after study-drug administration. Pain scores were reported with ascending severity on a 1-10 point VAS. Of the (n=45) patients who received IV acetaminophen, 36 (80%) reported a decrease by pain score reporting of ≥ 2 from presentation at the 90-minute mark. Nine patients reported pain scores that were unchanged from initial presentation, increased, or

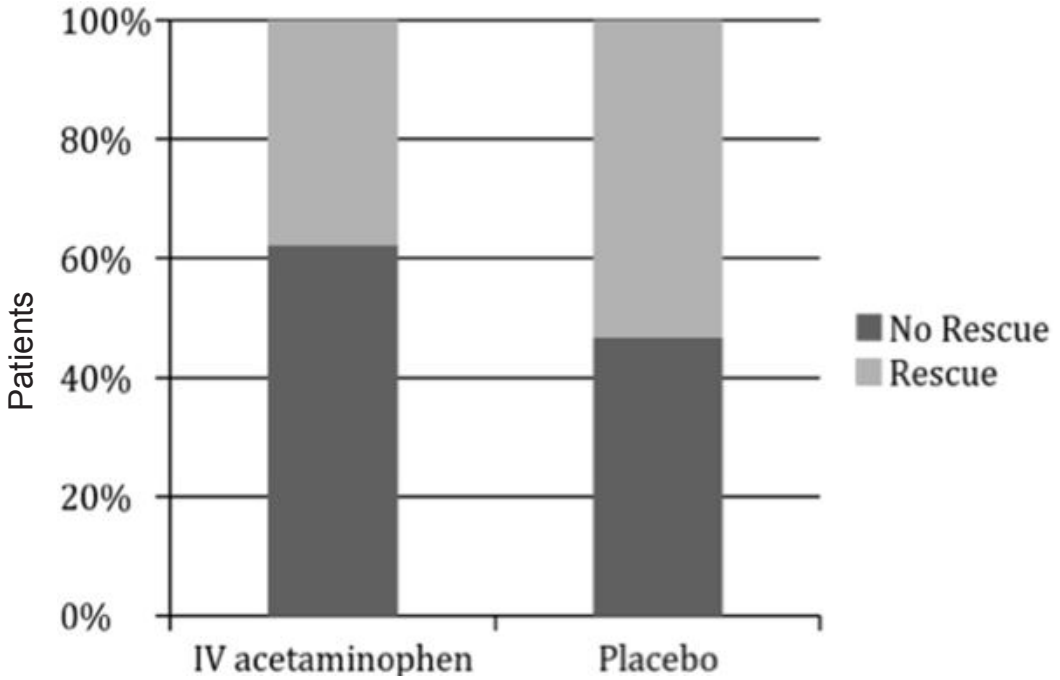

Figure 3. Comparative percentages of those requiring rescue analgesia in both IV (intravenous) acetaminophen and placebo.

decreased by <2 at the 90-minute assessment. Of the (n=45) patients who received placebo, 25 (55%) reported a decrease by pain score reporting of ≥ 2 from presentation at the 90-minute mark. Twenty patients reported pain scores that were either increased, unchanged from initial presentation, or decreased by <2 at the 90-minute assessment (p <0.01) 95% confidence interval [CI] (5%-41%) (Figure 2).

Forty-one patients required some form of "rescue" medication in addition to the initially administered medications; 17/45 (38%) of patients who received IV acetaminophen required rescue analgesia, as opposed to 24/45 (53%) of patients in the placebo group, which did not reach statistical significance.

Seventeen out of the 41 patients who required rescue analgesia received IV ketorolac as part of the rescue regimen: eight in the IV acetaminophen treatment arm and nine in the placebo arm. Nine patients received opioids as part of a rescue formulation: four in the IV acetaminophen treatment arm and five in the placebo arm (p=0.72). The opioids administered included hydrocodone, hydromorphone, meperidine, and fentanyl. Some patients received combination rescue medications including opioids and NSAIDS alone, in combination or in addition to other medications including orphenadrine, triptans, and steroids depending on clinician discretion (Figure 4). The level of "opioid-sparing effect" was not felt to be significant in this case, and was further confounded by co-administration of different classes of rescue medications.

Mean time to clinically significant reduction in pain score as defined by at least a two-point decrease was 49.2 minutes post administration of IV acetaminophen, prochlorperazine and diphenhydramine. Mean time to clinically significant pain reduction was 71.3 minutes post administration of IV 0.9% NS, prochlorperazine and diphenhydramine. Mean pain intensity scoring (VAS) was noted for both groups. For the acetaminophen arm the initial mean pain score was 8.67, for the placebo arm 8.61. At 30, 60, and 90 minutes, corresponding mean pain scores were 6.61, 4.41, and 2.23 for the acetaminophen group, and 7.14, 5.12, 3.99 for the placebo group. A statistically significant difference in mean pain score was not observed until the 90-minute mark (p<0.01, CI 95% (0.8%-16%))(Figure 5).

Mean length of stay (LOS) was 161 minutes for the acetaminophen arm and 159 minutes for the placebo arm. LOS was extrapolated from the time of physician contact to disposition entered in the electronic health record (EHR) and included (in both groups) additional rescue medications and additional reassessment times. The maximum LOS for either treatment arm was 361 minutes. Disposition for two patients was admission and thus associated LOS was excluded from analysis. All other patients were discharged.

DISCUSSION

Treatment of headaches in the clinical setting is difficult and requires an evidence-based and often patient-tailored approach, as there is a paucity of published data suggesting

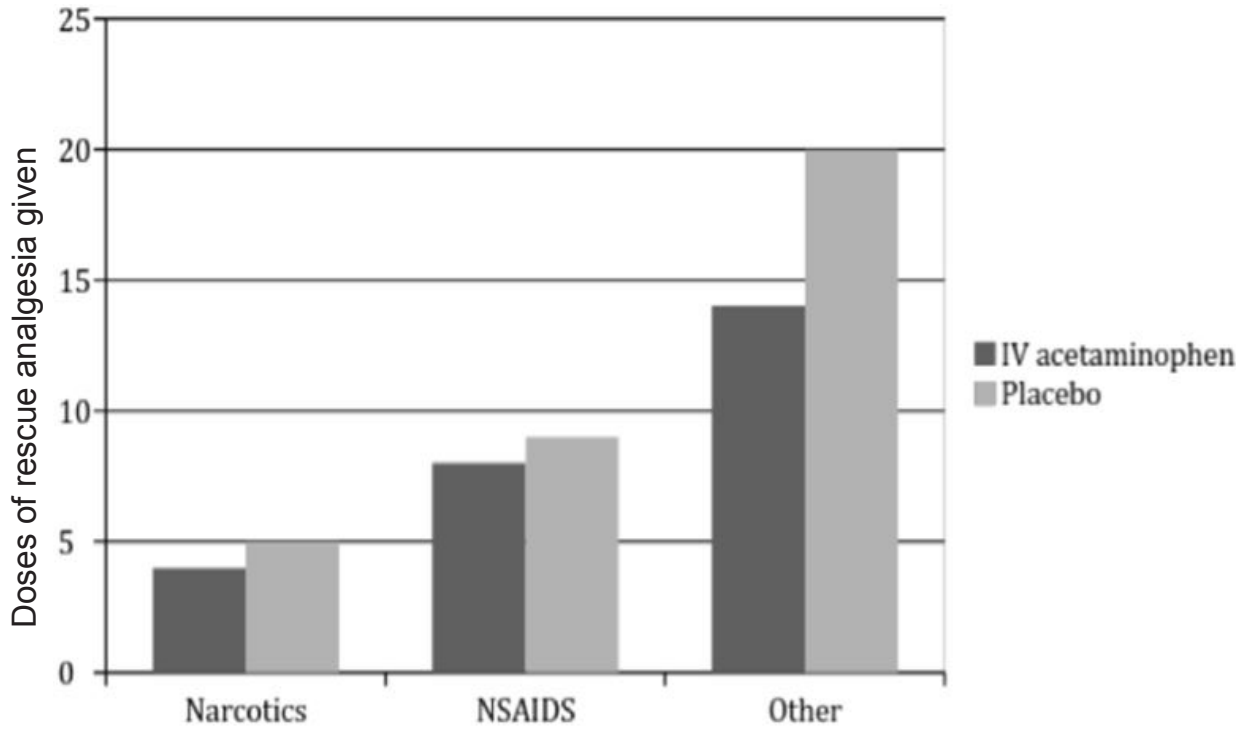

Figure 4. Numeric comparison of rescue analgesics for both intravenous acetaminophen and placebo arms. (p=0.13) 95% CI (-5%-34%)
NSAIDS, non-steroidal anti-inflammatory drugs

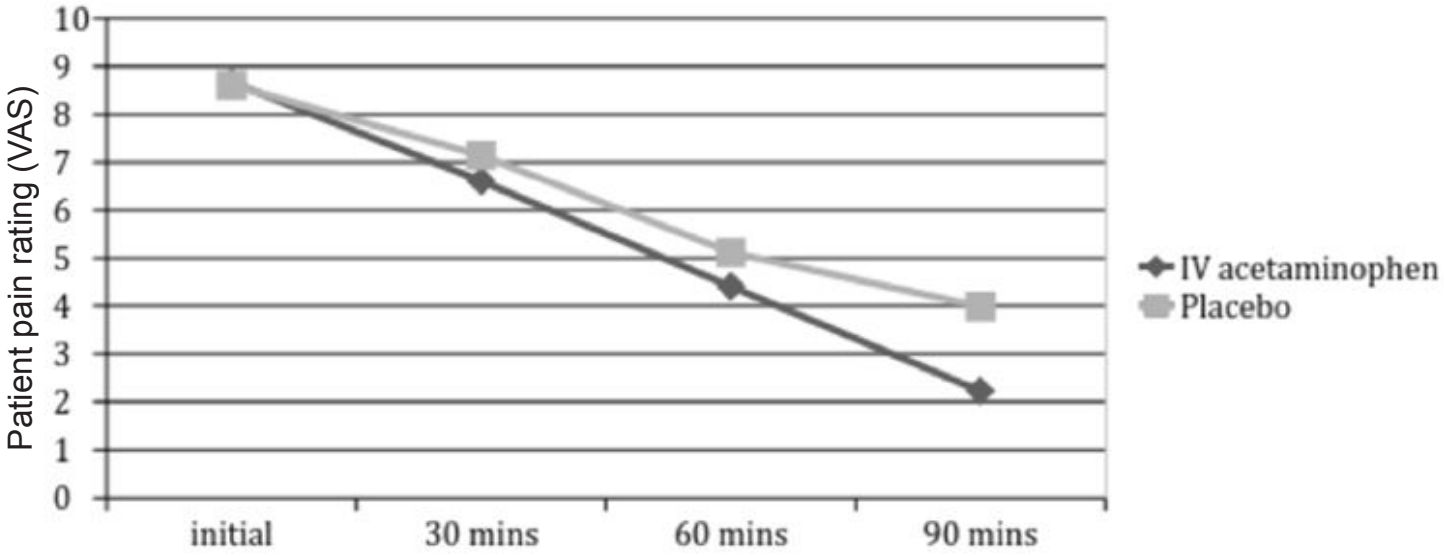

Figure 5. Distributions of the mean visual analog pain scores at predefined intervals from time of patient arrival in intravenous (IV) acetaminophen and placebo arms.
(p=0.13), 95% CI [-5%-34%].

optimal headache therapy.[6] The American Headache Society recommendations have endorsed certain medications as effective for various headache presentations including triptans, ergotamine derivatives, NSAIDs, opioids, and combination medications.[7] As of late, there has been a significant driving force in the medical community to reduce the application of opioids.[2,3] Opioids used routinely in headache presentations are not widely considered standard monotherapy, as they can contribute to rebound effects, increased reliance and addiction.[6,7] Colman et. al. discovered a significantly increased likelihood of patient return to the ED within seven days with first-line opioid treatment of headache.[8] Several adverse effects are associated with opioid use[3] and may lead to prolonged recovery times, increased length of hospital stay, and higher incurred costs to the institution when applied to postoperative pain management strategies. Using multi-modal therapy with non-opioid agents is likely to be beneficial to both physicians and patients alike.[2,9]

Clinical strategies using parenteral acetaminophen as an adjunct have become increasingly popular as there are notable opioid-sparing effects demonstrated in surgical and anesthesia literature with minimal side effects and a low risk/benefit ratio.[3,4,9-16] Intravenous acetaminophen has a diverse and broad compatibility with other agents, making it a successful adjunct to other agents, additional NSAIDS, and opioids.[14] It also synergistically has been shown to increase analgesic affect in multimodal analgesia.[14,17]

Minimal literature is present regarding the opioid-sparing effects of parenteral acetaminophen outside of peri-operative settings.[12] To our knowledge, only one study exists in the emergency medicine literature investigating the use of parenteral acetaminophen. Bektas et. al. compared 1,000 mg IV paracetamol (European name for acetaminophen) to morphine (0.1mg/kg) and placebo for the treatment of renal colic in the ED. Mean pain reduction and requirement of rescue analgesia was similar to morphine, with a noted trend in superiority in early pain assessment at 15 minutes.[5]

A recently published American Headache Society evidence assessment of migraine pharmacotherapies cited Level A evidence by Lipton et. al. demonstrating the efficacy of 1,000 mg of oral acetaminophen vs. placebo in treatment of acute migraine with regard to pain relief, functional disability, phonophobia and photophobia, though the study population was limited to those with minimal nausea and need for bed rest.[18] This is a select population of patients that is perhaps less likely to present to the ED for treatment, though the documented efficacy of acetaminophen is quite profound. Additionally, patients presenting to the ED with severe headache often suffer from associated nausea and vomiting,[19] further strengthening the potential application of parenteral acetaminophen where administration of oral formulation may not be possible. A pharmaceutical-sponsored study of OFIRMEV® (acetaminophen 1,000 mg/100 ml Cadence Pharmaceuticals) demonstrated peak IV acetaminophen plasma and cerebrospinal fluid concentrations were higher than oral or rectal acetaminophen.[19,20] Additionally, IV acetaminophen does not undergo first-pass metabolism in the liver, reducing hepatic exposure to acetaminophen and thus diminishing the potential for hepatic injury.[16,19,21]

The use of IV acetaminophen as primary therapy for

headaches would decrease the pitfalls of using primary NSAIDS such as ketorolac or ibuprofen in cases such as possible headache associated with intracranial hemorrhage where there is a platelet aggregation inhibition,[22] potentially worsening clinical outcomes. Single doses of OFIRMEV® up to 3,000 mg and repeated doses of 1,000 mg every six hours for 48 hours have not been shown to cause a significant effect on platelet aggregation nor have any immediate or delayed effects on small vessels.[19]

Reviewing data findings, we obtained various pain scores in 30-minute intervals, of which only the first three pain scores (after the initial assessment) for a total of 90 minutes post-medication administration were considered. Pain scores were reported on a 1-10 VAS because of previously established integration with the her, thus enhancing data collection and ease of nursing-documented pain assessments essential to the study. Bijur et. al. reported decrease of pain by at least 1.4 as significant when investigating the VAS for pain reporting.[23] We therefore considered a decrease in pain score reporting of ≥ 2 a "clinically significant" reduction.

The mean age of participants was 31 in males and 38 in females. This is consistent with reported headache-sufferer demographics according to the American Headache Society.[1,7] A significantly higher portion of women (70) when compared to men (20) were noted as participants in the study. This demographic trend is consistent with data published by the Agency for Healthcare Research and Quality, which state that women typically outnumber men 3:1 in terms of presenting to EDs seeking treatment for acute headaches.[1]

The definition of rescue medications administered in this study included opioids, additional NSAIDS, steroids, orphenadrine, ergotamines, triptans or additional dopamine agonists. LOS was extrapolated from the time to disposition from first provider contact entered electronically per the EHR and included in both groups additional rescue medications and additional reassessment times. The time to disposition for either arm was very similar, which was an unexpected finding given the trend towards superior pain reduction in the acetaminophen group at 90 minutes. This may be attributed to the small size of our study, thus relatively small number of patients requiring rescue analgesia. In theory, those with improved pain reduction should require less rescue medications and would be suitable for discharge sooner. The maximum LOS for either treatment arm was 361 minutes in which the particular patient required significantly longer assessment due to refractory presentation. When compared to the additional subjects this was an outlier and did not greatly alter the data significance.

During enrollment, several physicians cited concern with excluding analgesic medications such as ketorolac from initial treatment. Several studies have demonstrated the superiority of combination metoclopramide plus diphenhydramine over NSAIDS,[24,25] Regarding the efficacy of dopamine antagonist therapies for treatment of cephalgia, studies suggest a superiority of prochlorperazine to metoclopramide,[26,27] though Friedman et. al. did not achieve statistical significance between treatment arms as opposed to prior studies.[27] Diphenhydramine was administered to all patients due to the significantly reduced akathistic response with prophylactic administration.[28] We believed the initial treatment regimen would be a reasonable and efficacious baseline regimen despite patients randomized to the placebo group not being given an NSAID medication upon initiation of treatment.

LIMITATIONS

We identified some limitations during trial completion. Our intention was to enroll a consecutive series of eligible patients, but this relied on both patient and physician participation and consent to trial participation, which were both factors not within controlled limits of the study. Based on the projected sample size to achieve appropriate power, a sample size of (n=100) was deemed optimal; due to exclusion criteria and other factors as noted before, a sample size of (n=90) was ultimately available for analysis. While the ultimate study population was smaller than initially intended, we observed a greater outcome effect than anticipated such that statistical significance was still achieved, though this did require 90 minutes until a statistically significant difference was achieved. Individual emergency medicine providers were encouraged to enroll all eligible patients according to the study protocol; however, data displayed non-consecutive enrollment. We speculate this may have been due to some provider reluctance to participate in the study or patient refusal, preventing consecutive series enrollment. The degree of subject refusal was not recorded during the enrollment period for further reflection. At time of patient enrollment, treatment was initiated in both arms with initial administration of prochlorperazine and diphenhydramine within several minutes. In either arm, the "study drug" required the blinded product to be sent from pharmacy to the ED, resulting in subsequent administration to the initial medications as noted above. The level of effect of this on study outcomes is difficult to determine, since as noted in the placebo group the time to significant pain score decrease was slower than the acetaminophen group and pain score decrease more profound in the acetaminophen group, although both arms had delayed "study drug" administration by up to 15 minutes post initial medications. To maximize our sample size and decrease exclusion burden, we did not target a specific subset of headache populations. Total patient LOS was defined as arrival to the ED and time to disposition. The beginning of LOS was not recorded as initial provider assessment and study enrollment, which is certainly a confounding variable. The observed difference in LOS between the two study groups was not substantially different, and it is unclear if

further analysis in this regard would have significantly changed the reported LOS between the groups.

It would be beneficial to delineate in a larger trial if the observed benefit of IV acetaminophen is specific to certain headache conditions. Going forward, it would be worthwhile to study a head-to-head comparison of IV acetaminophen alone with a standard NSAID or opioid therapy to ascertain if similar efficacy exists in treatment of cephalgia as it was reported in treatment of renal colic by Bektas et. al.[5]

Results may further support evidence suggesting that avoidance of opioids in treatment of headache presentations is wise. It is also worthwhile to note that a cost analysis was not performed in this trial, and all medications were provided without cost to patients involved in the trial. This is important as OFIRMEV® as currently available in clinical practice does carry moderate increase in patient cost compared to therapies that have been traditionally used, and may represent a different or increased billing charge toward the patient. Further investigation is required to weight financial burden versus therapeutic effect.

CONCLUSION

IV acetaminophen when used with prochlorperazine and diphenhydramine to treat acute headaches in the ED resulted in statistically significant pain reduction compared with prochlorperazine and diphenhydramine alone as measured by both threshold of lowering VAS pain score by at least two points (NNT = 4) and overall decline in VAS pain score. Further study is required to validate these results.

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Clinician-Performed Bedside Ultrasound in Improving Diagnostic Accuracy in Patients Presenting to the ED with Acute Dyspnea

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Introduction: Diagnosing acute dyspnea is a critical action performed by emergency physicians (EP). It has been shown that ultrasound (US) can be incorporated into the work-up of the dyspneic patient; but there is little data demonstrating its effect on decision-making. We sought to examine the impact of a bedside, clinician-performed cardiopulmonary US protocol on the clinical impression of EPs evaluating dyspneic patients, and to measure the change in physician confidence with the leading diagnosis before and after US.

Methods: We conducted a prospective observational study of EPs treating adult patients with undifferentiated dyspnea in an urban academic center, excluding those with a known cause of dyspnea after evaluation. Outcomes: 1) percentage of post-US diagnosis matching final diagnosis; 2) percentage of time US changed providers' leading diagnosis; and 3) change in physicians' confidence with the leading diagnosis before and after US. An US protocol was developed and standardized prior to the study. Providers (senior residents, fellows, attendings) were trained on US (didactics, hands on) prior to enrollment, and were supervised by an US faculty member. After patient evaluation, providers listed likely diagnoses, documenting their confidence level with their leading diagnosis (scale of 1-10). After US, providers revised their lists and their reported confidence level with their leading diagnosis. Proportions are reported as percentages with 95% confidence interval (CI) and continuous variables as medians with quartiles. We used the Wilcoxon signed-rank test and Cohen's kappa statistics to analyze data.

Results: A total of 115 patients were enrolled (median age: 61 [51, 73], 59% female). The most common diagnosis before US was congestive heart failure (CHF) (41%, 95%CI, 32-50%), followed by chronic obstructive pulmonary disease (COPD) and asthma. CHF remained the most common diagnosis after US (46%, 95%CI, 38-55); COPD became less common (pre-US, 22%, 95%CI, 15-30%; post-US, 17%, 95%CI, 11-24%). Post-US clinical diagnosis matched the final diagnosis 63% of the time (95%CI, 53-70%), compared to 69% pre-US (95%CI, 60-76%). Fifty percent of providers changed their leading diagnosis after US (95%CI, 41-59%). Overall confidence of providers' leading diagnosis increased after US (7 [6, 8]) vs. 9 [8, 9], p: 0.001).

Conclusion: Bedside US did not improve the diagnostic accuracy in physicians treating patients presenting with acute undifferentiated dyspnea. US, however, did improve providers' confidence with their leading diagnosis. [West J Emerg Med. 2017;18(3)382-389.]

INTRODUCTION

Dyspnea, the perception of the inability to breathe comfortably, is one of the most common presenting patient complaints in the emergency department (ED).[1] Patients with dyspnea pose difficult challenges in diagnosis and management to the acute care clinician, as the differential diagnosis for this complaint is broad and varied. Emergency physicians (EP) are often required to make rapid diagnoses and treatment plans for these patients. Because time is of the essence in patients with this critical chief complaint, their presentation requires an aggressive and precise approach.

The initial management for undifferentiated dyspnea includes a history, physical examination, electrocardiogram (ECG), and chest radiograph. This diagnostic approach has been shown to have only intermediate accuracy, identifying the cause of dyspnea in only about two thirds of patients.[2] Point-of-care ultrasound (POCUS) in the ED is quickly accessible during acute situations, and there is growing evidence to support the role of thoracic US in facilitating an accurate diagnose in dyspneic patients.[3,4] The ability of US to discern between cardiac and non-cardiac etiologies for the source of dyspnea has also been demonstrated.[5-7] There is little data, however, to describe bedside US's direct effect on physician decision-making in the acute care of the dyspneic patient.

The authors examined the impact of a bedside, clinician-performed cardiopulmonary US protocol on the clinical impression of EPs evaluating patients with dyspnea. The authors hypothesized that integrating such a protocol into the diagnostic work-up of the dyspneic patient would increase the accuracy of EPs' initial diagnosis, facilitate physicians' decision-making during patient evaluations, and increase physicians' confidence level with their leading diagnosis.

Population Health Research Capsule

What do we already know about this issue?
There is growing evidence to support the role of point-of-care ultrasound (POCUS) in the diagnostic work-up of patients presenting to the ED with acute dyspnea.

What was the research question?
Does a bedside US protocol impact physicians' diagnosis and confidence level when evaluating dyspneic patients?

What was the major finding of the study?
US did not improve diagnostic accuracy, but did improve physicians' confidence level with their leading diagnosis.

How does this improve population health?
In dyspneic patients with only mild-to-moderate disease, US may not be as diagnostically impactful on the clinical impression of ED providers compared to patients with higher disease severity.

METHODS

This was a prospective observational study of EPs caring for a convenience sample of adult patients who presented to an urban academic medical center with undifferentiated dyspnea. Physicians assigned as the primary EP to a dyspneic patient > 18 years of age were approached by the study investigators and enrolled in the study. Enrollment and patient screening was performed by the study investigators and supervising US faculty members. The study took place over an eight-month period.

Inclusion

Physicians enrolled included senior (i.e., postgraduate year [PGY]-3 and -4) emergency medicine (EM) residents, fellows, or attending physicians. Physicians were identified after they were assigned to an ED patient with a chief complaint indicating dyspnea (i.e., "shortness of breath"); or with objective signs of dyspnea, specifically tachypnea (respiratory rate > 20 breaths per minute), hypoxemia (pulse oximetry < 94% on room air), or obvious signs of respiratory distress on triage, as noted by the triage nurse in his/her note in the electronic medical record. Patients in this study were of sufficient diagnostic uncertainty; if their pathology was immediately discernable after initial evaluation (i.e., acute asthma exacerbation), they were excluded, as described below.

Exclusion

Physicians excluded from the study were those providers assigned to one of the following patients: a patient referred from a clinic or office with a known diagnosis; a patient transferred from an outside facility with a known diagnosis; or a patient with a known cause of dyspnea immediately after initial evaluation. The cause of dyspnea for patients was considered to be "known" if patients endorsed the etiology of their symptoms (i.e., asthma exacerbation typical with previous exacerbations), or if patients arrived to the ED with documentation and/or diagnostic results suggesting a diagnosis for their symptoms.

Study Protocol

Per study protocol, EPs first performed a history and physical examination, and reviewed an ED-performed ECG during an untimed initial evaluation of the dyspneic patient. Baseline patient information was also collected; this included patient demographics, presenting symptoms, symptom onset, patient-reported dyspnea severity (Likert scale from 1 ["not

short of breath"] to 10 ["very short of breath"]), vital signs, and past medical history. Following initial patient evaluation, physicians were surveyed and asked to select and rank the most likely diagnoses for their patient's dyspnea from a list of possible diagnoses to choose from, as well as to document their confidence level with their leading diagnosis (scale of 1-10). Physicians then performed a supervised focused point-of-care cardiopulmonary US on their dyspneic patient. On completion of the US exam, providers were surveyed for a second time, allowing them to revise their differential diagnoses and confidence levels. A chest radiograph was not part of the initial untimed work-up; therefore, a radiograph was not reviewed prior to the bedside cardiopulmonary US exam.

Outcomes

Outcomes of the study included the following: 1) percentage of the post-US diagnosis matching the final diagnosis, which was determined by blinded chart review (i.e., two investigators separately reviewed patients' charts and determined the final diagnoses; discrepancies were solved by a third investigator's blinded review); 2) percentage of time US changed the leading diagnosis determined by the provider; and 3) change in physician confidence level with the leading diagnosis before and after US by surveying the provider.

Ultrasound Protocol

The US protocol was developed and standardized prior to study. The protocol consisted of at least two views of the heart (parasternal long, parasternal short, subxiphoid, apical views), as well as anterior and posterolateral views of the lungs bilaterally. While enrolled providers were encouraged to obtain all of the aforementioned views, they were required to acquire US images that would assist them in answering specific point-of-care questions for their dyspneic patients. Based on images acquired, providers were asked the following questions: to describe left ventricular (LV) wall motion (i.e., depressed, normal, hyperdynamic); to identify the presence of a pericardial effusion and, if present, to describe its size (i.e., small moderate, large); to identify the presence of right ventricular (RV) strain (i.e., RV dilatation or a D-shaped LV); to identify lung A lines and/or B lines by location (i.e., right anterior, right posterolateral, left anterior, left posterolateral); to identify the presence or absence of a [right and/or left] pulmonary effusion; and to identify the presence of lung sliding bilaterally. With specific regards to lung US, providers were asked to qualitatively report if there was a predominance of an A-line or B-line pattern for lung images acquired; providers were not asked to quantify the number of B-lines appreciated. Supervising US faculty recorded the US findings, which were verbalized by the provider performing the patient US.

Providers (PGY-3 or -4, fellows, attendings) were trained on US (didactics and hands-on) prior to enrollment, and were supervised by the enrolling US faculty member for quality assurance and recording purposes. Supervising US faculty members did not provide feedback during scanning, and did not influence the EP's image interpretation. Upon completion of the second provider survey, supervising US faculty members then discussed patient US images with respective providers to ensure salient findings were noted so as to not compromise and/or delay patient care.

Ultrasound Training

US training is provided to all residents, fellows, and faculty in the department. EM residents undergo a two-week US rotation at some point during the first half of their curriculum. Cardiac and lung US scans are taped during quality assurance review sessions.. While on rotation, each resident receives at least two hours of didactics dedicated to cardiac and pulmonary applications of US, and are required to complete a minimum of 15 cardiac and thoracic quality scans. Residents' procedural competency is supervised and assessed by the US rotation director; those residents who do not demonstrate competency are remediated until procedural competency is achieved. US fellows are credentialed early during their fellowship to perform cardiac and non-cardiac scans according to American College of Emergency Physician (ACEP) guidelines. Faculty members in the department attend biannual US skills training workshops, offered by credentialed US faculty members within the department, where cardiac and lung US skills are reinforced and assessed for procedural competency.

Knowledge of POCUS skills (i.e., image recognition, identification of pathologic findings) was demonstrated prior to enrollment, by achieving a score of >80% on the cardiac and lung portions of the ACEP online US examination, available at: http://emsono.com/acep. In addition, all enrollees received a brief 15-minute refresher bedside training session on cardiac and lung US views. The US examination and refresher session were complete for all residents, fellows, and faculty before initiating enrollment in the ED where the study was performed.

Ultrasound Machines and Quality Assurance

A SonoSite portable M-Turbo ultrasound unit and a GE LOGIQ P5 machine were used for the study. US examinations were performed using a 5-2 MHz curved-array transducer for lung studies, and a 5-1 MHz phased-array transducer for cardiac studies. All US images and clips were saved and recorded onto the US system, and reviewed by emergency US fellowship-trained faculty at weekly departmental performance improvement / quality assurance tape review sessions.

Consent

Study investigators obtained written informed consent before physician enrollment. Investigators offered a detailed explanation of the study's objectives and benefits, and answered any questions prior to enrollment. All physician subjects had the right to refuse enrollment into the study. Patients

were provided with an information sheet that described the study. The institutional review board approved the study.

Statistical Analysis

The study was powered based on initial pilot data that the US protocol would result in a change in differential diagnosis in 75% of cases. We aimed to demonstrate this with a 95% CI precision of 10%, which necessitated at least 73 physician-patient ED encounters of acute dyspnea be enrolled using a binomial exact calculation.[8] Proportions are reported as percentages with 95% CI, calculated by the Agresti-Coull method; and continuous variables are reported as medians with quartiles. We used the Wilcoxon signed-rank test and Cohen's kappa statistics to analyze data.

To facilitate comparisons between pre- and post-US diagnoses with the final diagnosis, we categorized diagnoses into three super-types: cardiac (i.e., congestive heart failure [CHF], pulmonary (i.e., chronic obstructive pulmonary disease), and other (i.e., anemia). To avoid multiple comparisons, similar diagnoses were categorized into these three super-type categories using weighted Cohen's kappa statistics. We used Cohen's kappa to measure the concordance between pre- and post-US diagnoses with the final diagnosis across cardiac, pulmonary, and other diagnoses.

RESULTS

We included a total of 115 physician-patient encounters of patients presenting to the ED with dyspnea in the study. Patients were 59% female; and the median age was 61 years [51, 73]. Almost all patients (99%) provided a triage complaint of "shortness of breath" with 54 (47%) presenting with symptoms of dyspnea for less than 24 hours. The most common self-reported comorbid conditions in participants' past medical histories were hypertension (67%), diabetes (44%) and CHF (29%) (Table 1.

All patients underwent POCUS assessment conducted by the enrolled physician, under the supervision of a credentialed US faculty member. Twenty-seven physicians in total participated in the study, which included third- and fourth-year EM residents; ultrasound fellows; and EM faculty members. Of the ultrasounds performed, 23 were performed by PGY-3 residents (20%); 31 were performed by PGY-IV residents (27%); 20 were performed by US fellows (17%); and 41 were performed by faculty members (36%). Providers were able to obtain all four cardiac views and all four lung views in 93% of cases (107 out of 115 physician-patient encounters).

The top seven diagnostic conditions, and their respective proportions, are presented in Table 2, along with the final diagnosis. Overall, CHF was the most common diagnosis before US (47%, 95% CI [32%-50%]), followed by COPD and asthma. CHF remained the most common diagnosis after US (46%, 95% CI [37%-56%]), while COPD became less common after ultrasonographic assessment (pre-US, 22%, 95% CI [15%-30%]; post-US, 17%, 95% CI [11%-24%]) (Table 2). Post-US clinical diagnosis matched final diagnosis 63% of the time (95% CI [53%-70%]), compared to 69% pre-US with the final diagnosis (95% CI [60%-76%]).

Survey of enrolled physicians demonstrated that US narrowed the differential diagnosis in 78% of cases. There was a change in the leading diagnosis post-US in 32% of cases, while the diagnosis remained the same in 68% of cases. One out of two physicians reported that the incorporation of bedside US into the patient management changed the diagnosis and/or treatment plan (Table 3). After completion of the US protocol, providers' lists of differential diagnoses narrowed (or decreased) by one diagnosis (median change, -1, $p<0.001$, via the Wilcoxon signed-rank test).

Providers' confidence level with their leading diagnoses increased after the US protocol. The median pre-US confidence level was 7 out of 10, compared to 9 out of 10 post-US; the median +2 change suggesting increased confidence was statistically significant by the Wilcoxon signed-rank test ($p<0.001$). Sub-analysis of the 79 cases where the leading pre-US diagnosis remained the same post-US also demonstrated an increased in confidence level, 8 out of 10 to 9 out of 10, respectively ($p<0.001$).

Agreement of physicians' leading diagnoses before and after US with the final diagnosis, as determined by the Cohen's kappa statistic, was moderate. Agreement with the final primary diagnosis was slightly lower pre-US compared to the post-US diagnosis (Kappa: 0.45 pre-US vs. 0.56 post-US) (Table 4).

DISCUSSION

The agreement of physicians' leading diagnosis before and after US with the final diagnosis was moderate, suggesting that bedside US has minimal impact on the clinical evaluation of acute dyspnea; however, we observed a modest increase in physician's diagnostic confidence, as well as changes in the management in some cases,.

There are several other studies that address the effect of US in differentiating the etiology of acute dyspnea. They differ from this study in that their US protocol is either limited to lung imaging, evaluates for the presence or absence of interstitial syndrome (i.e., typically CHF), or relies on few experienced sonographers. (In certain cases, studies do not provide details of sonographers' experience levels.) The specific effect on clinical decision-making in a patient's acute management has not been thoroughly studied.

Goffi et al. studied 50 ED patients with acute undifferentiated dyspnea, and did find a significant diagnostic and therapeutic impact of lung US on management.[9] Lung US changed the diagnosis in 44% of cases and the management in 58% of cases, a significant difference from our data. They found fair agreement of clinical diagnosis to the final diagnosis (Cohen's kappa coefficient = 0.25, 0.32, and 0.26 for main, pathophysiologic, and etiological diagnosis, respectively; $p<0.01$), and excellent agreement between US-assisted diagnosis and final diagnosis (Kappa coefficient = 0.94, 0.84, and 0.81, respectively; p

Table 1. Baseline patient demographics and characteristics in study of the usefulness of bedside ultrasound in diagnosing dyspnea.

Variables	N = 115	%	Median (quartiles)
Demographics			
Female gender	68	59%	--
Age (median, quartiles)	115	--	61 (51, 73)
Presenting symptoms			
Shortness of breath	114	99%	--
Chest pain	8	7%	--
Edema	4	4%	--
Symptom onset			
<24 Hours	54	47%	--
1-7 Days	32	28%	--
>7 Days	29	25%	--
Dyspnea severity*			
Overall (median, quartiles)	104	--	8 (6, 9)
2-5	19/104	18%	--
6-7	29/104	28%	--
8-10	56/104	54%	--
Vital signs (median, quartiles)			
SBP (mmHg)	115	--	144 (122, 167)
DBP (mmHg)	115	--	83 (76, 96)
Heart rate (beats/min)	115	--	87 (76, 106)
Respiratory rate (breaths/min)	115	--	22 (18, 26)
Oxygen saturation (%)	113	--	98 (96, 100)
Temperature (degrees F)	112	--	98 (98, 99)
Past medical history			
Diabetes	51	44%	--
Hypertension	77	67%	--
Renal	21	18%	--
CHF	33	29%	--
CAD	31	27%	--
Asthma	24	21%	--
COPD	21	18%	--
Smoker	13	11%	--
DVT/PE	4	4%	--
Cancer	5	4%	--
Other	61	53%	--

* Dyspnea severity was reported by the patient, and measured on a visual analogue scale of 1 (mild) to 10 (severe).
SBP, systolic blood pressure; *DBP,* diastolic blood pressure; *CHF,* congestive heart failure; *CAD,* coronary artery disease; *COPD,* chronic obstructive pulmonary disease; *DVT,* deep vein thrombosis; *PE,* pulmonary embolism

<0.01). This study did not include cardiac imaging, and the number of sonographers and their level of experience were not clearly outlined.

Liteplo et al. proposed the ETUDES (Emergency Thoracic Ultrasound in the Differentiation of the Etiology of Shortness of Breath) exam for undifferentiated dyspnea in 2009.[10] This application was mainly designed to differentiate between CHF and COPD by counting the number of B-lines in multiple thoracic zones. They studied 94 patients for the possible diagnosis of CHF using an eight-zone lung exam, and found a positive likelihood ratio of 3.88 and a negative likelihood ratio of 0.5.

In 2012 Cibinel et al. attempted to differentiate cardiogenic

Table 2. Comparison of pre- and post-ultrasound diagnostic categories to final hospital diagnosis.

	Pre-US	Post-US	
Leading diagnosis	N (%, 95% CI)	N (%, 95% CI)	Final diagnosis
All diagnoses	Total N=115	Total N=115	Total N=115
ACS	4 (4%, 1 to 9%)	4 (4%, 1 to 9%)	7 (6%, 3 to 12%)
CHF	47 (41%, 32 to 50%)	53 (46%, 38 to 55%)	39 (34%, 26 to 43%)
Pneumonia	5 (4%, 2 to 10%)	8 (7%, 3 to 13%)	5 (4%, 2 to 10%)
Asthma/reactive airway disease	14 (12%, 7 to 20%)	8 (7%, 3 to 13%)	12 (10%, 16 to 18%)
COPD	25 (22%, 15 to 30%)	19 (17%, 11 to 24%)	24 (21%, 14 to 29%)
PE	11 (10%, 5 to 16%)	9 (8%, 4 to 14%)	1 (1%, 0 to 5%)
Other	9 (8%, 4 to 14%)	14 (12%, 7 to 20%)	27 (23%, 17 to 32%)
Physicians' confidence level* (Median, quartile)	7 (6, 8)	9 (8, 9)	---

US, ultrasound; *CI,* confidence interval; *ACS,* acute coronary syndrome; *CHF,* congestive heart failure; *COPD,* chronic obstructive pulmonary disease; *PE,* pulmonary embolism

Table 3. Impact of ultrasound on physicians' differential diagnosis and confidence level before and after the ultrasound.

Impact of ultrasound	n/N	95% CI
Narrowed differential diagnosis list	90/115	78% (70 to 85%)
Changed leading diagnosis	37/115	32% (24 to 42%)
Change in confidence level*	2 (1, 2)	-
Pre-US diagnosis matched final diagnosis	79/115	69% (60 to 76%)
Post-US diagnosis matched final diagnosis	72/115	63% (53 to 70%)
Overall change in diagnosis and/or treatment**	58/115	50% (41 to 59%)

US, ultrasound; *CI,* confidence interval

* Determined by calculating the difference in physicians' confidence level in their leading diagnosis before and after the ultrasound.

** Determined by surveying the treating physicians.

and non-cardiogenic etiologies of dyspnea in the ED.[11] They evaluated 56 patients for alveolar interstitial syndrome (AIS) or pleural effusions. They found diffuse AIS to be 93% sensitive and 84% specific for cardiogenic dyspnea. Detection of pleural effusions, however, was not helpful in the differentiation (84% sensitive, 52% specific). Anderson et al. examined the effect of a multi-organ approach to diagnosing acute decompensated heart failure (ADHF) in 2013.[12] They examined left ventricular ejection fraction, inferior vena cava, and eight thoracic zones on 101 patients. US exams were performed by five expert sonographers. Specificity for diagnosing ADHF was 100%. In another study by Unluer et al., US was placed in the hands of ED nurses who performed the bedside lung ultrasound in emergency (BLUE) protocol on 96 acutely dyspneic ED patients to discern between a cardiac versus respiratory underlying etiology.[13,14] Agreement with the final diagnosis was 0.917; sensitivity and specificity were 95.35% and 95.74%, respectively. A study by Kajimoto et al. in 2012 did include lung, cardiac, and inferior vena cava US in the evaluation of acute dyspnea in 90 patients.[15] They demonstrated a sensitivity, specificity, negative predictive value, and positive predictive value of 94.3%, 91.9%, 91.9%, and 94.3%, respectively, for the diagnosis of acute decompensated CHF.

Appraisal of the literature demonstrates that bedside cardiopulmonary ultrasonography has the capacity to gather accurate diagnostic information in the acutely dyspneic patient for the purpose of narrowing the differential diagnosis, if not helping arrive at the specific diagnosis. What has not been definitively demonstrated by the evidence is whether bedside US performs better than the standard clinician evaluation. The data in our study do not support this practice. In fact, in contrast to prior studies, our results imply that US can decrease diagnostic accuracy for acute undifferentiated dyspnea. This may indicate that cardiopulmonary US requires significant experience to use accurately. Primarily, the clinicians in this study were not US specialists. There was significant variability in US skill and experience among sonographers; subgroup analyses may yield different results when stratified by sonographer experience.

There is little doubt that cardiopulmonary sonography yields objective signs of specific pathology.[16-22] B-lines, for example, are

Table 4. Agreement of leading diagnoses (cardiac vs. pulmonary vs. other) before and after the ultrasound with the final diagnosis.

Clinical impression	Kappa	95% CI
Pre-US vs. final diagnosis	0.45	0.31 to 0.58
Post-US vs. final diagnosis	0.56	0.43 to 0.69

US, ultrasound; *CI*, confidence interval

a well-defined sign of interstitial syndrome; however, the number and severity of B-lines, as well as their clinical significance, may elicit subjective interpretations. Some US applications have inherently greater inter-rater variability in interpretation. Thus, some applications may be classified as advanced, requiring greater experience and understanding than others to interpret and accurately apply in clinical scenarios.

An important point to consider in this investigation is that the most critically ill dyspneic patients were not enrolled in the study. Table 1 shows that 56 patients (54% of all patients enrolled) rated their dyspnea severity an 8 or higher on a 10-point Likert scale. Previous studies have highlighted the positive impact US has had on the clinical impression of critically ill dyspneic patients. Our results suggest that US may not have a similar diagnostic impact in patients with mild-to-moderate disease. Furthermore, given the variability of US training level in the physician providers enrolled, the use of POCUS for patients with mild-to-moderate dyspnea severity may not be as helpful as suggested in previous studies with higher percentages of dyspneic patients with severe cases of disease.

The implication for clinical practice is that bedside cardiopulmonary US may be useful and change patient management. Findings may be misleading and should not be used without proper training and adequate awareness of the limitations of both imaging and sonographer. ECG and chest radiography, for example, are operator dependent as well. It should be emphasized here that the integration of bedside US in the hands of non-specialists, as well as the degree of training required for this purpose, remains to be determined.

While no definitive conclusions can be drawn, the study does raise questions for further consideration and investigation. Results imply that US may only be accurate for specific diagnoses in experienced hands, while its ability to narrow a differential diagnosis may be possible for sonographers of varied skill levels. This study suggests that in the hands of non-US specialists, US may be diagnostically misleading. Larger studies on clinical bedside US's influence on non-expert physician-sonographer's decision-making process would be valuable to investigate this claim.

Prospective studies should randomize patients to diagnostic treatment arms supplemented with POCUS, similar to the strategy executed by Laursen et al. in 2014.[23] In their study, dyspneic patients were enrolled by both vital signs and symptoms, and were randomly assigned to a standard diagnostic strategy (control group) versus standard diagnostic strategy with POCUS imaging of the heart, lungs, and deep veins of the lower extremities (treatment group). Furthermore, prospective studies should include severely dyspneic patients who cannot provide a history and/or consent, or who require emergent endotracheal intubation; these considerations would potentially demonstrate US's diagnostic efficacy.

LIMITATIONS

There are several study limitations worth noting. A subgroup analysis of specific factors may refine the study's results; these include patient severity of disease on presentation and the variable experience level of the sonographers. Determining the specific US view(s) (i.e., specific cardiac and/or lung windows) or US finding(s) that had the greatest influence on the diagnosis may clarify the value of the study's US protocol. It is likely that severe disease will be more obvious on US examination, compared to mild to moderate disease. It is also likely that less pre- to post-US change is found in dyspneic patients with obvious clinical presentations, where the diagnosis is suspected before the US; it is in patients where there is significant diagnostic uncertainty where the US protocol has significant potential to change provider's diagnosis and their confidence in their diagnosis.

A subgroup analysis of specific US images (read later by experienced emergency US faculty) would clarify whether equivocal results were a result of incorrect image interpretation. It would also determine whether the clinical bedside environment influenced image interpretation. This analysis was not performed. Furthermore, patients may have had multiple co-diagnoses (i.e., COPD and CHF), which may have confounded the results. The study is also biased toward mildly to moderately dyspneic patients with potentially more subtle pathologies. Larger numbers would be needed to further elucidate the effect of these limitations.

CONCLUSION

Bedside US did not improve the diagnostic accuracy in physicians treating ED patients with acute undifferentiated dyspnea in the present study. The incorporation of clinician-performed bedside US for acutely dyspneic patients, however, may help narrow the clinician's differential diagnoses and change the diagnostic and/or therapeutic plan in half of cases. Bedside US did not affect the actual diagnosis based on the clinical assessment and US imaging when compared to the final diagnosis; however, larger studies on clinical outcomes and decision-making effects of clinician-performed bedside US for patients with acute dyspnea may be necessary to further elucidate the trends suggested by our data. Results suggest that in dyspneic patients with mild-to-moderate severity of disease, cardiopulmonary US may not be as diagnostically impactful on the clinical impression of the provider when compared to studies of patients with higher severity of disease.

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Gender Differences in CDC Guideline Compliance for STIs in Emergency Departments

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Introduction: Sexually transmitted infections (STIs) are a common reason for emergency department (ED) visits. The objective of this study was to determine if there were gender differences in adherence to Centers for Disease Control and Prevention (CDC) STI diagnosis and treatment guidelines, as documented by emergency providers.

Methods: We performed a retrospective chart review to identify patients treated for urethritis, cervicitis, and pelvic inflammatory disease (PID) in the EDs of three hospitals in a Pennsylvania network during a calendar year. Cases were reviewed to assess for compliance with CDC guidelines. We used descriptive statistics to assess the distributions of study variables by patient sex. In the analysis we used Student's t-tests, chi-square tests, and logistic regression. Statistical significance was set at $p \leq 0.05$.

Results: We identified 286 patient records. Of these, we excluded 39 for the following reasons: incorrect disease coding; the patient was admitted and treated as an inpatient for his/her disease; or the patient left the ED after refusing care. Of the 247 participants, 159 (64.4%) were female. Females were significantly younger (26.6 years, SD=8.0) than males (31.2, SD=11.5%), (95% confidence interval [CI] [2.0- 7.0], p=0.0003). All of the males (n=88) in the cohort presented with urethritis; 25.8% of females presented with cervicitis, and 74.2% with PID. Physician compliance for the five CDC criteria ranged from 68.8% for patient history to 93.5% for patient diagnostic testing, including urine pregnancy and gonorrhea/chlamydia cultures. We observed significant differences by patient sex. Fifty-four percent of the charts had symptoms recorded for female patients that were consistent with CDC characteristics for diagnostic criteria compared to over 95% for males, OR=16.9; 95% CI [5.9-48.4], p<0.001. Similar results were observed for patient discharge instructions, with physicians completely documenting delivery of discharge instructions to 51.6% of females compared to 97.7% of complete documentation in males, OR=42.3; 95% CI [10.0-178.6] p<0.001). We observed no significant sex differences in physician documentation for physical exam or for therapeutic antibiotic treatment.

Conclusion: This retrospective study found patient gender differences in how emergency providers complied with documenting with regard to the 2010 CDC guidelines for the diagnosis and treatment of urethritis, cervicitis, and PID. Specifically medical records of men were more likely to have complete documentation of symptoms recorded (95% CI 5.9-48.4) and to have discharge instruction documentation (95% CI 10.0-178.6) than records of women. [West J Emerg Med. 2017;18(3)390-397.]

INTRODUCTION

According to a recent report by the Centers for Disease Control and Prevention (CDC), the rate of infection of sexually transmitted diseases (STIs) is rising; as compared to 2013, the rates of infection of chlamydia and gonorrhea increased by 2.8% and 5.1%, respectively in 2014.[1] This amounted to over 1.4 million cases of chlamydia and over 350,000 cases of gonorrhea reported in 2014.[1] STIs are a common reason for emergency department (ED) visits.[2] In fact, up to 7% of patients seeking treatment for STIs do so in EDs.[3] Furthermore, each year there are 171,000 adolescent ED visits for STIs.[4] Women who develop a chlamydial or gonorrheal infection of the upper genital tract, also known as pelvic inflammatory disease (PID), are at increased risk for long-term sequelae including infertility and ectopic pregnancy.[2] Men with untreated STIs can continue to transmit infections to others.[5] Due to both the high incidence of ED visits for STIs and their potentially serious complications, ED providers must be adept at properly diagnosing and treating them.

The need to recognize and adjust for sex and gender differences is a growing topic in medical research. In fact, in 2015 the National Institutes of Health announced a new funding policy, stating that sex must be accounted for as a biological variable in research designs submitted after January 25, 2016.[6] Despite this increasing focus on gender differences, a recent literature review found that only 18% of emergency medicine (EM)-related studies examined health outcome by gender, and that only 2% of studies included gender in the primary hypothesis.[7] Additionally, this review determined that EM-based gender research lagged behind many other medical specialties including general medicine, cardiology, and oncology. Because EDs experience 136 million patient visits annually, emergency physicians (EP) have the opportunity to be a leading source of gender-based research that will optimize and individualize outcomes for patients in the acute care setting.[8] In respect to terminology, while "sex" is the preferred term in basic science research, in this manuscript we have used the terms male/female or "gender" – referring to the socially constructed biological roles of an individual based on their XX or XY status, as it is more commonly used by clinicians.

We chose to assess for gender differences in physician compliance with the CDC's 2010 guidelines for diagnosing and treating STIs. In particular, we evaluated EP-documented compliance across five domains – -history, physical exam, diagnostic testing, antibiotic treatment, and discharge instructions – to assess for differences by patient gender.

The objective of this study was to perform a chart review to determine if there were gender differences in adherence to CDC STI diagnosis and treatment guidelines as documented by emergency providers for the diagnoses of urethritis, cervicitis, and PID in the ED.

Population Health Research Capsule

What do we already know about this issue?
Sexually transmitted infections (STIs) are a common reason for emergency department (ED) visits.

What was the research question?
Are there gender differences in compliance with CDC STI diagnosis and treatment guidelines as documented by emergency providers?

What was the major finding of the study?
Physicians were more likely to document compliance with CDC guidelines for evaluation and treatment of STIs (95% CI 5.9-48.4) and to have discharge instruction documentation (95% CI 10.0-178.6) for men compared to women.

How does this improve population health?
Raising awareness may serve as a catalyst to improve patient care. Our findings should encourage clinicians to be more attentive to documentation.

METHODS

Following network institutional review board (IRB) approval, we performed a retrospective chart review to identify all patients treated for urethritis, cervicitis, and PID in the EDs of three affiliated hospitals in Northeastern Pennsylvania from January 1, 2011, to December 31, 2011. These three sites have a combined ED census of greater than 185,000 visits per year (Table 1). Patients were identified by International Classification of Diseases (ICD-9) discharge diagnosis code. Included in the study were discharged patients over the age of 14 with the following ICD-9 codes: 098.00 through 098.39 for gonorrhea; 099.50 and 099.53 through 099.55 for chlamydia; 597.80 and 597.89 for urethritis; 614.90 for PID; and 616.0 for cervicitis. We reviewed the included cases as described using standard methods for chart reviews[9] to assess for compliance with 2010 CDC guidelines that were used in the ED setting and determined to be essential for documentation across five domains: 1) history; 2) physical exam; 3) diagnostic testing including urine human chorionic gonadotropin (hCG), and gonorrhea and chlamydia cultures;

Table 1. Hospital site comparisons in study of gender-based differences in following guidelines for STI treatment.

Site	Annual ED census	Character
1	100, 000	Level 1 trauma center
2	45,000	Suburban hospital
3	20,000	Inner city hospital

STI, sexually transmitted infections; *ED,* emergency department

4) antibiotic treatment; and 5) discharge instructions. The study principle investigator trained abstractors (EM residents and attendings, coordinators and research associates) using explicit protocols of inclusion and exclusion before data collection was initiated and variables were precisely defined. A standardized abstraction form (IRB approved) was used to guide data collection. Regular meetings with the study team (including abstractors) to review project status occurred during the study period. Abstractors were aware of the protocol to detect compliance with CDC guidelines for STIs but were blinded to the study goal of determining gender differences. Each chart was reviewed again by a single research associate who completed a second abstraction form. Abstracted data from both reviews were assessed by one senior (attending physician) study investigator, and any minor discrepancies were resolved by a third chart review by the senior study investigator. Because the abstraction process was extensive (all charts reviewed twice, some three times), we did not conduct formal statistical analysis of interrater reliability.

Of note, this was a secondary analysis of a prior study that analyzed whether compliance with CDC guidelines improved when an electronic medical record (EMR) was implemented as compared to a study in which handwritten, non-templated charting was used. [10, 11]

We assessed compliance with 2010 CDC standards across five domains for cases of urethritis, cervicitis, and PID.[5] The outcomes evaluated included documentation of historical and diagnostic components, diagnostic testing, treatment provided, and follow-up instructions. Specifically, for urethritis, historical components included dysuria, urethral pruritus, or discharge. Physical exam findings were discharge of mucopurulent or purulent material. Diagnostic testing included obtaining cultures for gonorrhea and chlamydia. Antibiotic regimens were compared with CDC standards (Figure 1). Proper discharge instructions required safe-sex

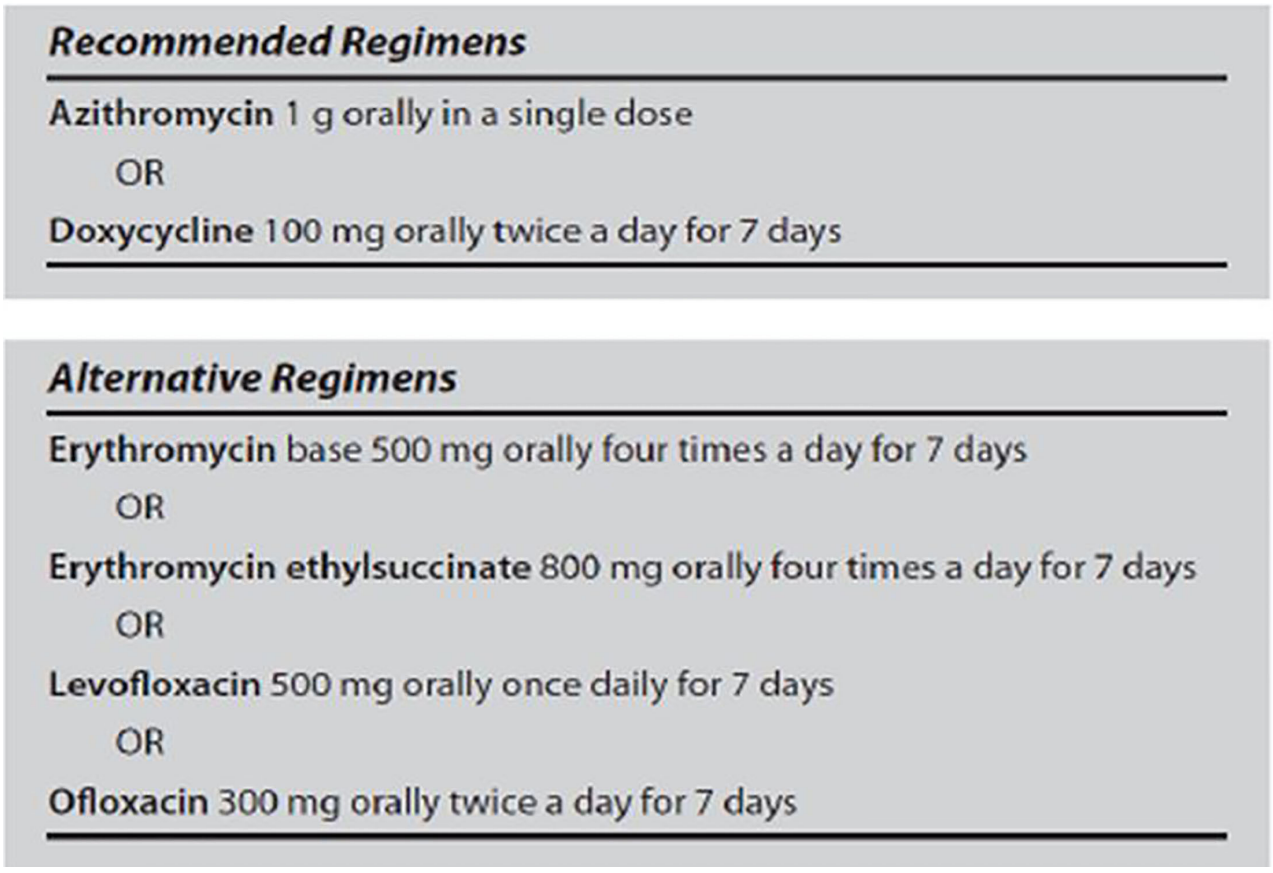

Figure 1. 2010 urethritis and cervicitis guidelines[5].

instructions. For cervicitis, diagnostic components included having a mucopurulent or friable cervix along with a history not suggestive of PID; patients must not have experienced a history of abnormal vaginal bleeding, dyspareunia, vaginal discharge or abdominal pain. Similarly, physical exam documentation required ruling out findings for PID, including a documented fever or experiencing any tenderness of the lower abdomen, adnexa or with cervical motion. Diagnostic testing included obtaining cultures as well as a pregnancy test. Antibiotic regimens and discharge instructions were the same as for urethritis. For PID, historical components and physical exam findings applied appropriately were as listed for cervicitis above. Diagnostic testing included cultures and a pregnancy test. Antibiotic regimens were compared with CDC standards (Figure 2). Discharge instructions included safe-sex instructions, follow-up, and return instructions.

We used descriptive statistics and graphical methods to assess the distributions of study variables by patient sex. Student's t-tests and chi-square tests were used to evaluate the associations between study variables and patient sex. In addition, we used logistic regression to assess differences in physician documentation of the CDC 2010 guidelines by patient sex while controlling for patient age. Statistical significance was set at $p \leq 0.05$. We performed all analyses with Stata v14.0, Stata Corporation, College Station, TX.

RESULTS

We identified a total of 286 patient records. Of these, we

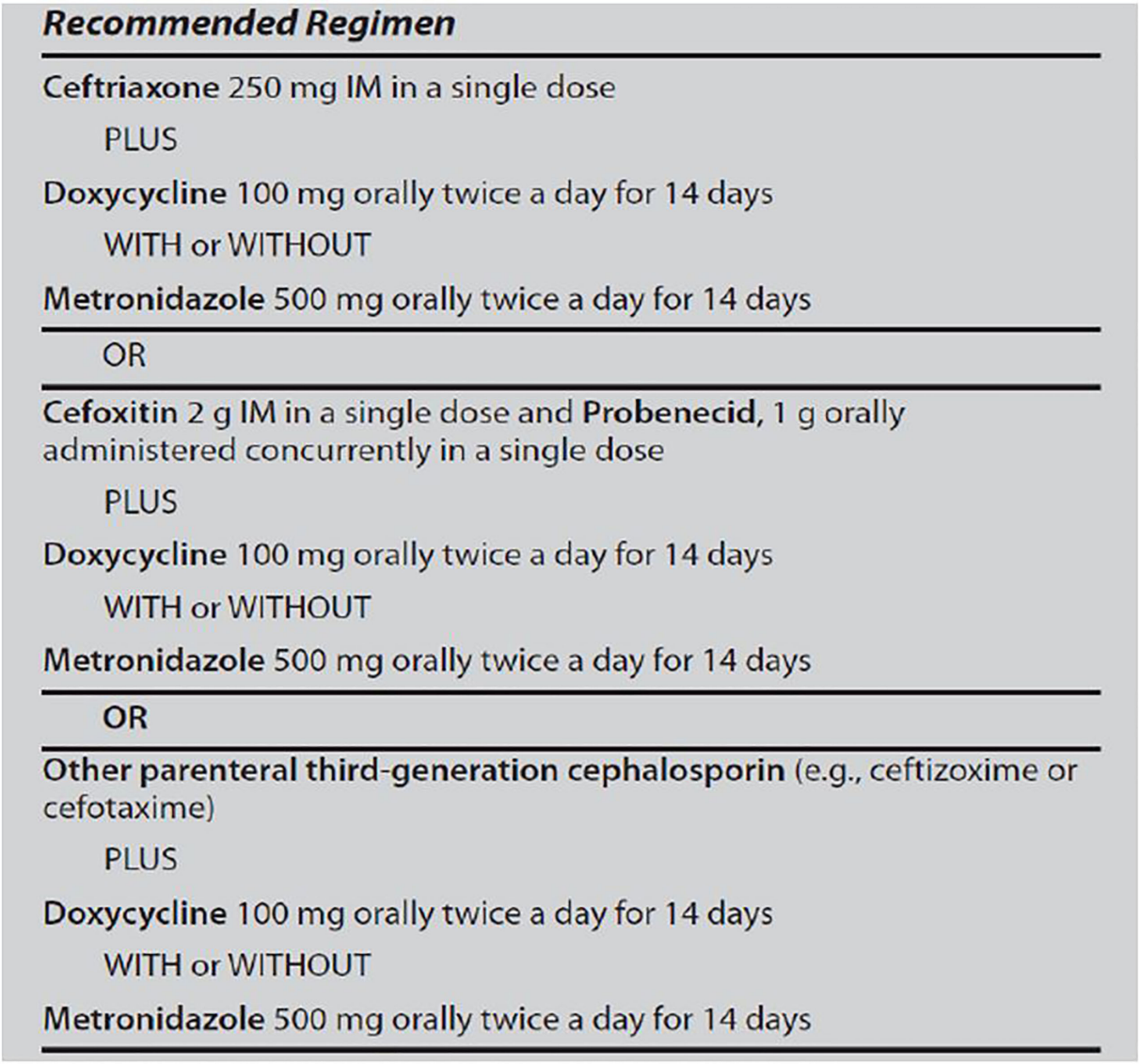

Figure 2. 2010 CDC guidelines for treatment of pelvic inflammatory disease[5].
CDC, Centers for Disease Control and Prevention.

excluded 39 due to incorrect disease coding (n=14), or because either the patient was admitted and treated as an inpatient for his/her disease (n=22) or left the ED after refusing care (n=3). The resultant sample size included 247 participants. Of the 247 participants, 159 (64.4%) were female. Females were significantly younger (26.6 years, SD=8.0) than males (31.2, SD=11.5%), (95% confidence interval [CI] [2.0-7.0], p=0.0003). By definition, all of the males (n=88) in the cohort presented with urethritis, whereas 25.8% of females presented with cervicitis, and 74.2% with PID.

The distribution of physician documentation compliance with CDC 2010 guidelines for treatment of STIs by patient sex are presented in Table 2. Physician compliance for the five CDC criteria ranged from 68.8% for patient history to 93.5% for patient diagnostic testing including urine *human chorionic gonadotropin (*hCG), gonorrhea, and chlamydia cultures. We observed significant differences by patient sex. Fifty-four percent of physician histories for female patients were compliant with the CDC guidelines, compared to over 95% for males, OR=16.9; 95% CI [5.9-48.4], p<0.001. Similar results were observed for patient discharge instructions, with physicians completely documenting delivery of discharge instructions to 51.6% of females compared to 97.7% of complete documentation in males, odds ratio (OR)=42.3; 95% CI [10.0-178.6], p<0.001. Documentation for diagnostic testing was marginally higher for female patients (96.8% versus 87.5%, p=0.011). We observed no significant sex differences in physician documentation for physical exam or for therapeutic antibiotic treatment.

DISCUSSION

Our study identified significant patient gender differences in multiple aspects of emergency provider compliance with the 2010 CDC guidelines for the diagnosis and management of STIs. While it is reassuring that the therapeutic compliance category is not different between genders, the documented historical data and discharge instructions for males were significantly more compliant with CDC guidelines than for females. The finding that only 51.6% of females received CDC-compliant discharge instructions as compared to 97.7% of males is especially concerning. Because untreated chlamydia infections and cervicitis can progress to PID and incorrectly treated PID in women places them at risk for increased morbidity and mortality from conditions such as infertility or ectopic pregnancy,[2] it is a compelling public health interest that women receive appropriate treatment, instructions for follow-up and reasons to return to the ED. Raising awareness and drawing attention to this problem through the results of this study optimally serves as a catalyst to potentiate improved patient care. Specifically, our findings should compel clinicians to be more attentive to documentation. For instance, we must be clear about the importance of documenting follow-up for these patients to prevent disease progression, incomplete treatment or untoward

Table 2. Distribution of compliance with CDC 2010 guidelines for treatment of sexually transmitted disease by patient sex.

Compliance criteria categories	Coding	Female	Male	Total	OR (95% CI)*	p-value
History						
	No (ref)	73 (45.9%)	4 (4.6%)	77 (31.2%)	--	--
	Yes	86 (54.1%)	84 (95.5%)	170 (68.8%)	16.9 (5.9-48.4)	<0.001
Physical exam						
	No (ref)	49 (30.8%)	20 (22.7%)	69 (27.9%)	--	--
	Yes	110 (69.2%)	68 (77.3%)	178 (72.1%)	1.5 (0.8-2.7)	0.222
Diagnostics						
	No (ref)	5 (3.2%)	11 (12.5%)	16 (6.5%)	--	--
	Yes	153 (96.8%)	77 (87.5%)	230 (93.5%)	0.2 (0.1- 0.7)	0.011
Therapeutic						
	No (ref)	12 (7.6%)	8 (9.1%)	20 (8.1%)	--	--
	Yes	147 (92.5%)	80 (90.9%)	227 (91.9%)	0.8 (0.3-2.0)	0.592
Discharge instructions						
	No (ref)	77 (48.4%)	2 (2.3%)	79 (32.0%)	--	--
	Yes	82 (51.6%)	86 (97.7%)	168 (68.0%)	42.3 (10.0-178.6)	<0.001

CDC, Centers for Disease Control and Prevention; *OR*, odds ratio.
*All odds ratio estimates were adjusted by participant age. In the models, females were coded as zero and males coded as 1. The odds ratios are to be interpreted as the odds of charting compliance for male relative to female patients.

complications during pregnancy (ectopic). While necessary for pure clinical outcomes, documentation is also important from a medical legal perspective: absence of documentation is interpreted as absence of care delivered.

One could argue that compliance was lower in history and discharge documentation for PID as compared to urethritis because PID required more data points in these two domains. However, PID also required more data points for physical exam documentation, yet our study found no sex difference in this domain. Furthermore, cervicitis and PID both required more documentation for diagnostic testing than did urethritis, yet in this domain EPs were actually found to be more compliant for females than males (96.8% versus 87.5%). Therefore, these unaccounted-for gender differences in historical data and discharge instructions illustrate real yet unexplained trends that require further research before they can be fully understood and resolved.

Poor physician compliance with CDC guidelines for PID has been documented elsewhere in the literature. In 2011, Shih et al. examined over 1.6 million patients discharged from EDs nationwide with the diagnosis of PID and found that ED providers were only adherent with CDC antibiotic guidelines in 30.5% of cases.[12] Although that study did not compare its outcomes to those of male patients, it does coincide with our findings that physicians require more familiarity with essential guidelines to ensure better patient care. In terms of gender differences in guideline compliance, a 2014 study by Manteuffel et al. analyzing the pharmacy claims for 29.5 million U.S. adults determined that women were consistently less likely to be prescribed guideline-based medications for diabetes and cardiovascular conditions.[13] Most strikingly, they found that of the adults with coronary artery disease, only 59% of women were prescribed a cholesterol-lowering medication as compared to 71.5% of men.[13] The unexplained gender differences found in our study echo those found in this much larger study, indicating a real disparity that might very well impact the clinical outcomes of those affected.

There is also a growing body of EM literature demonstrating gender differences in many common EM topics. Chen et al. found that women presenting to the ED with acute abdominal pain were 13-25% less likely than men to receive opioid analgesia.[14] Additionally, they found that the women who did receive opioids waited on average 16 minutes longer than men to receive them.[14] Furthermore, a study by Chang et al. determined that men presenting with acute coronary syndrome were more likely to undergo cardiac catheterizations (adjusted OR,1.72; 95% CI [1.40-2.11]) and stress tests (adjusted OR, 1.16; 95% CI [1.01-1.33]) than women.[15] Finally, a recent study by Ryoo et al. that surveyed 27.9 million U.S. ED visits related to drug use determined that men were more likely than women to be referred to detoxification programs, even after controlling for patients who presented "seeking detox."[16] Although there is a growing recognition of gender differences in EM, very little else has been published about gender differences in STI management in the ED. Thus, our findings help highlight yet one more aspect of EM that requires further analysis to identify and alleviate gender differences. Interestingly, the historical cohort our study emulated also found that women were less likely to receive appropriate discharge instructions for cervicitis.[10] This indicates that despite the use of a templated EMR, gender differences continue to exist in discharge instructions for patients treated for STIs.

Of note also is the difference in diagnostic testing compliance (more consistent in female patients than male). It is unclear why this difference exists, and this offers an area of opportunity for future study. There are multiple other directions to consider for future study. Most pressingly, there is a continued need to identify and correct gender differences in documentation (particularly discharge instructions) to prevent adverse medical outcomes. Additionally, evaluation of the CDC guidelines themselves for gender differences should be reviewed. At first blush, a persistent difference between recommendations regarding HIV/syphilis testing is present in both the 2010 and the newer 2015 CDC guidelines for urethritis and cervicitis (i.e., men have formal recommendation and women do not).[5,17]

It might also be worthy to assess how physician gender interacts with patient gender to affect outcomes. Some progress has been made in this area already. A prospective, multicenter study of 840 patients by Safdar et al. found that male EPs were more likely to prescribe opioids to males, and that female EPs were more likely to prescribe opioids to females.[18] Furthermore, Napoli et al. found that male EPs were significantly less likely to stress-test female patients with chest pain (OR, 0.82; 95% CI [0.68–0.99]).[19] With regard to gender differences in STI guideline adherence, future studies might discover interesting findings about how physicians' own genders might impact their comfort in correctly performing exams, and level of comfort in discussing STIs with different patient genders.

LIMITATIONS

One limitation of our study was that it was geographically restricted to three hospitals in Northeastern Pennsylvania. It is unclear how our study population compares to the overall population of individuals with STIs in the U.S. as a whole; thus, these results might not be generalizable. We also studied only care in the ED; it is unknown if patients presenting to the ED for these ICD-related complaints fundamentally are different from patients presenting to a primary care office or urgent care with similar symptoms. Additionally, we do not know what impact that having a female/male provider had on the findings in our study; we were unable to assess this because the majority of patients had multiple providers (residents, mid-level providers, and/or attending physicians).

Also, this is a convenience sample and the impact of the sampling method on the results we report is unknown.

Furthermore, we did not study HIV/syphilis or trichomonas; the outcomes of physician documentation for these diseases are not known. Also, the impact of subtle (asymptomatic) differences in clinical presentations between men and women on physician documentation is not known. Furthermore, no effort was made to control for the difference in disease complexity between urethritis and PID. Additionally, there may have been some cases in which delivered care and follow-up instructions were done and not documented. Additionally, in the time frame between study initiation and completion, the CDC revised their recommendations for diagnosis and treatment of STIs.[17] While there were few overall changes between the 2010 and 2015 guidelines, the impact on the study outcomes is not defined. Additionally, because our study was a retrospective chart review, it is subject to the limitations inherently found in these types of studies.

CONCLUSION

This retrospective study found patient gender differences in how emergency providers complied with documenting with regard to the 2010 CDC guidelines for the diagnosis and treatment of urethritis, cervicitis, and PID. Specifically medical records of men were more likely to have complete documentation of symptoms recorded (95% CI 5.9-48.4) and to have discharge instruction documentation (95% CI 10.0-178.6) than records of women.

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Correlation of Physical Exam Findings with Fever in Patients with Skin and Soft Tissue Infections

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Introduction: The objectives of this study were to determine the prevalence of fever in adult ED patients with skin and soft tissue infections (SSTI) and to determine which, if any, physical exam, radiograph and laboratory test findings were associated with fever.

Methods: We conducted a prospective, observational study at an urban county trauma center of adults who presented to the ED for evaluation of suspected SSTI. ED providers measured area of erythema and induration using a tape measure, and completed data sheets indicating comorbid conditions and the presence or absence of physical exam findings. Fever was defined as any recorded temperature ≥ 38°C during the first six hours of ED evaluation.

Results: Of the 734 patients enrolled, 96 (13.1%) had fever. Physical and laboratory exam findings associated with the presence of a fever in multivariable logistic regression were the area of erythema, particularly the largest quartile of area of erythema, 144 – 5,000 cm^2, (odd ratio [OR] = 2.9; 95% confidence interval [CI] [1.6 – 5.2]) and leukocytosis (OR = 4.4, 95% CI [2.7 – 7.0]). Bullae, necrosis, streaks, adenopathy, and bone involvement on imaging were not associated with fever.

Conclusion: Fever is uncommon in patients presenting to the ED for evaluation of suspected SSTI. Area of erythema and leukocytosis were associated with fever and should be considered in future decision rules for the evaluation and treatment of SSTI. [West J Emerg Med. 2017;18(3)398-402.]

INTRODUCTION

Skin and soft tissue infections (SSTI), primarily cellulitis and abscesses, are increasingly common reasons for presentation to acute care facilities and admission to inpatient hospital facilities.[1-3] Despite this commonality of SSTI, very little evidence-based literature addresses the early evaluation of SSTI, and acute care diagnosis and treatment are largely driven by traditional teaching and convention.

Medical decision-making in the emergency department (ED) is often based on the presence or absence of fever.[4] The 2005 Infectious Disease Society of America (IDSA) guidelines acknowledge that the majority of SSTIs are not of significant severity but recommend further diagnostic evaluation in patients with signs and symptoms of systemic toxicity, including fever.[5] The febrile patient with cellulitis or an abscess is much more likely to be admitted to the hospital than the afebrile patient. Sabbaj et. al. found that the presence of fever was the strongest predictor of need for hospitalization for > 24 hours.[6] Similarly, it is standard practice to admit all injection drug users (IDUs) with fever and no clear source.[4,7]

Little is known regarding SSTI physical examination findings as they relate to fever. Lonergan et. al. reported that

fewer than 25% of patients with necrotizing fasciitis have a fever on presentation.[8] The objectives of this hypothesis-generating, prospective, observational study were to determine the prevalence of fever in patients presenting to the ED with SSTI and to determine which (if any) physical exam, laboratory and radiologic findings are associated with fever.

Population Health Research Capsule

What do we already know about this issue?
Fever is a major factor in admission and treatment decisions in patients with skin and soft tissue infections (SSTI), especially in injection drug users (IDU).

What was the research question?
We sought to determine the prevalence of fever in patients presenting to the ED with SSTI and to determine patient characteristics associated with fever.

What was the major finding of the study?
Fever is uncommon in patients presenting to the ED with SSTI. Area of erythema and leukocytosis were the only characteristics associated with fever.

How does this improve population health?
Clinicians should consider these findings when considering admission and treatment decisions in patients with SSTI, especially in IDU.

METHODS

Study design, setting and participants

This was an observational, prospective study of adult patients who presented to the ED of an urban county trauma center from June 2009 to January 2013. All patients greater than 18 years of age who presented to the ED for evaluation of suspected SSTI were eligible for enrollment. At the time of this research, the hospital had an urgent care clinic open on weekdays and a wound care clinic open two days per week; patients presenting primarily to these sites were not included.

We enrolled subjects according to the availability of research assistants, primarily from 11 a.m. to 11 p.m. on weekdays. Research staff and treating clinicians identified all potential enrollees based on chief complaints and treating-provider diagnosis of suspected SSTI. Patients were excluded if no temperature was recorded in the ED chart.

Data collection

We recorded all temperatures measured in the initial six hours after ED presentation (including triage temperatures). Research assistants provided the data collection form to treating clinicians (attending physician, resident physician, or nurse practitioner), who recorded various elements of history (history of diabetes mellitus, known human immunodeficiency virus [HIV], reported history of injection drug use, prior trauma or surgery to area), physical exam (location of infection, area of erythema, presence or absence of purulence, bullae, adenopathy, streaks, necrosis), and laboratory (complete blood counts [CBC]) and imaging results (computerized tomography [CT] and plain film radiography). Treating clinicians were provided with a disposable paper centimeter ruler attached to the data collection form to measure the size of erythema and/or abscess, both recorded as total area (cm^2).

Bone involvement on imaging was considered present if the patient had radiograph or CT imaging with evidence of osteomyelitis or periosteal reaction. A patient was considered to have multiple sites of infection if more than one area of the body had evidence of SSTI.

Data Analysis

We primarily analyzed these data using standard descriptive statistics. We calculated odds ratios and 95% confidence intervals (CI) for the outcome of fever. Additionally, we performed tests of association (univariate analysis and logistic regression) to determine whether certain clinical findings, such as total area of erythema, were associated with fever. When analyzing CBC and imaging characteristics for association, we used only those patients who received those tests. We analyzed data using SAS (version 9.2; SAS Institute, Inc., Cary, NC).

RESULTS

Of the 734 patients, 96 (13.1%; 95% CI [0.8-15.7]) had fever during the first six hours of ED evaluation. Their mean age was 45 years (interquartile range 35 – 55), 77%, were male, and 246 (33.5%) were admitted to the hospital with a hospital mortality of 0.6%. Current injection drug use was reported in 30% of patients; 18% had diabetes mellitus, and 8% were known to have HIV.

Febrile patients were more commonly admitted to the hospital (77.1% versus 27.3%; mean difference 49.8%: 95% CI [39.8%-57.8%]). The mortality of febrile patients (0.7%) was similar to that of those without fever (0.6%).

The mean total area of erythema in patients without a fever was 137 cm^2 (standard deviation [SD] 378) and in patients with a fever was 187 cm^2 (SD 294). In Tables 1 and 2 we present the univariate analysis, in which the characteristics of area of erythema, leukocytosis and adenopathy were

Table 1. Univariate analysis of clinical characteristics (physical exam and laboratory findings) and fever in patients with SSTI.

	N (%)	Afebrile with finding %	Afebrile without finding %	Febrile with finding %	Febrile without finding %	OR (95% CI)	P -value
Purulence	430 (54%)	85%	87%	15%	13%	1.1 (0.8 - 1.8)	0.42
Adenopathy	143 (18%)	78%	87%	22%	14%	1.8 (1.1 – 2.8)	0.013
Bullae	81 (10%)	83%	86%	17%	14%	1.2 (0.7 – 2.3)	0.48
Multiple locations*	115 (14%)	81%	86%	19%	14%	1.5 (0.88 – 2.4)	0.15
Necrosis	37 (5%)	92%	85%	8%	15%	0.5 (0.2 – 1.7)	0.26
Streaks	116 (14%)	84%	86%	16%	14%	1.2 (0.7 – 2.0)	0.57
Leukocytosis (N = 601)	246 (41%)	69%	91%	31%	9%	4.4 (2.8 – 7.0)	<0.0001
Bone involvement on imaging (N = 406)	29 (7%)	83%	81%	17%	19%	0.9 (0.3 – 2.4)	0.81

SSTI, skin and soft tissue infection; *OR*, odds ratio.
* More than 1 SSTI location on individual patient

associated with fever. However, when controlling for covariates in multivariable logistic regression (Table 3), only leukocytosis (odds ratio (OR) 4.4; 95% CI [2.7 – 7.0]; p < 0.0001) and higher quartiles of area of erythema remained statistically associated with fever.

LIMITATIONS

Likely the greatest limitation of our study method was that we were unable to control for anti-pyretic use prior to or during ED evaluation, which may have decreased the rate of fever detected in our study. Although we captured all temperatures recorded by ED personnel in the first six hours, we may have missed spikes in temperature that were not observed by staff. We did not characterize other makers of systemic illness, such as tachycardia and tachypnea, which are also important data points in triage and treatment decisions for patients with SSTI. Finally, our ED demographics may not reflect the patients seen at other institutions, especially with regard to our large proportion of IDU patients and overall high admission rate of patients with SSTI. Many patients with minor SSTI were seen at the urgent care and wound care clinics – this spectrum bias would likely lead to an even lower rate of fever in patients with SSTI.

Table 2. Univariate analysis of area of erythema and fever in patients with SSTI.

Quartile	Presence of fever	OR (95% CI)	p-value
0.5 – 9 cm^2	8%		
10 – 30 cm^2	15%	2 (1.1 – 3.7)	0.026
32 – 140 cm^2	15%	2 (1.1 – 3.8)	0.023
144 – 5000 cm^2	20%	2.9 (1.6 - 5.2)	0.0004

SSTI, skin and soft tissue infection; *OR*, odds ratio.

DISCUSSION

Emergency medicine practitioners commonly treat patients with SSTI, and the presence or absence of fever is a major factor in admission and treatment decisions. In this prospective, observational study, we have characterized the presentations of patients with SSTIs with several findings that may impact their evaluation and management. First, we found that fever is relatively uncommon in patients with SSTIs – even in IDUs. This simple observation of prevalence of fever may be important when considering admission decisions, especially regarding the current standard practice of admitting febrile IDUs without a clear source. As expected, patients with fever were more commonly admitted to the hospital than afebrile patients. Both febrile and afebrile patient groups had very low overall mortality.

Table 3. Multivariable logistic regression analysis of patient characteristics including physical exam findings and the presence of fever in patients with SSTI.

Variable	OR (95% CI)	p – value
Age	1.0 (0.9 – 1.0)	0.39
Purulence	1.2 (0.7 – 1.8)	0.53
Adenopathy	1.5 (0.9 – 2.5)	0.10
Multiple locations	1.4 (0.8 – 2.6)	0.22
Sex	0.8 (0.5 – 1.4)	0.55
Leukocytosis	4.4 (2.7 – 7.0)	<0.0001
Area of erythema		
Quartile 2	2.2 (1.1 – 4.4)	0.026
Quartile 3	1.9 (0.9 – 4.0)	0.058
Quartile 4	2.1 (1.034 – 4.1)	0.04

SSTI, skin and soft tissue infection; *OR*, odds ratio.

Second, we determined that area of erythema and leukocytosis are the only two clinical and laboratory characteristics associated with fever. When the area of erythema was less than 9 cm^2, fever was unusual. IDUs commonly have small areas of erythema and abscess at injection sites. When evaluating IDUs with fever in the ED, practitioners should likely not attribute the fever to these minor areas of infection and should consider further evaluation and admission for the true source of fever.

Third, notable characteristics that have been stated to indicate more serious infections, such as bullae, streaks, necrosis and bone involvement on imaging, were not associated with fever. This finding is similar to that of other studies in which a minority of patients with necrotizing fasciitis and other serious infections had fever in the ED.[8]

Finally, the mortality for admitted patients was very low, precluding a meaningful analysis as to whether fever portends worse prognosis. Other investigators have similarly found low mortality rates among patients with SSTIs. Carratala et. al. found that the strongest predictor of mortality in patients with SSTIs was shock on presentation.[9]

Physical exam findings have been inconsistently used in prior studies to predict the need for hospitalization or outcomes in patients with SSTIs. In a study by Sabbaj et. al. the presence of fever was found to be a predictor of > 24-hour hospitalization in patients with non-facial SSTIs.[6] The investigators attempted to create a clinical decision rule to guide hospital admission in patients with SSTIs, but were unable to create a highly sensitive model. Schrock et. al. conducted a study to predict those patients who would fail ED observation unit placement.[10] The authors found that female patients and patients with white blood count greater than 15,000 to be more likely to require hospitalization, but other physical exam findings were not considered in the analysis.

In patients with the most severe form of SSTIs, necrotizing fasciitis, physical exam findings have also been inconsistently used in the diagnosis and the prediction of outcomes.[8,11-14] The laboratory risk indicator for necrotizing fasciitis score (LRINEC), which has been shown to predict diagnosis and outcomes in patients with necrotizing fasciitis, includes leukocytosis in the score, but does not include any physical exam finding.[11,12] Notably, fever has not been found to be a predictor of mortality or limb loss.[13] However, in another study of patients with necrotizing infections, mean percentage of body surface area has been shown to be a predictor of mortality in patients.[14]

In the United States, ambulatory care visits and hospitalizations for SSTIs have been increasing.[1,3] Given resource constraints and costs of inpatient care, appropriate disposition of patients with SSTIs is becoming increasingly important. Clinical decision rules for admission versus discharge and for triage to intensive care units have been developed for other illnesses, including infectious diseases like pneumonia.[15,16] Considering the low mortality seen in SSTI patients, future investigations to similarly develop SSTI admission criteria will require multi-center protocols with larger sample sizes.

CONCLUSION

Fever is uncommon in patients with SSTI. Of the physical and laboratory exam findings examined, only leukocytosis and area of erythema were associated with fever. Small areas of SSTIs are unlikely to be sources of fever in patients presenting to the ED. Mortality was very low in admitted patients with SSTI.

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Agreement Between Serum Assays Performed in ED Point-of-Care and Hospital Central Laboratories

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Introduction: Point-of-care (POC) testing allows for more time-sensitive diagnosis and treatment in the emergency department (ED) than sending blood samples to the hospital central laboratory (CL). However, many ED patients have blood sent to both, either out of clinical custom, or because clinicians do not trust the POC values. The objective of this study was to examine the level of agreement between POC and CL values in a large cohort of ED patients.

Methods: In an urban, Level I ED that sees approximately 120,000 patients/year, all patients seen between March 1, 2013, and October 1, 2014, who had blood sent to POC and CL labs had levels of agreement measured between serum sodium, potassium, blood urea nitrogen (BUN), creatinine, and hematocrit. We extracted data from the hospital's clinical information system, and analyzed agreement with the use of Bland-Altman plots, defining both 95% confidence intervals (CIs) and more conservative CIs based on clinical judgment.

Results: Out of 163,661 patients seen during the study period, 14,567 had blood samples sent both for POC and CL analysis. Using clinical criteria, the levels of agreement for sodium were 98.6% (within 5mg/dL), for potassium 90.7% (0.5 mmol/L), for BUN 89.0% (within 5 mg/dL), for creatinine 94.5% (within 0.3 mg/dL), for hematocrit 96.5% (within 5 g/dL).

Conclusion: Agreement between POC and CL values is excellent. Restricting the analysis to clinically important levels of agreement continues to show a high level of agreement. The data suggest that sending a serum sample to the hospital CL for duplicate assays is unnecessary. This may result in substantial savings and shorter ED lengths of stay. [West J Emerg Med. 2017;18(3)403-409.]

INTRODUCTION

Point-of-care (POC) testing has been used in various medical settings for rapid determination of a variety of laboratory values without confirmatory testing.[1-4] However, duplication of the POC test with central lab (CL) testing often occurs.[5] Many reasons have been suggested for duplicate testing, such as distrust of the POC result, preference for a "real test" and fear that consultants or admitting physicians would not rely on the POC values.[6] In the ED, duplication of POC testing is inefficient and wastes time, resources, and manpower.[7]

Potential causes of disagreement between tests may be secondary to sample collecting/handling (pre-analytical) or be related to the machine/test itself (post-analytical). Post-analytical problems are rare, as most institutions have strict guidelines and testing prior to introducing a new POC test as well as regular monitoring of all laboratory testing, including POC, to ensure ongoing accuracy. There are also strict guidelines and regulations as outlined by CLIA (Clinical Laboratory Improvement Amendments of 1988)[8] and the Joint Commission[9] to ensure the quality of laboratory testing.

Pre-analytical problems are more likely culprits of actual or perceived disagreement and generally are caused by not strictly following guidelines for obtaining blood specimens, rather than the POC device itself.[10] Hemolysis may also occur in POC testing and may accurately reflect the content of the blood tube but not the physiologic state of the patient (i.e. hyperkalemia in a hemolyzed sample); this can occur in CLs as well, though it may be more easily identified.[6]

While multiple studies have examined the impact of POC testing in the emergency department (ED),[11-14] there is limited data on the level of agreement between POC and CL testing in the ED concerning electrolytes and hematocrit values.[15] Prior literature examining testing in the intensive care unit reports varying levels of agreement with overall small sample sizes.[16] Critical to the adoption of POC testing and reduction of duplication through CL ordering is high quality data supporting good agreement between the two tests. This study was designed to measure the level of agreement between POC and CL results. Our hypothesis was that they would be sufficiently concordant to allow reduction of duplicate testing.

Population Health Research Capsule

What do we already know about this issue?
Point-of-care and central laboratory testing are often duplicated due to concerns of disagreement between the two testing modalities.

What was the research question?
Is there clinically significant disagreement between point-of-care and central laboratory testing?

What was the major finding of the study?
Agreement between point-of-care and central laboratory testing is excellent.

How does this improve population health?
High level of agreement between testing modalities can lead to reduced duplicate testing, eliminating waste.

METHODS

In an urban, Level I ED that treats approximately 120,000 patient visits/year, we examined the level of agreement between POC and CL values drawn simultaneously. The POC machine used was the iStat 1 wireless analyzer, MN: 300W by Abbott Point of Care Inc. The CL used the chemistry DDP analyzer by Roche, and for the complete blood count the CELL-DYN Sapphire by Abbott Diagnostics. For the purposes of this study, blood samples time-stamped within one hour by the CL and POC lab were considered to be simultaneous. All patients age 21 years or older treated from March 2013 to September 2014 who had blood sent to POC and CL labs had levels of agreement measured for serum sodium, potassium, blood urea nitrogen (BUN), creatinine, and hematocrit.

For each lab test, we defined, *a priori*, a range of agreement that we considered clinically sensible. The ranges of agreement were as follows: sodium 5 mEq/L, potassium 0.5 mEq/L, BUN 5mg/dL, creatinine 0.3mg/dL and hematocrit 5%. Clinical agreement was determined by a group of senior clinicians in our department. The group attempted to choose range values that would, if true, potentially impact clinical disposition, ordering diagnostic tests (creatinine), or place patients into a higher severity of electrolyte imbalance. For instance, 5mEq/L was chosen for sodium values, as a difference of this magnitude on either end of the normal sodium range 135-145mEq/L would place a patient in the moderate hyponatremia or hypernatremia category.[17,18] A similar approach was taken for potassium,[19] BUN,[20] creatinine,[21] and hematocrit.[22]

Data were extracted from the hospital's clinical information system and exported to STATA (Version 13). We analyzed agreement with the use of Bland-Altman plots, defining both 95% confidence intervals (CI) and more conservative CIs based on clinical judgment.[23-25]

The institution's Human Investigations Committee approved this retrospective study, and informed consent from patients was waived.

RESULTS

There were 163,661 patient visits in the study period, of whom 18,268 (11.2%) had at least one assay measured in both CL and POC labs. The mean age (±SD) for these 18,268 patients was 59.9±19.4 years; 50.3% were male. Further demographic details and visit characteristics are given in Table 1.

Out of 163,661 patient visits, 14,567 (8.9%) had blood samples sent both for POC and chemistry CL analysis; and 16,908 (10.3%) had POC hematocrit and CL hematocrit.

Table 2 shows the levels of clinical agreement: for sodium, 98.6%; potassium, 90.8%; BUN, 89.1%; creatinine, 94.6%; hematocrit, 96.5%. Figures 1-5 display the Bland-Altman plots for each test. The mean difference with 95% limits of agreement for each value is as follows: sodium -1.55 (-12.2, 9.1), potassium -0.10 (-1.1, 1.0), BUN -1.31 (-10.1, 7.5), creatinine -0.11 (-0.6, 0.3), hematocrit -0.37 (-6.3, 5.6). (Figures 1-5; Table 2).

DISCUSSION

In a cohort of subjects treated over 19 months at a single

Table 1. Characteristics of the sample of patients in a study comparing agreement between serum assays in the emergency department point-of-care setting vs. the hospital central lab.

Characteristic	N (%) 18,268
Age (yr) (mean, SD)	59.9 ± 19.4
Gender, n, (% male)	9179 (50.3)
Race	
White	11,043 (60.5)
Black	4,254 (23.3)
Other	2807 (15.4)
Asian	164 (0.90)
Insurance, n (%)	
Private/HMO	3,827 (20.9)
Medicaid	3,974 (21.8)
Medicare	8,471 (46.4)
Self-pay/uninsured	1,932 (10.6)
Other	64 (0.4)
Arrival by ambulance, n (%)	11,227 (61.5)
Triage acuity, ESI	
Level 1	1,098 (6.0)
Level 2	11,817 (64.7)
Level 3	5,096 (27.9)
Level 4	113 (0.6)
Level 5	4 (0.02)
ED disposition, n (%)	
Admit	13,003 (71.2)
Discharge	4935 (27.0)
Other	328 (1.8)

HMO, health maintenance organization; *ESI,* emergency severity index; *ED,* emergency department.

Table 2. Clinical agreement between central laboratory and ED point-of-care values for common blood tests

	Range	Agreement (%)
Sodium	5 mEq/L	98.64%
Potassium	0.5 mEq/L	90.75%
BUN	5 mg/dL	89.06%
Creatinine	0.3 mg/dL	94.55%
Hematocrit	5%	96.53%

BUN, blood urea nitrogen.

hospital, we found very good agreement between POC and CL values. Though overall agreement was excellent, there is some variability between individual tests. Disagreement is more common at the extremes of lab ranges. Ranges of agreement were designed to highlight agreement within normal or near-normal values. In contrast, for grossly abnormal values, greater discordance is often not clinically relevant. For example, a difference of 1 mg/dL of creatinine from 1.0 to 2.0 is clinically significant, whereas the difference between creatinines of 7.0 and 8.0 is clinically unimportant. In this study, both sets would have been flagged as clinically important disagreement.

Sodium values had the highest degree of agreement. Interestingly, a subset (n=19) of the discordant labs resulted with POC sodium values ranging from >190-220. These results, clearly in error, were included in the analysis. It is unclear what caused these abnormal results; however, it is reasonable to assume that these values were immediately recognized as lab error and samples were either rerun or sent to the lab.

Potassium had a 90.25% percent of agreement. Most discordant pairs occurred when the POC result was in the high-normal to elevated range. Among these pairs, instances of lower POC potassium were exceedingly rare.

The percent agreement of BUN was the lowest at 89%. The clinical significance of this discordance is not clear. It is noteworthy that BUN was the only test in which the majority of the normal range disagreement resulted in lower POC than CL values.

The percentage agreement of creatinine was 94.6%. A window of 0.3 was chosen with the express purpose of detecting changes in the renal function that would be actionable.

Hematocrit values had an agreement of 96.53%. Insofar as hematocrit values are often used to determine indications for transfusions of blood products, the high degree of concordance is reassuring. Most discordant pairs occurred at values greater than 30, and thus are unlikely to affect decisions to transfuse.

The data indicate that values obtained from the hospital core lab should not be considered the criterion standard. POC values are sufficiently concordant for the blood tests we examined. Insofar as all blood tests are approximations of an *in vivo* phenomenon, some minimal level of variation is to be expected.

It is also important to note that different clinical scenarios might require ranges of agreement different from those used in this study. For example, a level of agreement of 98.64% at 5 mEq/L for sodium is sufficient for most clinical scenarios. However, in cases of severe hypo- or hypernatremia, the need for slow, precise correction over hours to days may require a tighter range for agreement. However, values from either the CL or POC appear sufficiently accurate and precise to manage scenarios of deranged sodium metabolism.

Our data suggest that, for the tests we studied, CL and POC testing are sufficiently concordant so that duplicate testing is unnecessary. If patient care or disposition is dependent on a timely value, then POC testing is preferred. If blood is being drawn as part of "routine" care for an admitted patient, then the CL might be preferred, insofar as the POC typically requires

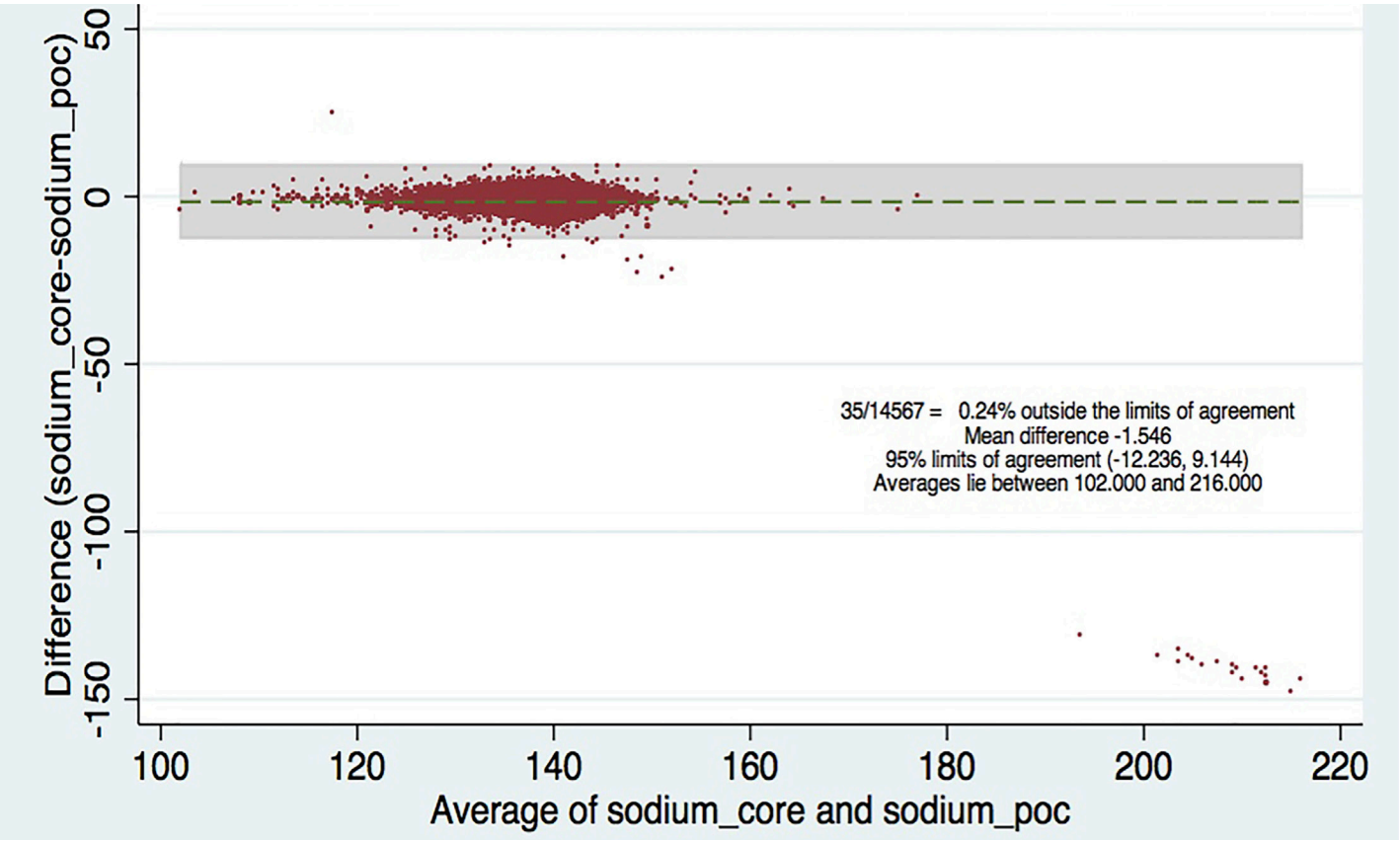

Figure 1. Bland-Altman plot for sodium. Comparing hospital central lab and emergency department point-of-care (POC) values.

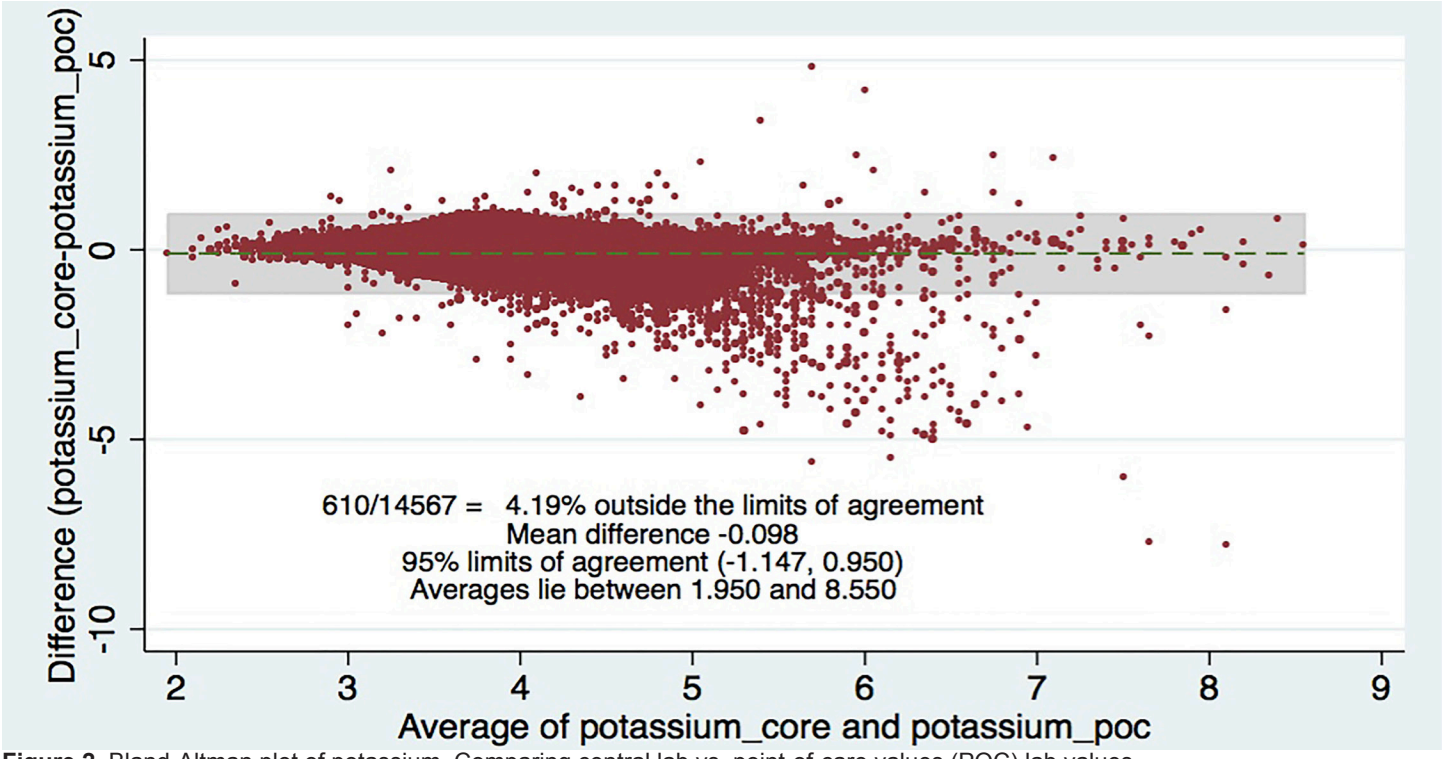

Figure 2. Bland-Altman plot of potassium. Comparing central lab vs. point-of-care values (POC) lab values.

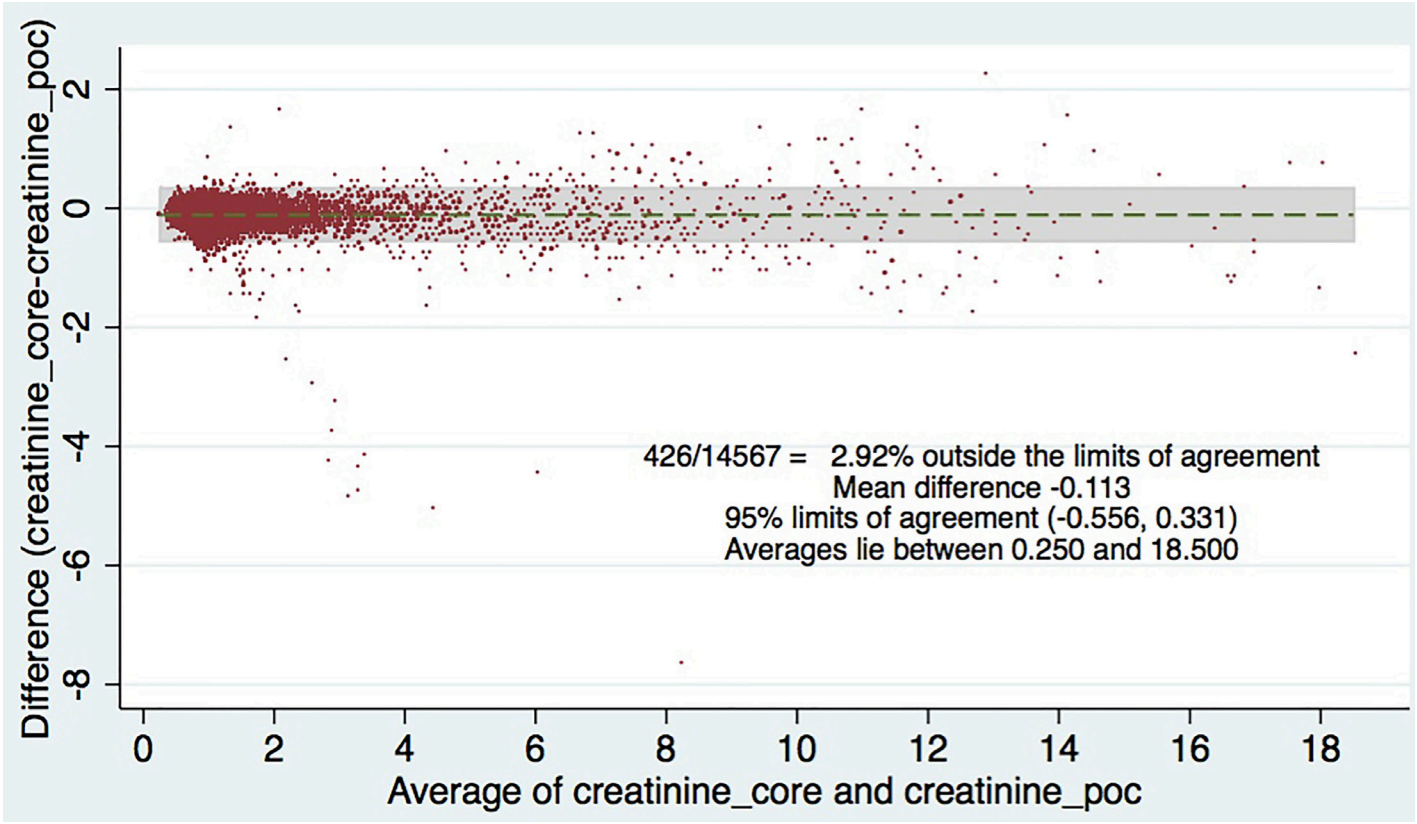

Figure 3. Bland-Altman plot of creatinine. Comparing central lab vs. point-of-care (POC) lab values.

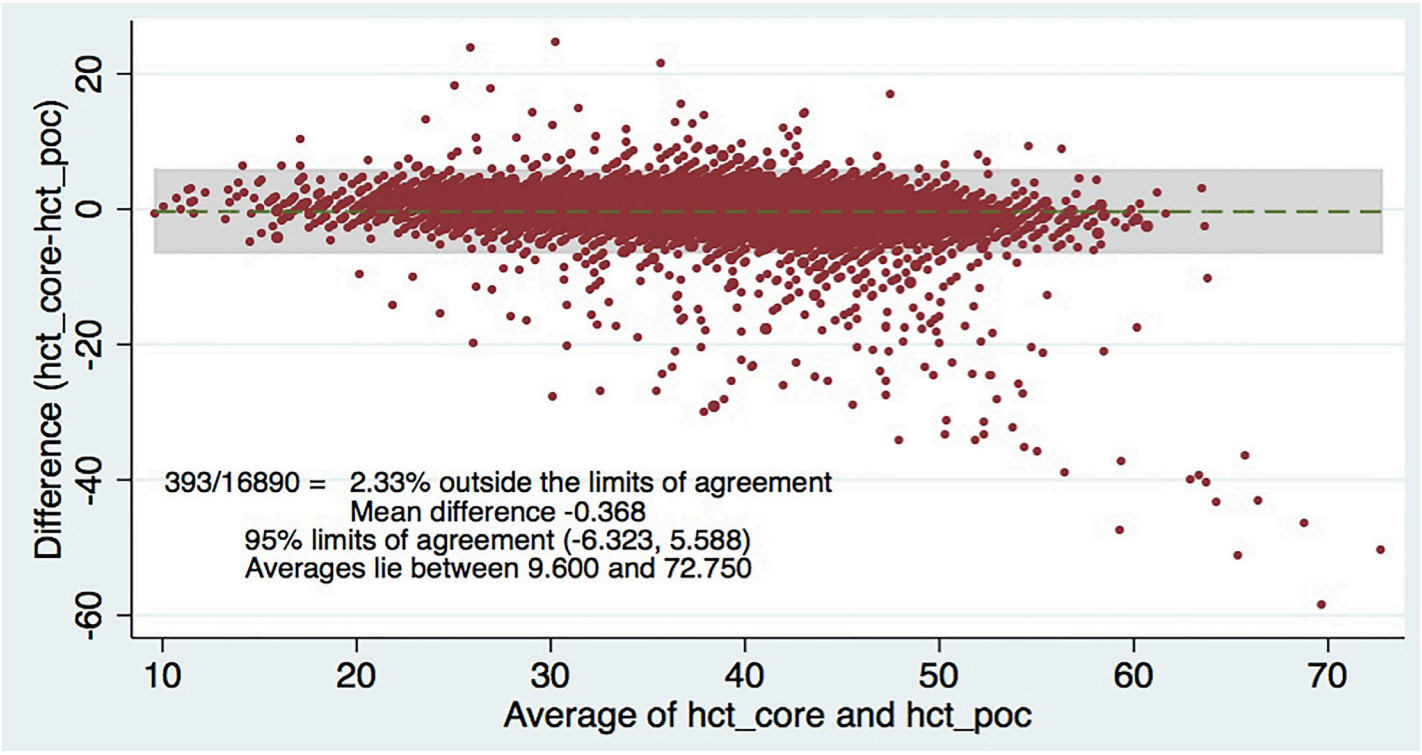

Figure 4. Bland-Altman plot for hematocrit (HCT). Comparing central lab vs. point-of-care (POC) lab values.

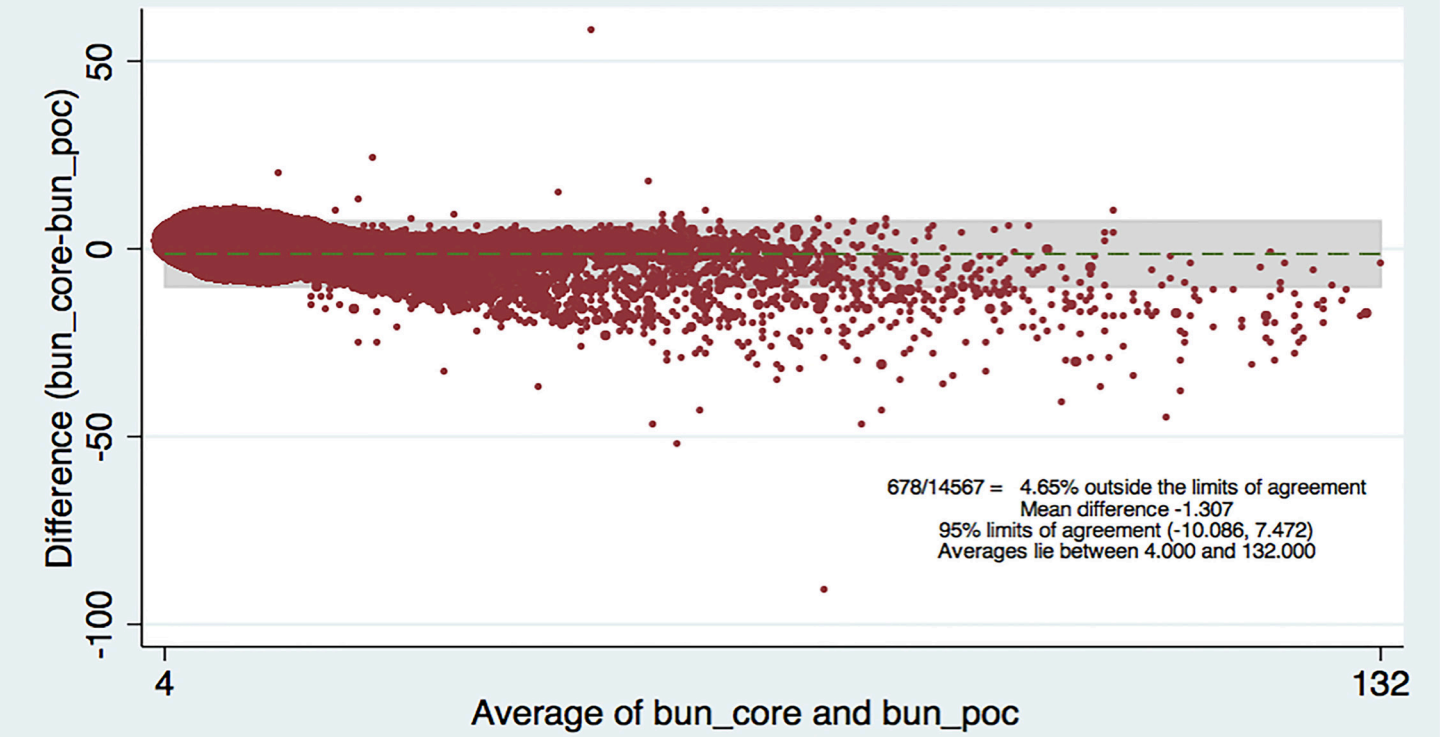

Figure 5. Bland-Altman plot of blood urea nitrogen (BUN). Comparing central lab vs. point-of-care (POC) lab values.

time and effort from ED nurses and nursing assistants. If any test result appears unexpectedly and critically abnormal, then it should be repeated, irrespective of which lab runs it.

Reduction of duplicate testing may result in significant savings of cost and effort, and improved patient flow through the ED. Based on our data (18, 268 duplicated studies in a 19-month time frame) and assuming a lab test cost of $14.37 for a chemistry study based on 2014 Medicare reimbursement values,[26] the annual cost savings would be $165,796/year. By improving the efficiency and timeliness of care, reduction of duplicate testing enhances two of the domains of quality of care, defined by the Institute of Medicine.[27]

LIMITATIONS

There are several limitations in this study. The retrospective design required the use of time-stamp proxies within the electronic medical record to locate the duplicate pairs. We chose one hour as a clinically sensible time range within which lab tests might be considered to yield comparable results. Another limitation is the use of time-stamp data as a proxy for time of venipuncture. For CL samples, the time represents the time of arrival in the lab; for POC samples, it represents the time the test was run. The difference between those two times is less than one hour, and likely within about 15 minutes. Hence, time stamp is likely a reasonable proxy for time of venipuncture.

Another limitation is the lack of universally agreed-upon ranges of clinically significant agreement. In this study, ranges of clinical agreement were determined by a group of experienced emergency physicians, with the goal of defining ranges that would not change practice. Others may define slightly different ranges of clinical concordance. Additionally, one might contend that although the proportion of agreement was high, it was still not sufficient. The Bland-Altman plots can provide additional insight into the clinical implications of discordance, particularly at very high absolute values.

This single-institution study may have limited generalizability. However, our sample is diverse with respect to age, gender, race, ethnicity, and insurance. Therefore, it is likely that these results would be similar elsewhere. In any event, we offer a method by which other institutions may assess the concordance between their POC and CL blood values.

Lastly, we did not perform an economic analysis to estimate the potential cost savings from decreasing or eliminating duplicate testing.

CONCLUSION

We found a high level of clinical agreement for point-of-care and central lab chemistry tests. Duplicate ordering from POC and CLs may be unnecessary and wasteful. Using the data from this study, our institution has formed a clinical design team whose purpose is to eliminate unnecessary POC-CL testing. Education of clinicians, nurses and techs regarding study results and indications for testing is ongoing and the

ordering workflow has been adjusted to further support these efforts. Further study of these efforts and the success of individual interventions is ongoing.

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Applying Systems Engineering Reduces Radiology Transport Cycle Times in the Emergency Department

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Introduction: Emergency department (ED) crowding is widespread, and can result in care delays, medical errors, increased costs, and decreased patient satisfaction. Simultaneously, while capacity constraints on EDs are worsening, contributing factors such as patient volume and inpatient bed capacity are often outside the influence of ED administrators. Therefore, systems engineering approaches that improve throughput and reduce waste may hold the most readily available gains. Decreasing radiology turnaround times improves ED patient throughput and decreases patient waiting time. We sought to investigate the impact of systems engineering science targeting ED radiology transport delays and determine the most effective techniques.

Methods: This prospective, before-and-after analysis of radiology process flow improvements in an academic hospital ED was exempt from institutional review board review as a quality improvement initiative. We hypothesized that reorganization of radiology transport would improve radiology cycle time and reduce waste. The intervention included systems engineering science-based reorganization of ED radiology transport processes, largely using Lean methodologies, and adding no resources. The primary outcome was average transport time between study order and complete time. All patients presenting between 8/2013-3/2016 and requiring plain film imaging were included. We analyzed electronic medical record data using Microsoft Excel and SAS version 9.4, and we used a two-sample t-test to compare data from the pre- and post-intervention periods.

Results: Following the intervention, average transport time decreased significantly and sustainably. Average radiology transport time was 28.7 ± 4.2 minutes during the three months pre-intervention. It was reduced by 15% in the first three months (4.4 minutes [95% confidence interval [CI] 1.5-7.3]; to 24.3 ± 3.3 min, P=0.021), 19% in the following six months (5.4 minutes, 95% CI [2.7-8.2]; to 23.3 ± 3.5 min, P=0.003), and 26% one year following the intervention (7.4 minutes, 95% CI [4.8-9.9]; to 21.3 ± 3.1 min, P=0.0001). This result was achieved without any additional resources, and demonstrated a continual trend towards improvement. This innovation demonstrates the value of systems engineering science to increase efficiency in ED radiology processes.

Conclusion: In this study, reorganization of the ED radiology transport process using systems engineering science significantly increased process efficiency without additional resource use. [West J Emerg Med. 2017;18(3)410-418.]

INTRODUCTION

Emergency department (ED) crowding is a global issue, with myriad and well-documented negative effects on ED patient care measures, including delayed care, medical errors, increased cost, and even mortality.[1-10] In addition, capacity constraints on EDs are worsening and exacerbating the access block for many

patients to receive effective, safe, high-quality ED care.[11,12]

In its 2006 report, "Hospital Based Emergency Care: At the Breaking Point," the Institute of Medicine (IOM) recommended that systems science innovations be used to improve emergency care efficiency and quality.[1] Yet ED care systems and institutions vary widely, and the ideal solutions are not clear. In addition, patient arrival rates and inpatient bed capacity represent two important factors that are often outside the influence of ED administrators.[13,14] Thus, the most readily available potential solutions reside in systems engineering designed to improve throughput and reduce waste and waits.[15,16]

Radiology testing is a frequently used process, and a robust area of potential improvement.[17] Modeling has shown that decreasing radiology turnaround times improves ED patient throughput and decreases patient waiting time.[18] While previous research has demonstrated the effectiveness of Lean methodologies in reducing laboratory cycle times,[19,20] further research in radiology and other testing is needed, underscored by the link between ancillary testing and ED length of stay (LOS) and capacity.[21]

Population Health Research Capsule

What do we already know about this issue?
Emergency department (ED) crowding has been associated with lower quality of care. Through systems engineering approaches such as Lean methodologies, ED leaders can potentially reduce patient wait times.

What was the research question?
We sought to investigate the impact of systems engineering science targeting ED radiology transport on patient throughput times.

What was the major finding of the study?
The average radiology transport time reduced from 29 minutes to 21 minutes. This was achieved without any additional resources.

How does this improve population health?
This innovation demonstrates the potential value of systems engineering science to increase both patient safety and the patient experience by improving the efficiency of diagnostic testing.

Reducing Waste Through Systems Engineering

Systems engineering science, broadly defined as the study of designing and optimizing systems as a whole, has seen many advances in recent years. And while systems improvement tools are well established in other industries, including auto and service industries, healthcare has lagged behind, and relatively few published studies of its application exist in emergency medicine.[22-27] One example of systems engineering, known as Lean methodology, has excellent potential to improve complex systems of clinical practice while reducing waste.[22] In brief, Lean is a collection of continuous quality improvement (QI) tools, aimed at the "relentless" pursuit of reducing waste in all forms, and minimizing the non-value added activity within a system. This is achieved through focusing on individual steps in a process in a detailed fashion, usually with a multidisciplinary group of individuals involved in that process. The putative benefits include decreased wait times, increased efficiency, decreased cost, and improved patient care with fewer resources used – in short, being able to do more with less.[22-27] In this way, Lean methodologies frequently incorporate and synergize well with the application of multiple other systems engineering principles, such as demand-capacity matching, queuing theory, and flexible capacity.[22]

Emergency Radiology as a Microcosm

Emergency medicine and emergency radiology offer somewhat unique systems improvement opportunities as often, increased patient care efficiency both improves quality and reduces cost. This quality improvement manifests through the IOM domains of efficiency, effectiveness, timeliness, and safety. Emergency radiology represents an excellent model of potential improvement, and also an area in which to test approaches with broader ED applicability. ED radiology process flow typically involves multiple steps that must be conducted in series, with frequent potential for delays. In addition, while the extant literature does include some examples of using Lean methodologies to improve radiology process flow, very little has been published about ED radiology specifically.[28-32] In this initiative, systems engineering tools were used to reorganize radiology testing patient flow. We aimed to optimize the plain film radiology testing process, reduce transport time, decrease waste, and measure the effect of the intervention in a robust manner.

METHODS

Study Design

A prospective, before-and after-analysis of radiology process improvements in a hospital ED was used. As a QI initiative using anonymized data only, this study was exempted per institutional review board protocol. All adult patients seen during the study period of 8/2013 to 3/2016 were included. We defined the pre-intervention study period as three months prior to the intervention, 8/2013-11/2013. Implementation of the intervention occurred on 11/9/2013.

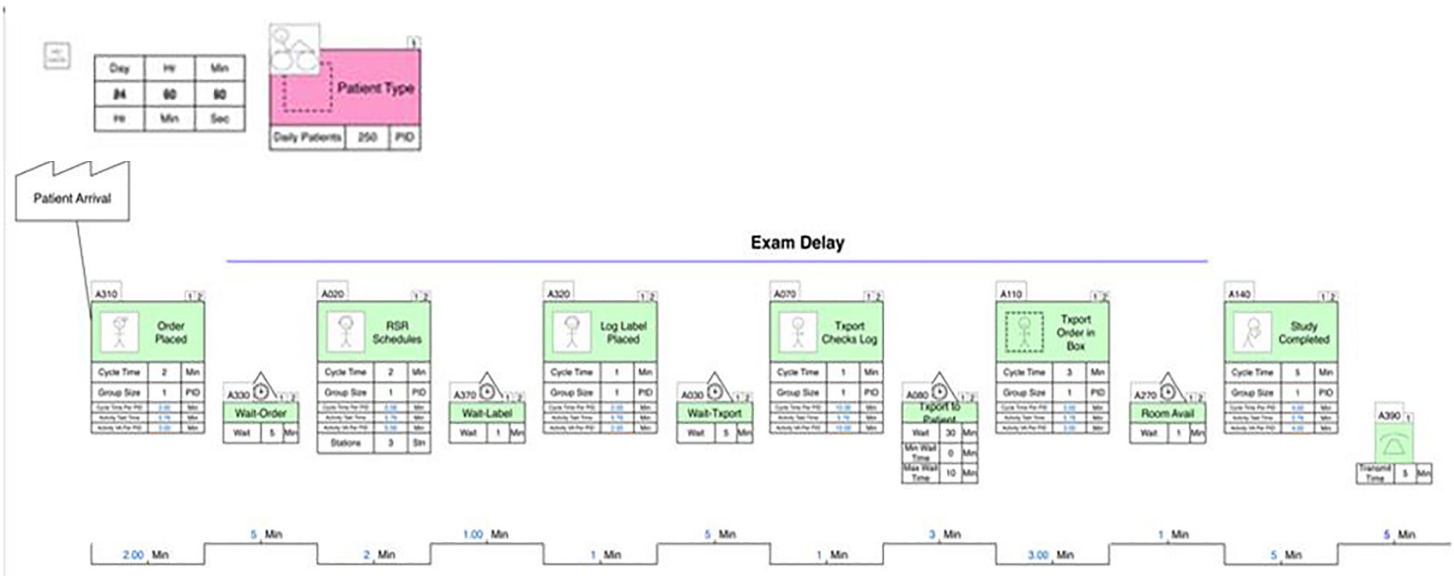

Figure 1. Pre-intervention radiology process flow. Lean value-stream map demonstrating multiple process steps required to achieve plain film radiology testing in the emergency department.

Post-intervention study periods consisted of three months immediately post intervention (11/2013-2/2014), a separate six months post intervention (3/2014-8/2014), and one full year (3/2015-3/2016), 16 months post intervention. In order to provide a large sample size, we chose a one-year period post intervention to measure the sustainability of observed effects, and to avoid seasonal bias.

Study Setting and Population

This study was performed in a large, urban, academic, hospital ED with an annual census of approximately 110,000 patient visits. The ED is a Level I trauma center for adult and pediatric patients, and a regional burn center. Approximately 31% of all visits arrive by ambulance, and approximately 26% of patients are admitted to inpatient services. Following patient arrival and registration, patient flow in the ED includes triage, evaluation in a care area, diagnosis and treatment, and disposition. Radiology studies are ordered following initial patient evaluation, and patients are then transported to the ED radiology area when radiology technologists are available to perform the study. The step-by-step testing process is described further below. We included all adult patients seen in the ED who received radiology (plain film) testing.

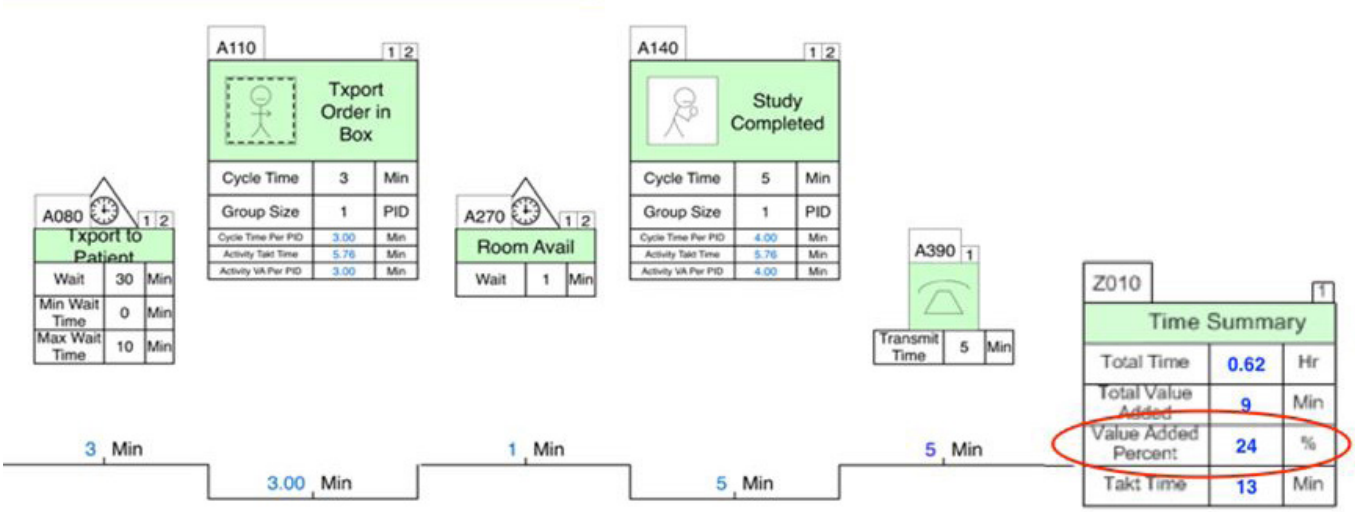

Figure 2. Pre-intervention radiology process flow value-added time summary. Lean value-stream map demonstrating the ability to calculate low value added percent time (24%) of the plain film radiology process, demonstrating opportunity for improvement.

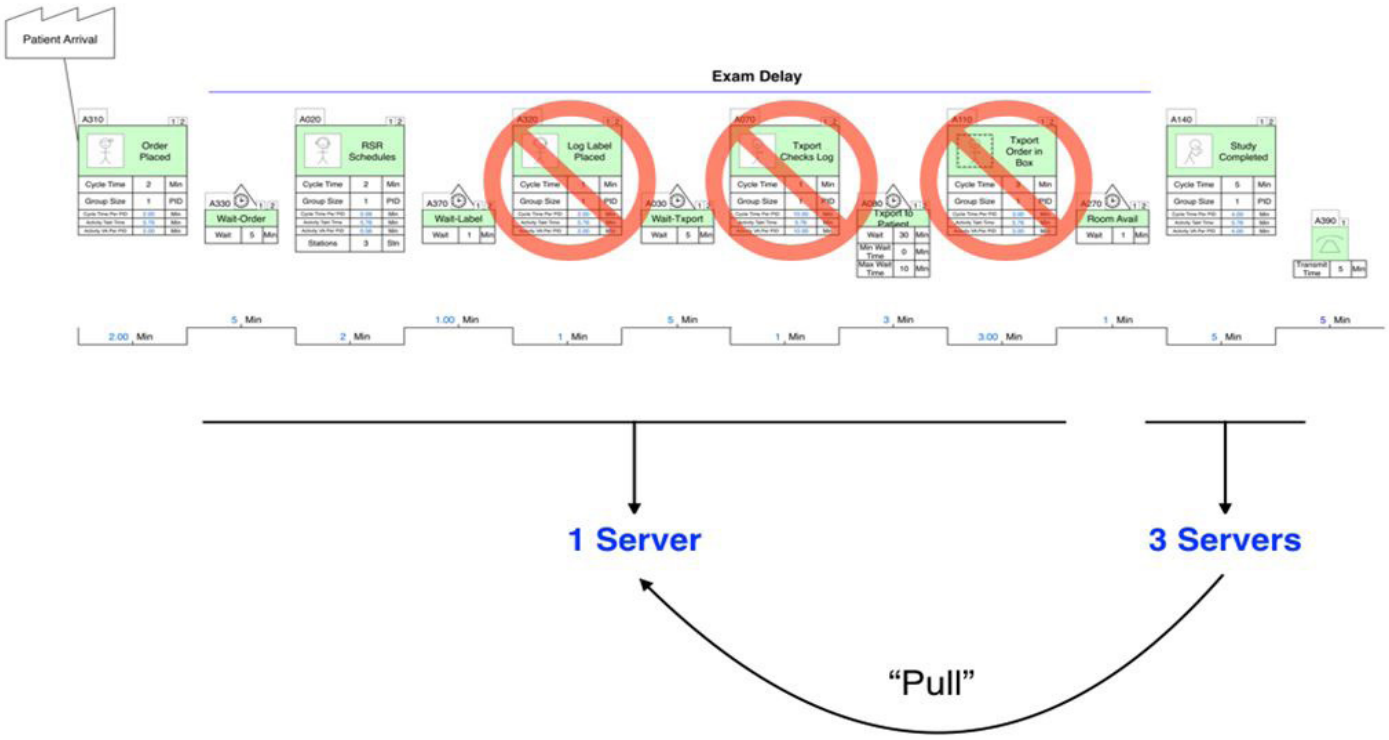

Figure 3. Post Intervention: Systems engineering-based radiology process flow. Lean value-stream map demonstrating opportunity to eliminate process steps and increase efficiency in the process, and minimize the effect of a single server queue.

Intervention

The intervention consisted of a series of process improvement steps based on Lean methodologies, and aimed at reorganizing radiology process flow. The overall aim was to eliminate non-value added waste when possible, with the goal of reducing transport delay. We used a granular, value stream mapping approach to analyze the current state (Figure 1) and identify opportunities to reduce process steps and increase value added activity (Figure 2). In our ED, as in most, a patient is registered, triaged, and then evaluated by a provider. This provider orders diagnostic testing, including plain film imaging when indicated. The order is then scheduled by the radiology scheduling receptionist and populates a queue for the radiology technologists. The patient is then transported to radiology through a number of steps (Figure 1) and then the study is performed. Each of the steps involved in performing plain film radiology following placement of an order were included in the initial process map. In addition, we used supply chain management science, queuing theory, and demand capacity matching to identify other opportunities.

This resulted in a change to a "pull" system rather than a "push" system, in which patients were actively moved to the subsequent step in their testing by the radiology technologists. In the new design, the technologist-based transport system replaced the single-server transporter, taking advantage of a pooled server approach in which any technologist not currently performing a study would find and transport the next patient in the queue. This resulted in a reduction in the number of process steps and associated bottlenecks (Figure 3).

No additions to staffing or other resources were associated with this intervention. In addition, no other significant operations changes affecting plain film ordering and transport process flow metrics were made in either the ED or ED radiology between the before-and-after measurement periods.

Methods of Measurement

The primary outcome measure was the ED radiology transport time for plain film testing. This was defined as the time interval in minutes between study order and study start time following patient transport. Data were aggregated on a weekly basis, and we used the average transport delay during each seven-day period in the analysis. The resulting sample sizes for each period were pre intervention (n=12), post intervention three months (n=13), post intervention six months (n=25), and post intervention one year (n=52).

Data Collection and Analysis

We extracted data from the Radiology Information System (RIS, Boston, MA) during the pre- and post-intervention periods. Testing data were included in the analysis if both time stamps (i.e., study order time and study complete time) were present. No data were specifically excluded from the analysis.

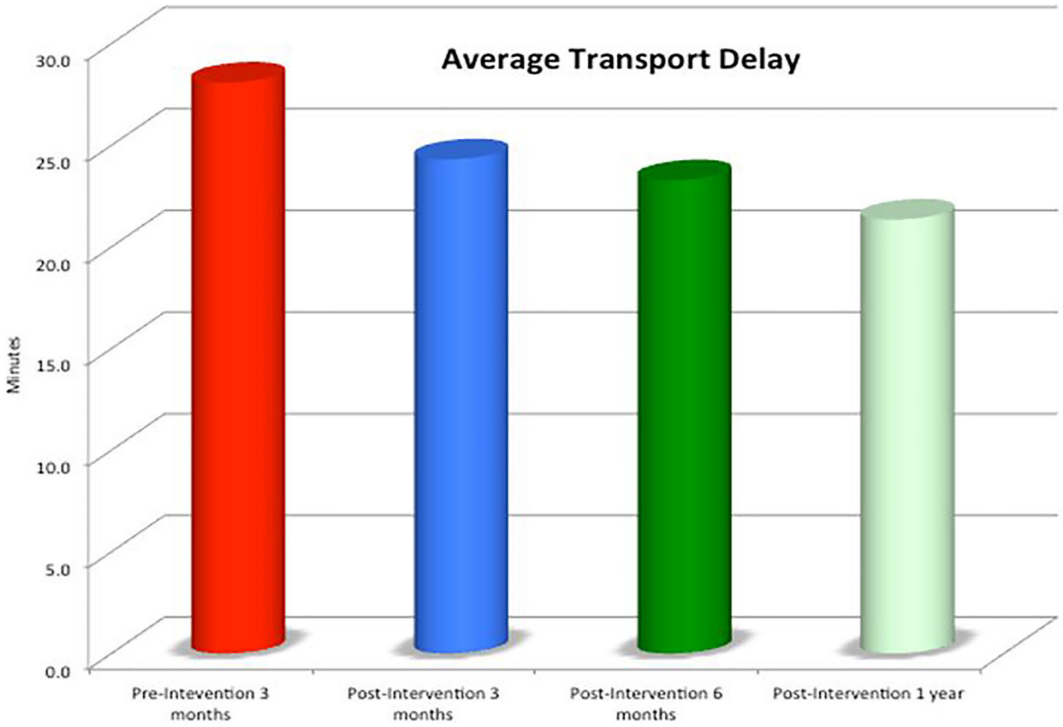

Figure 4. Average radiology transport time 2013-2016. Average radiology transport time following the intervention (minutes), demonstrating a significant trend towards improvement.

Weekly average delay had a normal-like distribution; therefore, it was summarized using the mean with standard deviation for each period, and each post-intervention period was compared to the pre-intervention period using a two-sample t-test. To address for seasonal effect, we also compared the data from the pre-intervention period (8/4/2013-11/9/2013) to the data from the same period post intervention (8/2/2015-11/7/2015). We used linear regression lines to indicate the trends over different time periods. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary NC), and we considered a two-sided p value of 0.05 or less statistically significant. Statistical review of the study was performed by a biomedical statistician, Yuchiao Chang, Ph.D.

RESULTS

Following the intervention, average transport time decreased significantly and sustainably. Average radiology transport time was 28.7 ± 4.2 minutes during the three months pre intervention. It was reduced by 15% in the first three months (4.4 minutes, 95% CI [1.5-7.3]; to 24.3 ± 3.3 min, P=0.021), 19% in the following six months (5.4 minutes, 95% CI [2.7-8.2]; to 23.3 ± 3.5 min, P=0.003), and 26% one year following the intervention (7.4 minutes, 95% CI [4.8-9.9]; to 21.3 ± 3.1 min, P=0.0001, Figure 4). When comparing the three months pre intervention to the same period post intervention, the average radiology transport time reduced from 28.7 ± 4.2 minutes to 20.6 ± 3.0 minutes (difference 8.1 minutes, 95% CI [5.2-11.0], P<0.0001). This result was achieved without any additional resources, and demonstrated a continual trend towards improvement (Figure 5).

DISCUSSION

In this before-and-after study, a reorganization of ED radiology process flow significantly and sustainably decreased transport time without additional capabilities or resources. One year following the intervention, transport time was reduced by 24%, or 6.8 minutes. Given the approximately 4,200 plain film visits to ED radiology per month in our ED, there was a reduction of as much as 476 hours of patient wait-time per month, or 5,712 hours per year.

Lean methodologies focus on eliminating non-value added waste within a system.[22] This includes any and all actions and activities that do not add value to the consumer in question, in this case the patient. In the case of radiology testing, there are a number of areas of potential waste, much of which manifests as waiting for serial process steps.[28-32] As a result, several factors may have contributed to the success of this Lean-based intervention.

First, the job of transporting a patient to radiology was filled by a single individual in the prior state, in what is termed a "single server system." Based on "queuing theory," briefly summarized as the science that describes waiting in lines, a system with a single server is by definition the most vulnerable to building a queue when that server's capacity is

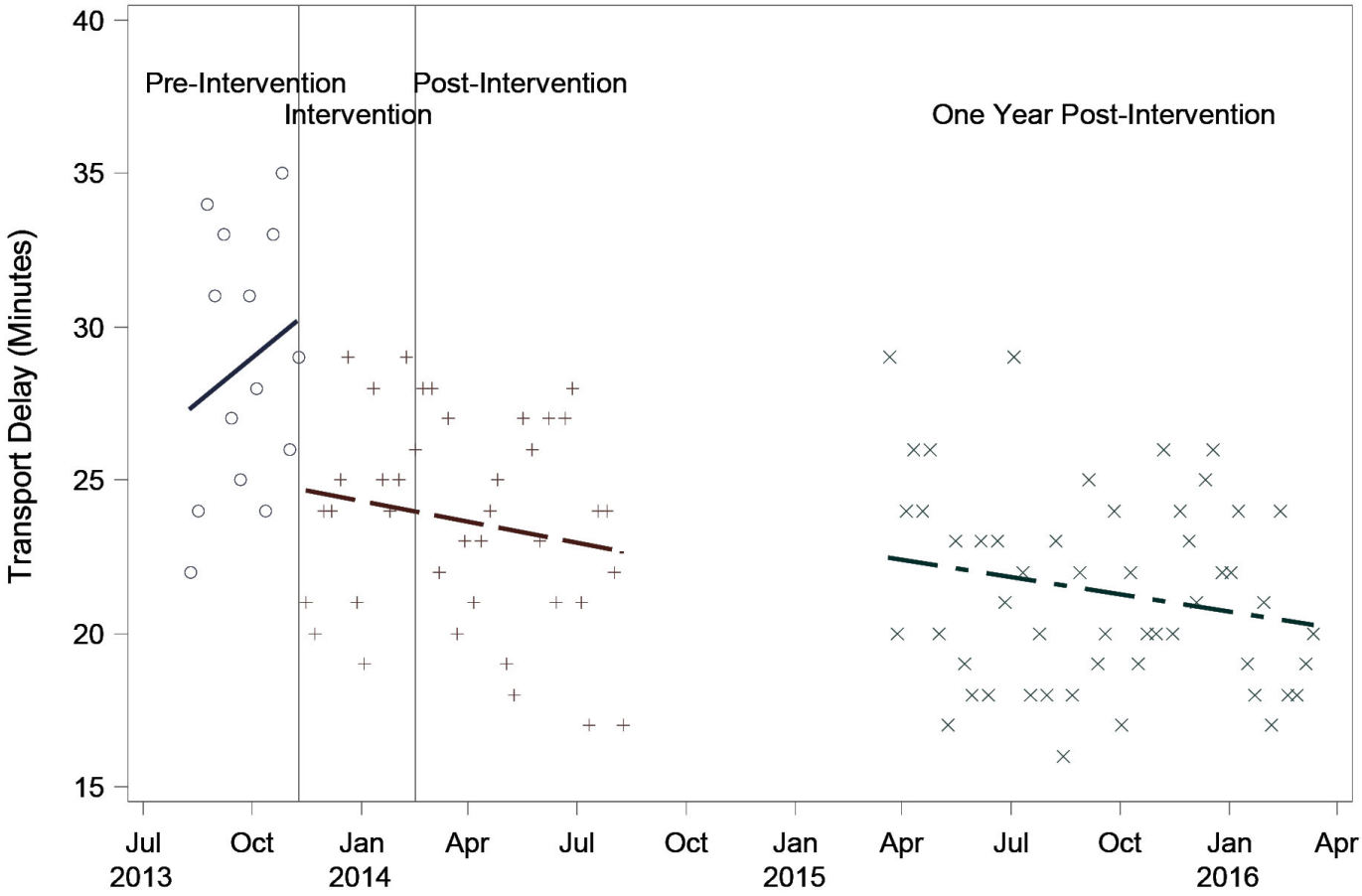

Figure 5. Average radiology transport time. Average radiology transport time (minutes) pre intervention and post intervention three, six, and 12 months following the intervention.

overwhelmed by demand. In addition, this effect is magnified when the "arrivals" into that system (in this case, a plain film being ordered for a patient) are variable in their timing. Like most ED patient-care processes, radiology study ordering is highly variable due to varying arrival rates of the patients themselves, varying patient needs and clinical indications, and varying provider practice patterns.[8-32] In addition, our previous single server transport system prioritized transporting patients ordered for computed tomography (CT), magnetic resonance imaging (MRI) or any study ordered from our high acuity area of the ED prior to plain film transports. In a single server system, this further decreased the service capacity from the perspective of the patient awaiting a plain film, and increased wait time.

Further, in the prior system the downstream radiology technician was only responsible for performing and processing images and was resourced with three available plain film radiology bays to accomplish this. This meant that intermittently there was "down time" in this server group, or what is termed "perishable service capacity" in systems engineering (i.e., when one server is idle and that idle time is both wasted and non-recoverable by the system).

Given that radiology technicians seemed to have intermittent available capacity and that their workflow was limited by the single-server system queue just upstream (or "bottleneck"), it is not surprising that an intervention aimed at eliminating this bottleneck by asking the technicians to help with transport when idle, and "pull" patients into testing, was successful. In systems engineering, this combination of tasks within a group of servers is referred to as "pooling servers," described as the process by which multiple servers are asked to bring together, or pool, their task lists and workflow. This has the putative benefit of allowing multiple servers to be available and balancing server capacity with the demand for that service. However, it is worth mentioning that asking a downstream server (e.g., radiology technician) to perform an upstream task is not without risk of what is termed "shifting bottlenecks." For

example, if the added task reduces their ability to perform the downstream task (e.g., performing the plain film), and thus this task forms a queue and associated delay, then this would become the new bottleneck for the system.

Regarding the cost vs. benefit implications of this project, the operational and efficiency benefit gained from this intervention appeared to outweigh the minimal resources (i.e., ED administrator time and effort) used to carry out these systems changes. No resources were added during the intervention, and yet measurable and sustainable reductions in radiology transport times were noted. This innovation demonstrates the potential value of systems engineering science to increase efficiency in ED radiology processes, and increase system capacity, a benefit of Lean methodologies that has been demonstrated in other studies.[31-33] Additionally, this work may inform radiology staffing decisions and workflow, and underscores the value of current state mapping and analysis, demand-capacity matching, and pooled-server resource use while adapting to changing workflows.[34] While other studies have demonstrated the value of systems engineering approaches in optimizing ED processes, these results underscore that significant opportunity to improve on key performance indicators and broaden the literature and experience in ED radiology remains.[33-38]

Finally, as ED administrators increasingly focus on ED patient experience, interventions that reduce patient waits while also improving the efficiency of diagnostic testing may represent a valuable approach for emergency medicine and emergency radiology administrators to achieve the win/win of enhancing patient care and experience simultaneously.

LIMITATIONS

As with any before-and-after study, while the change demonstrated in the observed outcomes may be correlated to the intervention, this does not prove causality. We could not fully exclude other contributing factors, such as subtle differences in the patient population studied or in individual productivity; however, it is unlikely that these factors played a significant role in the results. In addition, given that our unit of measure was weekly, we cannot fully exclude daily changes in volume as contributing to the effect, although given the duration of the study it is unlikely that this effect was due to daily changes in volume. Although we cannot fully exclude the Hawthorne effect from playing a role, its effect, if any, was likely limited due to the duration of the study and the fact that the staff was not aware of the focus on this metric. In addition, no other significant operations changes affecting plain film ordering and transport processes were identified in either the ED or ED radiology between the before-and-after measurement periods, and other potential contributors including testing volume did not change significantly during the period studied. The pre-intervention period of three months is also somewhat short but was chosen due to data availability limitations. Given the large number of studies performed during those three months, we believe this period had adequate sample size, and we compared a similar period post intervention to confirm a lack of seasonal effect. In addition, there was no change in the cycle time of the other radiology tests (e.g., CT, MRI) before and after the intervention. Thus, it is likely that the intervention was associated with the outcome measured.

The study was performed at a single center, potentially limiting generalizability to other EDs, especially those with markedly different radiology process flows and/or demographics. However, given that systems engineering tools are broadly applicable by definition, we anticipate our findings should be of interest to most ED and ED radiology administrators.

Finally, our study design did not permit measuring any increased radiology productivity as a result of these improvements, nor was it able to correlate decreased radiology turnaround time with decreased ED length of stay or other ED metrics such as left without being seen. While it may be assumed that a more efficient system may be more productive and less wasteful, this cannot be proven by our study.

CONCLUSION

In this study, reorganization of the ED radiology transport process using systems engineering science measurably increased process efficiency without additional resource use.

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Prehospital Care for the Adult and Pediatric Seizure Patient: Current Evidence-based Recommendations

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Introduction: We sought to develop evidence-based recommendations for the prehospital evaluation and treatment of adult and pediatric patients with a seizure and to compare these recommendations against the current protocol used by the 33 emergency medical services (EMS) agencies in California.

Methods: We performed a review of the evidence in the prehospital treatment of patients with a seizure, and then compared the seizure protocols of each of the 33 EMS agencies for consistency with these recommendations. We analyzed the type and route of medication administered, number of additional rescue doses permitted, and requirements for glucose testing prior to medication. The treatment for eclampsia and seizures in pediatric patients were analyzed separately.

Results: Protocols across EMS Agencies in California varied widely. We identified multiple drugs, dosages, routes of administration, re-dosing instructions, and requirement for blood glucose testing prior to medication delivery. Blood glucose testing prior to benzodiazepine administration is required by 61% (20/33) of agencies for adult patients and 76% (25/33) for pediatric patients. All agencies have protocols for giving intramuscular benzodiazepines and 76% (25/33) have protocols for intranasal benzodiazepines. Intramuscular midazolam dosages ranged from 2 to 10 mg per single adult dose, 2 to 8 mg per single pediatric dose, and 0.1 to 0.2 mg/kg as a weight-based dose. Intranasal midazolam dosages ranged from 2 to 10 mg per single adult or pediatric dose, and 0.1 to 0.2 mg/kg as a weight-based dose. Intravenous/intrasosseous midazolam dosages ranged from 1 to 6 mg per single adult dose, 1 to 5 mg per single pediatric dose, and 0.05 to 0.1 mg/kg as a weight-based dose. Eclampsia is specifically addressed by 85% (28/33) of agencies. Forty-two percent (14/33) have a protocol for administering magnesium sulfate, with intravenous dosages ranging from 2 to 6 mg, and 58% (19/33) allow benzodiazepines to be administered.

Conclusion: Protocols for a patient with a seizure, including eclampsia and febrile seizures, vary widely across California. These recommendations for the prehospital diagnosis and treatment of seizures may be useful for EMS medical directors tasked with creating and revising these protocols. [West J Emerg Med. 2017;18(3)419-436.]

INTRODUCTION

Seizures are a common medical condition, with 10% of Americans experiencing at least one seizure in their lifetimes and epilepsy developing in 3% by the age of 75. In the United States (U.S.), approximately 200,000 new cases of epilepsy are diagnosed each year, with the highest incidence among individuals younger than two years and older than 65 years of age.[1] Seizure evaluation and treatment makes up a significant portion of emergency medical services (EMS) utilization, accounting for 5 - 8% of all EMS calls.[2] Approximately 71% of these calls result in EMS transport and make up approximately 1.2% of all emergency department (ED) visits.[3] Prehospital interventions, such as airway management, establishing intravenous (IV) access, benzodiazepine administration and blood glucose testing are commonly performed.[4] In one study of 140 EMS providers across 40 states, prehospital treatment with a benzodiazepine was observed in 8.3% of seizure cases.[4] While advanced life support (ALS) care is common in prehospital seizure management, there are a broad range of interventions employed.

Population Health Research Capsule

What do we already know about this issue?
Seizure evaluation and treatment makes up a significant portion of EMS utilization; however, high-quality, specific guidelines have not yet been widely accepted.

What was the research question?
How do the prehospital seizure protocols of each of the 33 EMS agencies in California compare?

What was the major finding of the study?
EMS protocols for a patient with a seizure, including eclampsia and febrile seizures, vary widely across CA.

How does this improve population health?
Recommendations for the prehospital diagnosis and treatment of seizures may be useful for EMS medical directors tasked with creating and revising these protocols.

Status Epilepticus

Status epilepticus (SE) is defined as prolonged seizures (greater than five minutes), or multiple seizures without return to baseline between episodes. SE is a relatively common seizure disorder, with an annual incidence of approximately 40 per 100,000.[5] The occurrence of SE has tripled in the past 30 years, with approximately 60,000 new cases annually in the U.S.[5,6] SE has a significant impact on individual patients as well as the entire healthcare system. Although there have been substantial improvements in the treatment of SE, the overall mortality remains at approximately 20%.[5-7] The annual inpatient financial costs of SE are estimated at more than $4 billion in the U.S. alone.[5,8]

Although SE remains a significant source of morbidity and mortality, research has shown that appropriate prehospital treatment improves patient outcomes.[9] The optimal prehospital management of seizures continues to evolve as new medications and routes of administration are introduced. Without widely accepted guidelines, however, EMS care continues to vary greatly across the U.S. The Institute of Medicine report, "Emergency Medical Services at the Crossroads," notes that EMS needs more uniform, high quality care and specific standards for evaluating that care.[10] One such standard is the prehospital protocol that EMS providers use while caring for patients in the field. As such, we aim to provide a summary of the evidence for the prehospital evaluation and treatment of patients with seizure, and to assess the consistency of California protocols.

METHODS

The State of California divides EMS care into 33 local EMS agencies (LEMSAs), which are geographically divided governmental regulatory bodies. One set of governmental medical control policies regulates the first responders and ambulance transporters in each countywide or region-wide system, in accordance with EMS Authority scope of practice. Medical directors of those agencies, along with other EMS medical directors, make up the EMS Medical Directors Association of California (EMDAC). EMDAC supports and guides the various agencies and makes recommendations to the California EMS Authority about policy, legislation and scope of practice issues. In an effort to improve quality and decrease variability in EMS practice in California, EMDAC has endeavored to create evidence-based recommendations for EMS protocols. Those recommendations and previous reviews are intended to assist medical directors of the various local EMS agencies to develop high quality, evidence-based protocols.

A subcommittee of EMDAC developed this manuscript and chose by consensus the elements that should be included in any protocol for a patient with a suspected seizure. The subcommittee then created a narrative review of the existing evidence for prehospital treatment of seizures. Clinical questions regarding those interventions were developed in the PICO (population, intervention, control and outcome) format. Our population included those patients in the prehospital

setting with a suspected seizure. The intervention varied by clinical question. The control consisted of patients who were not receiving the specific intervention, and outcomes were defined by cessation of seizure activity after intervention.

We relied on recommendations made by various organizations that have performed systematic reviews and meta-analyses regarding treatment interventions, including the Neurocritical Care Society and the Cochrane Collaboration. We supplemented these recommendations with additional literature searches through PubMed from 1966 to 2016 for each question. During our primary literature review of PubMed, we searched for the terms "prehospital and seizure," "status epilepticus," "eclampsia," and "febrile seizure." That search yielded 161 articles, 59 of which were published in English and pertinent to the topics identified by the EMDAC subcommittee. It was supplemented with additional PubMed searches for specific topics.

We assigned levels of evidence (LOE) and graded our recommendations based on the American College of Emergency Physicians (ACEP) process of creating their clinical policies with slight modification to better fit our objectives.[11] This committee of EMDAC reviewed studies and assigned LOEs based on the study design, including features such as data collection methods, randomization, blinding, outcome measures and generalizability. LOE I consisted of randomized, controlled trials, prospective cohort studies, meta-analysis of randomized trials or prospective studies or clinical guidelines/ comprehensive review. LOE II consisted of nonrandomized trials and retrospective studies. LOE III consisted of case series, case reports, and expert consensus. After assigning LOEs to the studies, we translated those to clinical grades of recommendations using the following standards:

Level A Recommendations: Prehospital recommendations with a strong degree of certainty based on one or more LOE I studies or multiple LOE II studies.

Level B Recommendations: Prehospital recommendations with a moderate degree of certainty based on one or more LOE II studies or multiple LOE III studies.

Level C Recommendations: Prehospital recommendations based on only poor quality or minimal LOE III studies or based on consensus.

No Recommendation: No recommendation was given in those cases where only preliminary data or no published evidence exists and we had no expert consensus. We also withheld recommendation when studies, no matter their LOE, showed conflicting data.

After answering the clinical question and providing recommendations for diagnostic and treatment interventions, we reviewed each current seizure protocol for the 33 agencies for consistency with the recommendations. The clinical protocols were reviewed during the month of June 2015. We deemed institutional review board approval not necessary for this review of publicly available research and clinical protocols.

EVIDENCE REVIEW AND CURRENT RECOMMENDATIONS

What is the appropriate prehospital treatment for a patient with a witnessed seizure who is not actively seizing?

Most seizures are brief and spontaneously resolve within one to two minutes.[5] Patients with a seizure typically have transient hypoventilation that usually resolves quickly as long as their airway remains patent. Nonetheless, supplemental oxygen should be provided via nasal cannula or facemask, with suction and a nasopharyngeal airway readily available. Providers should be prepared to provide a jaw thrust and bag-valve mask ventilation as well to assist with spontaneous respirations if needed. Endotracheal intubation should be reserved for patients with respiratory failure after the seizure has stopped, and should be used only after other airway maneuvers and adjuncts have been attempted. Patients should be placed in a position of comfort that will also promote a patent airway, and which will minimize the risk of falls. The secondary survey should include an evaluation for signs of trauma. Initial management should also include a rapid assessment of blood glucose level. Although hypoglycemia is a relatively rare cause of seizures and has been demonstrated to be present in only 1.2% of patients with seizures, it is an inexpensive and rapid assessment tool that is widely available and hypoglycemia is readily reversible.[12]

There is conflicting opinion on the utility of routinely placing an intravenous line (IV) in patients who are not actively seizing. Since most patients will not require any medications once they are not actively seizing, there is not sufficient evidence to support routine IV access. The incidence of a second seizure within 72 hours has been reported to be approximately 6% and benzodiazepines administered intramuscularly (IM) are an effective treatment.[13] Continuous pulse oximetry should be used to monitor oxygenation, and end-tidal CO_2 monitoring, if available, should be used to detect hypoventilation in postictal patients until they have returned to their baseline mental status.

Patients who have had resolution of a seizure and have rapid return to their baseline sometimes refuse subsequent transport to the ED. In a 2016 retrospective study of patients who refused transport or were discharged at the scene by paramedics, improvement of symptoms in patients with a postictal state was a common reason for non-transport.[14] In order to refuse additional care and/or transport to the hospital, a patient must have medical decision-making capacity to refuse care, which includes being alert and oriented, exhibiting no signs of intoxication, and demonstrating an understanding of the risks, benefits, and alternatives to refusing transport.[15] Furthermore, the patient must be advised that paramedics will return if called again. This commonly involves the patient verbalizing an understanding of the medical condition and explaining the potential complications of refusing additional care and transport. A form documenting this encounter is

typically signed by the patient and paramedic. EMS providers should report seizure activity as appropriate, and patients should be counseled not to drive due to the risk of additional seizures with the subsequent potential to injure both themselves and others.

Patients with first time or new-onset seizures should be strongly encouraged to accept transport to the ED since there are multiple life-threatening conditions that may be present. If refusing transport, these patients should be made aware of potential underlying medical conditions. Patients with known seizure disorders, such as epilepsy, commonly have breakthrough seizures due to medication non-adherence or under-dosing, sleep deprivation, infection, illicit substance use, or interactions with other medications. Despite seizure patients being more likely to be transported by EMS than other patients, a relatively high proportion still refuse ambulance transport.[16] In a study of 2,619 pediatric calls for the chief complaint of seizure, 17% of parents/guardians refused transport to the ED. Rates of transport refusal may vary with geographic location, distance to the hospital, insurance status/cost of transport and individual frequency of complaint.

Current Prehospital Treatment Recommendation for a Patient with a Witnessed Seizure Who Is Not Actively Seizing:

Level A Recommendation:

- None given.

Level B Recommendation:

- None given.

Level C Recommendation:

- No medications are recommended for a patient with a witnessed seizure who is not actively seizing.
- Post-seizure management should include supplemental oxygen by nasal cannula, continuous pulse oximetry and end-tidal CO_2, if available, with suction and nasopharyngeal airway immediately available. Bag-valve mask ventilation should be initiated for respiratory depression with endotracheal intubation reserved for prolonged respiratory failure.
- Patients with a witnessed seizure who are not actively seizing should be placed in a position of comfort, which also helps maintain a patent airway and minimize risk of falls.
- Blood glucose should be routinely checked in patients with suspected seizure if not returning to their baseline mental status.
- Routine placement of a prehospital IV may not be necessary for patients who are not actively seizing, and may be avoided if IV medications are not needed.

What is the appropriate prehospital treatment for a patient who is actively seizing?

Choice of Benzodiazepine

Patients with prolonged or repeated convulsions lasting longer than five minutes are considered to be in SE and require immediate intervention.[17] For EMS providers, calls dispatched for seizing patients who have ongoing seizures at the time of EMS evaluation suggests SE.[2] Seizures lasting longer than 30 minutes have been shown to be less likely to terminate spontaneously and are associated with a higher mortality.[7] Prolonged seizures cause both direct neuronal cellular injury as well as secondary complications such as impaired ventilation and aspiration, resulting in immediate neuronal loss followed by programmed cell death. Additionally, animal evidence indicates that resistance to benzodiazepines increases with longer seizure duration.[5] As the time to effective treatment lengthens, the efficacy of first-line treatment with benzodiazepines decreases. Since earlier seizure cessation has been shown to improve outcomes and decrease cell death, rapid treatment and control of seizures has become a focus in the prehospital setting.[8]

With the knowledge that shorter time to seizure termination led to improved patient outcomes, prehospital providers began to initiate anticonvulsant therapy prior to hospital arrival. Since nearly all initial data were based on hospital and ED studies of seizures, research then began to focus on the safety and efficacy of prehospital EMS treatment with benzodiazepines. The Prehospital Treatment of Status Epilepticus (PHTSE) study was designed to determine whether benzodiazepines can be safely and effectively administered by paramedics to treat SE, whether prehospital treatment influences long-term patient outcome or ED disposition, and whether lorazepam, diazepam or placebo is superior for prehospital use in treating SE.[9] The PHTSE study showed that SE was terminated in more patients who received IV lorazepam and diazepam than placebo (59.1% and 42.6% v 21.1%). Although there was no difference found between the lorazepam and diazepam groups, the study demonstrated that benzodiazepines could be successfully administered by EMS for the treatment of SE. This study also demonstrated that the termination of SE by the time of arrival to the ED correlated with better patient outcomes.

The PHTSE study showed that IV benzodiazepines (lorazepam and diazepam) are superior to placebo in terminating SE. Patients treated with benzodiazepines also had lower rates of respiratory compromise necessitating intubation, likely due to the shorter duration of seizures in the treatment groups.

To further investigate the administration of lorazepam for SE, a prospective, double-blind, randomized study of pediatric patients in an ED treated for SE compared IV diazepam to IV lorazepam.[18] As part of the Pediatric Emergency Care Applied Research Network (PECARN), this study enrolled 273 pediatric patients with convulsive SE in 11 large academic hospitals in the U.S. No difference was found in the rate of cessation of seizures within 10 minutes (72.1% vs 72.9%), rate of recurrence within four hours (38.6% vs 39.2%) or rate of assisted ventilation (16.0% vs 17.6%) between the diazepam and lorazepam groups.

As midazolam became available for prehospital use, the Rapid Anticonvulsant Medication Prior to Arrival Trial (RAMPART) study was designed to compare IM midazolam to

IV lorazepam. This landmark multicenter, double-blind, randomized, non-inferiority study of prehospital treatment of SE hypothesized that IM injection of a benzodiazepine would result in faster and more reliable medication administration, yielding improved seizure control prior to ED arrival.[19] It used the Neurological Emergencies Treatment Trials (NETT) network to recruit adults and children estimated to weigh 13 kg or more. The findings of this study demonstrated that IM midazolam was as effective as IV lorazepam in terminating seizures without rescue therapy (73.4% vs 63.4%, $p < 0.001$ for non-inferiority and $p < 0.001$ for superiority), and was not associated with an increase in respiratory compromise or seizure recurrence. Additionally, the midazolam group had a lower rate of hospitalization. The RAMPART study concluded that although IV lorazepam had a quicker onset of action after administration, IM midazolam had a shorter time to administration since it did not require IV placement. Overall, however, there was no difference in time from medication box opening to seizure cessation between the IV and IM groups. Patients randomized to IM midazolam were more likely to have terminated seizures prior to ED arrival and were less likely to require hospital ward or intensive care unit (ICU) admission.[19] Since adverse-event rates were similar between the two groups and lorazepam needs to be refrigerated, midazolam was deemed to be a safe and effective alternative for EMS treatment of SE. Additionally, studies have shown that midazolam has superior first-dose seizure suppression than diazepam.[20]

Non-benzodiazepine anticonvulsant medications have also been tested as both primary and secondary therapy for generalized convulsive SE. A prospective, randomized, double-blind study conducted at 16 Veterans Affairs medical centers and six affiliated university hospitals compared lorazepam, phenobarbital, phenytoin, and diazepam followed by phenytoin in 384 adult patients with SE.[21]

This study demonstrated that benzodiazepines (particularly lorazepam) were superior in stopping seizures. Lorazepam successfully terminated overt SE in 65% of 97 cases, similar to the results seen with phenobarbital and diazepam plus phenytoin, and superior to phenytoin alone. In a recent prehospital, randomized, double-blind, phase 3, placebo-controlled, superiority trial, levetiracetam was administered in addition to clonazepam for treatment of generalized convulsive SE. This treatment presented no advantage over clonazepam alone in the control of SE before arrival to the hospital.[22]

Degradation of Drugs Issue

Which benzodiazepine is best suited to be stored in an ambulance environment?

EMS medications are frequently stored without temperature-control procedures, which may negatively impact the medication through degradation. Heat stability is an important factor in determining which benzodiazepine to deploy in an EMS system. Even in temperature-controlled environments, loss of power to mobile refrigerators and infrequently replaced cold packs in portable coolers may lead to inconsistent temperature regulation, especially in hotter climates.[23] With temperature extremes known to occur inside vehicles, the choice of benzodiazepine carried by EMS should take into account medication performance after exposure to heat stress.

In an experimental pharmaco-stability study, diazepam and lorazepam solutions were stored for 210 days at refrigerated (4 to 10°C), ambient (15 to 30°C), and heated temperatures (37°C) to simulate real-world conditions.[24] Drug concentration analysis was performed every 30 days to evaluate drug degradation. At ambient temperature, minimal (10%) concentration reduction was seen in diazepam after 30 days and lorazepam after 150 days. After 210 days, diazepam concentration reduction was 7% refrigerated, 15% ambient, and 25% heated. Lorazepam concentration reduction was 0% refrigerated, 10% ambient, and 75% heated. From these data, the authors concluded that diazepam had increased early degradation rates, but was more stable in the long term when heat stress was applied. Lorazepam exhibited better stability when refrigerated, but rapidly degraded when exposed to heat.

A subsequent study comparing midazolam to lorazepam demonstrated that midazolam remained stable at 60 days, but that lorazepam showed slight time- and temperature-dependent degradation.[25] When midazolam and diazepam were compared to lorazepam in a follow-up study, both midazolam and lorazepam experienced minimal degradation throughout 120 days of EMS deployment in high-heat environments. Lorazepam, however, experienced significant degradation over 120 days and appeared especially sensitive to higher temperature exposure.[26]

Route of Benzodiazepine

What is the preferred route of benzodiazepine administration in the treatment of status epilepticus?

Prehospital administration of benzodiazepines to terminate generalized convulsive seizures presents multiple safety considerations for both the treating provider and the patient. Involuntary muscle contractions during SE make prehospital IV placement more difficult to achieve and increase the chances of procedural complications. Providers may also be at increased risk for needle-stick injuries. Since time to medication and provider safety are priorities in treating SE, there have been studies of the preferred route of benzodiazepine administration. Traditionally, rectal (PR) or IV diazepam in children and IV diazepam in adults were considered to be the routes and drug of choice for prehospital medication administration.[17,27] Newer studies, however, have focused on intramuscular and intranasal (IN) midazolam, which have been shown to have improved heat stability and may be preferred for ambulance storage, as discussed

previously. To date, there are no data comparing IN to IM benzodiazepine administration. There have been a multitude of recent studies comparing intramuscular and intranasal midazolam to the traditional standard of IV diazepam or lorazepam; however, few studies exist that compare the novel administration routes of the same drug to each other. Additionally, much of the available research has focused on pediatric patients, with febrile seizures often included. Febrile pediatric seizures, therefore, will be discussed separately.

In a comparison of single dose PR vs IV diazepam for prehospital seizures in 31 pediatric patients, no difference was demonstrated in the rate of seizure cessation or recurrence of seizures prior to ED arrival.[27] Although this study was a small, retrospective chart review, it also found no difference in prehospital or ED intubation rates.

There have been multiple case reports and descriptive studies demonstrating intramuscular midazolam as an effective therapy for SE; however, only one direct comparison of IV and IM midazolam was identified in the literature.[28] In a retrospective chart review of 86 pediatric patients treated by EMS for prehospital seizures with either IV or IM midazolam, the IV group was found to have a significantly higher rate of clinical improvement, with no difference in admission rate.[29] This study did not define their endpoint of "clinical improvement" as seizure cessation, however, and had nearly twice as many patients in the intravenous group (49 IV vs. 25 IM). Considering their findings, the authors concluded that "prehospital IV midazolam was an effective intervention for pediatric seizures."

Despite the lack of research directly comparing IV with IM midazolam, the RAMPART study, previously described, demonstrated that IM midazolam was as effective as IV lorazepam in terminating seizures (73.4% vs 63.4). Although the IV group had a shorter time to seizure cessation after medication administration, the IM group had a shorter time to medication administration. This resulted in similar total times to seizure cessation between the groups. As previously noted, patients in the IM group were also less likely to be seizing upon arrival to the ED, regardless of the use or non-use of rescue therapy.[19] This remained true when the pediatric patients in the study were considered separately, as described in a subsequent secondary analysis.[30]

With the advent of mucosal atomization devices, midazolam has also been administered by the IN route for seizure control. A study of 57 pediatric patients with SE compared IN mucosal atomized midazolam (IN-MAD) to rectal diazepam.[31] The IN-MAD group, as compared to the rectal diazepam group, had shorter prehospital seizure duration and were less likely to have a seizure in the ED, undergo ED intubation, receive seizure medications for ongoing seizures in the ED, or be admitted to the hospital or pediatric ICU. Another study of 358 pediatric patients compared IN midazolam with rectal diazepam for the treatment of SE.[32] There was no difference in time from medication administration to seizure cessation or complications between the diazepam or midazolam groups. Similarly, a prospective, randomized study of 45 pediatric patients comparing rectal diazepam to IN midazolam demonstrated that midazolam was more effective in terminating seizures within 10 minutes (87% vs 70%).[33]

In a unique longitudinal, crossover study of 124 seizure episodes in 21 adults with refractory SE, patient caregivers were able to administer rectal diazepam or IN midazolam at home.[34] This study found no difference in successful treatment of seizure episodes between the diazepam group (89%) and the midazolam group (82%), and reported no severe adverse events in either arm.

While IN midazolam appears to be gaining popularity due to its ease and convenience of administration without needles, midazolam has also been delivered through a buccal route. In a study of adults living in a residential institution, buccal midazolam was found to be as safe and effective as rectal diazepam in terminating SE.[35] Similar studies in children have also demonstrated that buccal midazolam is as effective as rectal diazepam in terminating convulsive seizures.[36,37] Buccal midazolam has also been shown to be as effective as intravenous diazepam for seizure control in both partial and generalized convulsive seizures.[38] While the time from medication administration to seizure control was less with IV diazepam, the time from initiation of treatment to seizure control was less with buccal midazolam.

Dose of Benzodiazepine

What is the appropriate dose of intramuscular, intravenous, and intranasal benzodiazepine when treating status epilepticus?

Local protocols vary widely with regards to benzodiazepine dosing, with some using set dosages and others using a weight-based approach. The goal of either strategy is to maximize single-dose efficacy and minimize complications, such as respiratory depression. Factors that should be considered in choosing a medication dosage include the following: medication safety profile (i.e., toxic range); time to onset and peak level; duration of action; tissue distribution; and interactions with other medications. Although there have been relatively few studies that directly compare different dosages of the same medication delivered by the same route, much of the existing literature has used similar dosing ranges to demonstrate overall medication efficacy.

In a retrospective chart review of 288 pediatric patients with prehospital seizures, diazepam IV/rectal 0.2 to 0.5 mg/kg was compared to 0.05 to 0.1 mg/kg.[39] Patients in the higher-dose group were more likely to require prehospital intubation and admission. Additionally, the IV diazepam group was more likely to require intubation than the rectal group. No difference was observed in the number of repeat doses or ED interventions.

A retrospective chart review of 93 pediatric patients treated by EMS for seizures received either diazepam IV 0.25 mg/kg or rectal 0.50 mg/kg prior to 1 January 2000, or midazolam IV 0.1 mg/kg or IM 0.2 mg/kg after the specified date.[40] No difference was observed in rates of seizure cessation prior to ED arrival, seizure recurrence in ED, need for airway intervention, or admission rate. Significantly more patients initially administered IM midazolam required a second prehospital dose as well as additional benzodiazepines in the ED, compared to the IV midazolam group.

As discussed previously, the RAMPART study compared IM midazolam 10 mg to IV lorazepam 4 mg in adults and children weighing more than 40 kg, and IM midazolam 5 mg to IV lorazepam 2 mg in children with an estimated weight of 13 to 40 kg.[19] Pooling the high- and low-dosage data together, this study demonstrated that IM midazolam (448 patients) was as effective as IV lorazepam (445 patients) in terminating seizures without rescue therapy (73.4% vs 63.4%), and showed no difference in frequency of endotracheal intubation or seizure recurrence. Of note, both midazolam and lorazepam groups consisted primarily of high dosage administrations, with 386 (86% of midazolam and 87% of lorazepam) high dose administrations in both arms.

In a prospective, randomized, blinded comparison of IV diazepam 0.2 mg/kg to IN midazolam 0.2 mg/kg administered to 70 pediatric patients with acute seizures, no difference was observed in seizure cessation within 10 minutes.[41] Additionally, the time from seizure onset to treatment was shorter in the midazolam group, although the time from seizure onset to cessation was shorter in diazepam group. In a similar study, which used the same 0.2 mg/kg dose of IN midazolam but a higher, 0.3 mg/kg, dose of IV diazepam, there was also no difference in the rate of seizure termination between the groups, and the time from arrival at hospital to seizure cessation was shorter in the midazolam group.[42]

A retrospective, observational study of 57 pediatric patients comparing IN midazolam 0.2 mg/kg (max dose 10 mg) to PR diazepam 0.3-0.5 mg/kg (max 20 mg) found that the midazolam group had shorter prehospital seizure duration, were less likely to have seizure recurrence, undergo intubation, receive seizure medications for ongoing seizures in the ED, or be admitted to hospital.[31]

Appropriate Order of Benzodiazepine and Glucose Measurement

Should paramedics measure a glucose level in those patients with a history of a seizure prior to administering a benzodiazepine?

Most EMS protocols require blood glucose testing during the evaluation of SE. There has been little agreement on when this testing should be performed since hypoglycemia can manifest as seizures, but checking blood glucose may delay the administration of benzodiazepines.[12] While some protocols require checking blood glucose prior to the administration of benzodiazepines, others leave the timing to the discretion of the treating paramedic.[4,12]

In a retrospective observational study of 53,505 EMS calls for seizure where blood glucose was measured, hypoglycemia was present in 638 (1.2%) patients with seizures.[12] Seizing patients were treated with benzodiazepine in 8.3% and with glucose in 1.3% of patients. Obtaining a blood glucose measurement was associated with a 5.9-minute delay in benzodiazepine administration compared to patients who had no blood glucose tested, and 2.1-minute delay compared to patients who had glucose testing performed after benzodiazepine administration. Since rates of hypoglycemia were very low in patients treated by EMS for seizure, the study concluded that glucose testing prior to benzodiazepine administration was not supported.

IV Placement in Active Seizure Patient

Should paramedics place an IV in those patients who are actively seizing?

Despite the success of IM and IN benzodiazepines in terminating SE prior to ED arrival, there remains a significant number of patients who will require additional anticonvulsant therapy. If IM or IN therapies are not successful in terminating active seizures, IV benzodiazepines may be necessary. Additionally, since the rate of respiratory failure requiring intubation increases with the length of seizure activity, it is likely that IV placement will be needed if initial IM or IN treatment fails to terminate seizure activity.[9,17]

In a secondary analysis of the RAMPART study, 218 patients (21%) required endotracheal intubation for respiratory depression, altered mental status, or recurrent seizures after initial termination.[43] Fourteen (6.4%) endotracheal intubations were performed in the prehospital setting and 204 (93.6%) occurred in the hospital. Endotracheal intubation occurred less frequently in patients younger than 50 years of age and in women compared to men. Additionally, mortality was higher in patients undergoing late intubation (greater than 30 minutes after ED arrival). This analysis demonstrates that despite prehospital treatment of SE, there remains a substantial proportion of patients who require advanced airway management and additional therapy. Although an IV can be placed after the patient's arrival to the ED, EMS can shorten the time to definitive treatment by placement of an IV after prehospital therapy has been initiated.

Current Prehospital Treatment Recommendation for the Patient in Status Epilepticus:

Level A Recommendation:

- IM injection of midazolam should be the first-line EMS treatment of the patient in SE without an established intravenous line.
- The suggested initial dose of IM midazolam is 0.2 mg/kg,

with a max of 10 mg in adults and children greater than 40 kg.
- The suggested initial dose of IN and buccal midazolam is 0.2 mg/kg, with a max of 10 mg in adults and children greater than 40 kg.
- The suggested initial dose of IV midazolam and lorazepam is 0.1 mg/kg, with a max dose of 4 mg in adults and children greater than 40 kg.

Level B Recommendation:
- Midazolam is the preferred benzodiazepine when stored in an ambulance and potentially exposed to heat stress.
- If IM injection is contraindicated, IN or buccal midazolam should be used as a second-line therapy in SE.
- If midazolam is not available or contraindicated, IV lorazepam should be used as an alternative therapy in SE.

Level C Recommendation:
- Blood glucose should be routinely checked in patients with SE only after benzodiazepine administration.
- Routine placement of a prehospital IV is recommended, after initial dose of IM or IN benzodiazepine has been administered.
- When administering IN midazolam, a highly concentrated solution of 5 mg/1 ml is preferred to minimize volume of medication delivered.
- IV and rectal diazepam is no longer recommended for the routine initial treatment of SE in the prehospital environment.
- Post-seizure airway management should include supplemental oxygen by nasal cannula, continuous pulse oximetry and end-tidal CO_2 if available, with suction, nasopharyngeal airway, bag-valve mask and endotracheal intubation immediately available for signs of respiratory failure. Monitoring of the airway is particularly important for those patients who receive treatment with benzodiazepines.
- Caution should be used when administering benzodiazepines to the same patient by both IV and IM routes since absorption differs by route.

Pediatric Febrile Seizures

What is the appropriate prehospital treatment for a pediatric patient with febrile status epilepticus?

Among children with seizures, febrile seizures are the most common type, accounting for almost one third of all pediatric seizures in the ED.[16] Up to 10% of children with febrile seizures develop febrile status epilepticus (FSE).[44] This subset of pediatric seizures accounts for 25% of all childhood SE and more than two thirds of SE in the second year of life.[44]

Since both febrile and afebrile pediatric SE are thought to cause similar neuronal damage and respiratory complications, they have traditionally been treated similarly in the prehospital environment. There has been little research directly comparing the two groups, and much of the prehospital and ED seizure research to date has included both febrile and afebrile patients together. Benzodiazepines remain the mainstay of treatment for any generalized convulsion, and treatment of pediatric FSE by EMS has largely focused on rapid and minimally invasive routes of medication administration.

In recent years, efforts to improve the administration of anticonvulsant drugs through rapid non-invasive routes have become common in prehospital care. This is especially pertinent to the pediatric population, which may have increased difficulty with IV line placement. Findings from a study of 28 children in the prehospital setting showed that buccal midazolam was as safe and effective as rectal diazepam (75% in midazolam group vs 59% in diazepam group) in terminating seizures.[36] A subsequent randomized controlled trial found buccal midazolam to be superior to rectal diazepam for children actively seizing at the time of presentation to the ED.[37] Additionally, there was no difference in rates of respiratory compromise between the groups; however, the diazepam group had higher rates of seizure recurrence after initial cessation. As discussed previously, a randomized controlled study of 126 patients comparing buccal midazolam to IV diazepam also found no difference in overall rates of seizure control, but did demonstrate faster time from initiation of treatment to seizure cessation in the buccal midazolam group.[38]

Results from a prospective, randomized study of pediatric patients with prolonged febrile seizures showed that IN midazolam was as effective as IV diazepam for seizure control.[46] In this study, 44 children were randomized to receive IN midazolam 0.2 mg/kg or IV diazepam 0.3 mg/kg for febrile seizures lasting at least 10 minutes. The convulsions were determined to be febrile seizures in a retrospective chart review. The time from arrival at the hospital to seizure control was faster in the midazolam group, and no difference as observed in rates of respiratory depression or bradycardia between the groups.

Despite the relative safety and efficacy of benzodiazepine administration for prehospital seizures, there remains a significant proportion of patients who do not receive medication prior to arrival at the ED. In one study of pediatric patients with SE in the U.S., 63% of patients did not receive any anticonvulsant medication prior to hospital arrival.[47] Although some of these patients were enrolled prior to the results of the RAMPART study, this serves as a reminder of the ongoing need for improvement in our EMS systems.

Current Prehospital Treatment Recommendation for Febrile Seizures:

Level A Recommendation:
- IM injection of midazolam should be the first line EMS treatment of the actively seizing febrile pediatric patient.
- The suggested initial dose of IM midazolam is 0.2 mg/kg, with a max of 10 mg in children greater than 40 kg.
- The suggested initial dose of IN and buccal midazolam is

0.2 mg/kg, with a maximum of 10 mg in children greater than 40 kg.
- The suggested initial dose of IV midazolam and lorazepam is 0.1 mg/kg, with a max dose of 4 mg in children greater than 40 kg.

Level B Recommendation:
- If IM injection is contraindicated, IN or buccal midazolam should be used as a second-line therapy in the actively seizing febrile pediatric patient.
- If midazolam is not available or contraindicated, IV lorazepam should be used as an alternative therapy in the actively seizing febrile pediatric patient.

Level C Recommendation:
- Pediatric FSE should be treated with the same treatment considerations as afebrile pediatric SE.
- Febrile pediatric patients who are no longer actively seizing should be transported to the ED without any anticonvulsant medication administration.
- Cooling measures should be initiated after benzodiazepine administration, as long as they do not interfere with routine care.
- Blood glucose should be routinely checked in pediatric patients with SE only after benzodiazepine administration and if the patient does not show progressive improvement in mental status.

Eclampsia

What is the appropriate prehospital treatment for a mid- to late-term pregnant patient who is actively seizing?

Eclampsia, characterized by seizure activity after the 20th week of pregnancy, is a rare but significant cause of mortality worldwide.[48] Although eclampsia may occur alongside existing pre-eclampsia, characterized by hypertension and proteinuria during pregnancy, it may also occur independently. In the U.S., approximately 15% of obstetric deaths are associated with pre-eclampsia or eclampsia. The incidence of eclampsia worldwide approaches 150,000 cases annually, with approximately 0.92 cases per 1,000 deliveries in the U.S.[49] In a 2016 study of prehospital EMS activations for pregnancy-related emergencies, however, eclampsia made up only 0.5% (19/4,096) of calls involving a pregnant or post-partum patient.[50] Eclamptic seizures may occur during the second half of pregnancy, during labor, or after childbirth. Although the underlying cause and pathophysiology of eclampsia is not completely understood, risk factors that put patients at greater risk include the following: family history of eclampsia; reduced prenatal care; age less than 20 years; multiple prior pregnancies (≥4); and ≥ 2 symptoms including headache, abdominal pain, hyper-reflexia, or visual disturbances. Eclampsia has historically been treated with an anticonvulsant to control acute seizures as well as maintenance anticonvulsant therapy until delivery can be accomplished.

There remains controversy over whether magnesium sulfate is a true anticonvulsant and should be used to treat active seizures, or is instead primarily useful in preventing additional seizures.[51] Magnesium sulfate has been hypothesized to have central nervous system anticonvulsant effects through various mechanisms including NMDA-receptor down-regulation and blood-brain barrier protection, based on in-vitro and animal models.[52-55] Since few large-scale studies comparing treatments for eclampsia have been conducted, the Cochrane Collaboration published a systematic review of seven such randomized trials in 2010.[48] It should be noted, however, that 65% of the data (910/1,396 patients) came from a single study: "Collaborative Eclampsia Trial." An earlier study had found a trend towards improved outcomes in patients with eclampsia treated with magnesium sulfate compared to diazepam; however, the study was not powered to detect a difference in seizure recurrence.[56] The Cochrane Review, in contrast, demonstrated fewer recurrent seizures after treatment with magnesium sulfate compared to both diazepam and phenytoin.[48,57] Although there was no difference in neonatal or perinatal mortality, fewer babies had Apgar scores less than seven at one minute or at five minutes in the magnesium group vs diazepam group.[48] This remains the most conclusive evidence to date, and has been universally adopted as the standard of care in treatment of eclampsia.[58] In 2002, the American College of Obstetricians and Gynecologists published Level A recommendations for the treatment of eclampsia with magnesium sulfate IV or IM, typically with a 4 - 6 g initial IV loading dose followed by 2 g per hour infusion.[59] While the ideal prehospital treatment of eclampsia remains somewhat unclear, seizure control with an anticonvulsant agent and airway management are of paramount importance.

Current Prehospital Treatment Recommendation for Eclampsia:

Level A Recommendation:
- Actively seizing patients who are known to be pregnant or postpartum should be treated with magnesium sulfate 4 to 6 g IV.

Level B Recommendation:
- None given.

Level C Recommendation:
- If an IV cannot be established quickly, an initial dose of magnesium sulfate 10 g IM may be administered as an alternative (with 5 g administered IM in each buttock).
- IM or IV benzodiazepines should be considered in the treatment of refractory seizures in the pregnant or postpartum patient unresponsive to magnesium sulfate.
- Blood glucose should be routinely checked in patients with suspected eclampsia.
- Airway management should include supplemental oxygen, bag-valve mask ventilation, and endotracheal intubation immediately available for respiratory failure.

- Patients should be placed in a position of comfort, which also helps maintain a patent airway and minimize risk of falls. If hypotension is present, the patient should be placed in the left lateral decubitus position, as tolerated.

RESULTS

All 33 agencies have protocols, which were identified and reviewed for consistency with the recommendations made by EMDAC for prehospital seizure management (Tables 1 and 2). Every agency has a protocol relating to the treatment of seizures, although these protocols vary significantly. Multiple drugs, dosages, routes of administration, re-dosing instructions, and requirement for blood glucose testing prior to medication delivery were found. Examples of suggested language for protocol development that the committee felt was most consistent with the recommendations were taken from the agency protocols.

Witnessed Seizure Not Actively Seizing

Few of the seizure protocols in California specifically mention the treatment of patients who are not actively seizing. Routine care, including airway management and evaluation for underlying causes, are typically recommended.

Choice of Benzodiazepine in Actively Seizing Patient

The overwhelming benzodiazepine of choice in California for patients who are actively seizing is midazolam. There was variation in dosing of the IM, IN, and IV/IO routes described in each protocol. One EMS agency uses lorazepam as a first-line agent with midazolam available as a second-line therapy. Two rural California agencies have special use of diazepam for EMT-IIs in their counties. Several agencies provide the option of diazepam and/or lorazepam as possible substitutes in the case of drug shortages. All agencies have protocols for giving IV and IM benzodiazepines and 76% (25/33) have protocols for IN benzodiazepines.

Dose of Benzodiazepine in Actively Seizing Patient

IM midazolam dosages ranged from 2 to 10 mg per single adult dose, 2 to 8 mg per single pediatric dose, and 0.1 to 0.2 mg/kg as a weight-based dose. IN midazolam dosages ranged from 2 to 10 mg per single adult or pediatric dose, and 0.1 to 0.2 mg/kg as a weight-based dose. IV/IO midazolam dosages ranged from 1 to 6 mg per single adult dose, 1 to 5 mg per single pediatric dose, and 0.05 to 0.1 mg/kg as a weight-based dose.

Order of Benzodiazepine and Glucose Measurement in Actively Seizing Patient

Blood glucose testing *prior* to benzodiazepine administration is required by 61% (20/33) of agencies for adult patients and 76% (25/33) for pediatric patients. Nine percent (3/33) of agencies recommend checking blood glucose prior to benzodiazepine administration if hypoglycemia is suspected or there is a known history of diabetes mellitus. This has been identified as an area for improvement in our clinical protocols for the seizing patient.

Pediatric Febrile Seizures

Sixty-seven percent (22/33) of agencies specifically address the treatment of febrile seizures. One agency has a protocol for administering acetaminophen or ibuprofen to patients with febrile seizures. Fifty-eight percent (19/33) of agencies have a protocol for passive and/or active cooling *prior* to administration of benzodiazepines.

Eclampsia

Eclampsia is specifically addressed by 85% (28/33) of agencies. Forty-two percent (14/33) of agencies have a protocol for administering magnesium sulfate to patients with eclampsia, with dosages ranging from 2 to 6mg IV and 58% (19/33) allow benzodiazepines to be administered.

DISCUSSION

The adult and pediatric seizure protocols varied greatly in content and structure between local EMS agencies in the State of California. These government agencies consist of either a county or region that develops a system of care that includes first responders, ambulance transporters, and specialty receiving facilities. These systems reflect the needs and demographics of that county or region and operate under one set of medical control policies. A similar variation among protocols was seen in a recent study on statewide EMS protocols.[60] In 2014, the National Association of EMS Officials published model EMS guidelines that could be used to decrease this variability.

LIMITATIONS

This study is limited by the fact that only the protocols of one state were evaluated and might not be generalizable to other geographic areas. There are always inherent biases involved in the analysis of the available evidence and the synthesis into recommendations. Our clinical questions could not always be answered by specific prehospital research. When appropriate, research that was completed in a hospital setting was extrapolated to answer our question.

CONCLUSION

Protocols for adult and pediatric seizures, including eclampsia and febrile seizures, vary widely across the State of California. The evidence-based recommendations that we present for the prehospital diagnosis and treatment of this condition may be useful for EMS medical directors tasked with creating and revising these protocols.

Table 1. Adult Seizure protocols.

LEMSA	Blood glucosre prior To BZD	Midazolam			Eclampsia
		IN	IM	IV/IO	
Alameda County	No	5 mg	0.1 mg/kg to max 6mg, give full dose IM	0.1 mg/kg in 1-2mg increments (no specified frequency, max single dose 6mg)	Midazolam (follow seizure protocol)
Central California EMS	No	0.1 mg/kg IN to max of 4mg	0.1 mg/kg to max 4mg x 1 only	0.05 mg/kg to max 2mg, repeat x 1 at 10min	Midazolam, then Mag 5g IV over 20 min
Coastal Valleys EMS	Yes	5mg MR x1 at 10min	5 mg MR x1 at 10min	2mg Q5min PRN, net max 10mg by all routes	Midazolam 2mg, if transport > 1hr, optional Magnesium 2g followed by drip
Contra Costa County	Yes	N/A	0.1 mg/kg to max 5mg	1mg, titrate in 1-2mg increments to max 5mg	----
El Dorado County	Yes	5mg MR at 5min	5mg	2.5mg MR at 5min	Mag 6g IV over 1-2min
Imperial County	Yes	0.2 mg/kg to max 10mg, repeat x 1 per BH	0.2 mg/kg to max 10mg, repeat x 1 at 10min	0.1 mg/kg to max 5mg, repeat x 1 at 10min	Midazolam per SZ Protocol w/all repeat doses per BH
Inland Counties EMA	Yes	2.5mg MR at 5min (max 3 doses all routes)	5mg MR at 10min (max 3 doses all routes)	2.5mg MR at 5min (max 3 doses all routes)	Mag 4g over 3-4min, gtt at 0.6 g/hr to 2g
Kern County	Yes	1st line: lorazepam 2mg IV/IO/IM Q10min to max 4mg	2nd line: midazolam 1mg IV/IN Q2min PRN to max 5mg w/BHO	3rd line: diazepam 5mg IV Q10min PRN to max 30mg w/BHO	1st line: Mag 2-4g IV 2nd line: diazepam 5mg IV Q10min PRN to max 30mg
Los Angeles County	Yes	5mg MR x1 at 5min	5mg MR x1 at 5min	2-5mg MR x1 at 5min, net max 10mg by all routes	DO NOT delay transport for treatment
Marin County	Yes	5mg	0.1 mg/kg MR x 1 at 10min	1mg Q3min PRN to max 0.05 mg/kg	Midazolam, NTG for HTN
Merced County	No	N/A	0.2 mg/kg to max 8mg, may NOT repeat	0.1 mg/kg to max 4mg, MR (no specified frequency or net max)	Mag 2g IV over 2 min
Monterey County	No	2mg MR x1	2mg MR x1	1-2mg Q5min PRN to max 4mg	----
Mountain Valley EMS	Yes	N/A	5mg MR x1 at 10min	2mg then titrate 1mg increments to max 6mg (no specified frequency)	----
Napa County	Yes	5mg x 1 only (MR x1 at 5min for eclampsia)	0.1 mg/kg to max 6mg (max 5mg fpr eclampsia)	1mg then titrate 1mg increments to max 6mg (no specified frequency)	Midazolam, NTG for HTN (need base contact)
Nor-Cal EMS	Yes	0.2 mg/kg to max 10mg, MR x1 to 20mg w/BHPO	N/A	2mg Q2min PRN to max 10mg, max 20mg w/BHPO	Mag 4g IV over 20min followed by gtt at 2 g/hr

BZD, benzodiazepine; *IN,* intranasal; *IM*, intramuscular; *IV/IO,* intravenous/interosseous; *mg,* milligram; *mg/kg,* milligram per kilogram; *MAX,* maximum; *MAG,* magnesium; *MR,* may repeat; *PRN,* as needed; *Q,* every; *BH,* base hospital; *MIN,* minute; *SZ*, seizure; *GTT,* drops; *BHO,* base hospital; *NTG,* nitroglycerin; *HTN,* hypertension; *BHPO*, base hospital physician; *EMT-II,* emergency medical technician; *DM,* diabetes mellitus; *CBG,* capillary blood glucose; *PR,* per rectum; *SMC,* San Mateo County

Table 1. Continued.

LEMSA	Blood glucosre prior To BZD	Midazolam			Eclampsia
		IN	IM	IV/IO	
EMT-II		Diazepam 2.5-10mg IVP over 2min, if no access 10mg IM. MR x1 to max 20mg IV/IM/IO w/BHPO			
North Coast EMS	Yes	5mg w/10mg max	5mg (0.07 mg/kg)	1-2.5mg repeat PRN to max 0.1 mg/kg not to exceed 10mg	Mag 4g IV over 20min followed by gtt at 1-2 g/hr
EMT-II		Diazepam 2.5-20mg IVP titrated in 2.5mg increments to max 40mg. 5-10mg IM			
Orange County	No	5mg MR x1 at 3 min	5mg MR x1 at 3 min	N/A	Midazolam
Riverside County	Yes	2.5mg MR x1 (all dosages per chart)	5mg MR x 1	2.5mg MR x 1	Mag 5g IV over 10min or 2.5g IM x 2 divided doses
		May substitute lorazepam 5mg IM, 2.5mg IN/IV/IO OR diazepam 5mg IM, 2.5mg IV/IO. MR x1			
Sacramento County	Yes	0.1 mg/kg to max 6mg	0.1 mg/kg to max 6mg	0.1 mg/kg to max 6mg in 2mg increments	----
		May substitute diazepam (in context of midazolam shortage) 5-10mg IV/IO, 10mg IM, MR IM x1			
San Benito County	Yes	0.1 mg/kg to max 5mg, additional per BH	0.2 mg/kg to max 10mg, additional per BH	0.1 mg/kg to max 5mg, additional per BH	Midazolam (follow seizure protocol)
San Diego County	No	Midazolam IN/IM/IV/IO to max 5mg, MR x 1 at 10min to max 10mg (no specified increment or interval)			Midazolam IN/IM/IV/IO to max 5mg, MR x1 at 10min to max 10mg
San Francisco County	No	5mg x1	5mg x1	2.5mg MR at 5min, max dose 5mg	Magnesium sulfate
San Joaquin County	No	4mg MR Q5min to max 10	2 or 4mg(?) MR Q5min to max 10mg	2mg MR Q5min to max 10mg	Mag 2g IV over 3-5min after base hospital contact
San Luis Obispo County	No	5mg MR x1 at 10min	0.1 mg/kg to max 5mg MR x1 at 10min	1-2mg MR x1 at 10min	Midazolam (follow seizure protocol)

BZD, benzodiazepine; *IN,* intranasal; *IM*, intramuscular; *IV/IO,* intravenous/interosseous; *mg,* milligram; *mg/kg,* milligram per kilogram; *MAX,* maximum; *MAG,* magnesium; *MR,* may repeat; *PRN,* as needed; *Q,* every; *BH,* base hospital; *MIN,* minute; *SZ*, seizure; *GTT,* drops; *BHO,* base hospital; *NTG,* nitroglycerin; *HTN,* hypertension; *BHPO*, base hospital physician; *EMT-II,* emergency medical technician; *DM,* diabetes mellitus; *CBG,* capillary blood glucose; *PR,* per rectum; *SMC,* San Mateo County

Table 1. Continued.

LEMSA	Blood glucosre prior To BZD	Midazolam			Eclampsia
		IN	IM	IV/IO	
San Mateo County	No	N/A	1-2mg Q5min PRN to max 10mg	1-2mg Q5min PRN to max 10mg	Midazolam IV/IM 1-2mg Q5min PRN to max 10mg
Santa Barbara County	Yes if known h/o DM	N/A	0.1 mg/kg to max 5mg	1mg Q2min PRN to max 5mg	Mag 2g IV over 5 min, MUST repeat x1, midazolam if persistent seizures > 2 min
Santa Clara County	Yes	5mg	0.1 mg/kg to max 5mg	2mg Q2min PRN to max 5mg	midazolam (follow seizure protocol)
		2nd choice: diazepam 5-10mg IV, MR at 5min to max 15mg	3rd choice: lorazepam 1-2mg IV Q10min PRN to max 8mg		
Santa Cruz County	Yes	N/A	0.2 mg/kg to max 10mg	0.1 mg/kg to max 5mg	Midazolam (follow seizure protocol)
Sierra Sacramento Valley EMS	Yes	0.2 mg/kg to max 8mg MR x1 at 5min	0.2 mg/kg to max 8mg MR x1 at 5min	0.1 mg/kg to max 4mg MR x1 at 5min	Midazolam (follow seizure protocol)
Solano County	Yes	N/A	4mg	2mg	Midazolam (follow seizure protocol)
Tuolumne County	No	1-2mg Q3min PRN to max to max 10mg by all routes	2mg Q10min to max 10mg by all routes	1-2mg Q3min PRN to max to max 10mg by all routes	Midazolam (follow seizure protocol), THEN Magnesium 2g IV after base contact
Ventura County	Yes	N/A	0.1 mg/kg to max 5mg	2mg repeat 1mg Q2min PRN to max 5mg	Mag 2g IV over 5min, MUST repeat x1, midazolam if persistent seizures > 2 min
Yolo County	No	5mg may NOT repeat	0.1 mg/kg to max 6mg may NOT repeat	2mg repeat 1mg Q5min PRN to max 6mg	----

BZD, benzodiazepine; *IN,* intranasal; *IM*, intramuscular; *IV/IO,* intravenous/interosseous; *mg,* milligram; *mg/kg,* milligram per kilogram; *MAX,* maximum; *MAG,* magnesium; *MR,* may repeat; *PRN,* as needed; *Q,* every; *BH,* base hospital; *MIN,* minute; *SZ*, seizure; *GTT,* drops; *BHO,* base hospital; *NTG,* nitroglycerin; *HTN,* hypertension; *BHPO*, base hospital physician; *EMT-II,* emergency medical technician; *DM,* diabetes mellitus; *CBG,* capillary blood glucose; *PR,* per rectum; *SMC,* San Mateo County

Table 2. Pediatric seizure protocols.

LEMSA	CBG Prior to 1st dose BZD	Midazolam			Febrile
		IN	IM	IV/IO	
Alameda County	No after benzos	0.2 mg/kg	0.1 mg/kg to max 5mg, give full dose IM	0.1 mg/kg in 1-2mg increments (no specified frequency, max single dose 5mg)	cooling after benzos
Central California EMS	No	0.1 mg/kg IN to max of 4mg	0.1 mg/kg to max 4mg x 1 only	0.05 mg/kg to max 2mg, repeat x 1 at 10min	----
Coastal Valleys EMS	Yes	0.1 mg/kg MR x1 at 5min to max 5mg	0.1 mg/kg MR x1 at 5min to max 5mg	0.1 mg/kg MR x1 at 5min to max 5mg	cool if febrile
Contra Costa County	Yes	N/A	0.1 mg/kg to max 5mg	1mg increments to max 0.1 mg/kg	remove clothing to "address cooling"
El Dorado County	Yes	0.1 mg/kg max total 3mg	0.1 mg/kg max total 3mg	0.1 mg/kg max total 3mg	external cooling with water, Tylenol or Ibuprofen
Imperial County	Yes	0.2 mg/kg (not listed in peds drug guide)	0.2 mg/kg in max 1-2mL increments	0.1 mg/kg to max 5mg	----
Inland Counties EMA	Yes	0.2 mg/kg to max 5mg MR at 10min	0.2 mg/kg to max 5mg MR at 10min	0.1 mg/kg to max 2.5mg MR at 5min	cooling before benzos
Kern County	Yes	1st line: midazolam 0.2mg/kg IM MR at 15min, IV/IO/IN to max 6mg	2nd line: lorazepam 0.1 mg/kg IV/IM/IO MR at 5min to max 0.2 mg/kg not to exceed 4mg	3rd line: diazepam 0.3 mg/kg IV/IO MR Q25min to max 5mg, 0.5 mg/kg PR to max 10mg	----
Los Angeles County	Yes	0.1 mg/kg MR x1 at 5min to max 5mg by all routes	0.1 mg/kg MR x1 at 5min to max 5mg by all routes	0.1 mg/kg MR x1 at 5min to max 5mg by all routes	cooling before benzos
Marin County	Yes	0.2 mg/kg to max 5mg	0.1 mg/kg MR x 1 at 10min	0.05 mg/kg (max 1mg/dose) Q3min PRN to max 5mg	"treat fever prior to benzos"
Merced County	Yes	N/A	0.2 mg/kg to max 8mg, may NOT repeat	0.1 mg/kg to max 4mg, MR x1 at 15min	----
Monterey County	Yes	0.2 mg/kg to max 2mg, repeat by BHO only	0.2 mg/kg to max 2mg, repeat by BHO only	0.1 mg/kg to max 2mg, repeat by BHO only	External cooling with water, fans
Mountain Valley EMS	Yes	N/A	0.2 mg/kg to max 5mg MR x1 at 10min	0.1 mg/kg to max 5mg MR x1 at 10min	----
Napa County	Yes	0.2 mg/kg to max 5mg, may NOT repeat	0.1 mg/kg to max 5mg, may NOT repeat	1mg then titrate 1mg increments to max 5mg (no specified frequency)	----
Nor-Cal EMS	Yes	0.2 mg/kg to max 10mg, MR x1 to 10mg w/BHPO; PR 0.3 mg/kg MR x1*	N/A	0.1 mg/kg * *patient weight > 20kg, if less requires BHPO	----

BZD, benzodiazepine; *IN,* intranasal; *IM*, intramuscular; *IV/IO,* intravenous/interosseous; *mg,* milligram; *mg/kg,* milligram per kilogram; *MAX,* maximum; *MAG,* magnesium; *MR,* may repeat; *PRN,* as needed; *Q,* every; *BH,* base hospital; *MIN,* minute; *SZ*, seizure; *GTT,* drops; *BHO,* base hospital; *NTG,* nitroglycerin; *HTN,* hypertension; *BHPO*, base hospital physician; *EMT-II,* emergency medical technician; *DM,* diabetes mellitus; *CBG,* capillary blood glucose; *PR,* per rectum; *SMC,* San Mateo County

Table 2. Continued.

LEMSA	CBG Prior to 1st dose BZD	Midazolam			Febrile
		IN	IM	IV/IO	
EMT-II		Diazepam 0.2 mg/kg IM/IV/IO MR x1 to max 10mg w/ BHPO			
North Coast EMS	Yes	0.1 mg/kg	0.1 mg/kg subsequent up to 0.4 mg/kg to max 5mg, net max 10mg	0.05 mg/kg max 5mg, net max 10mg	Cool with moist towels
EMT-II		Diazepam 0.1-0.3 mg/kg IVP or 0.5 mg/kg PR to max 20mg			
Orange County	No	0.1 mg/kg to max 5mg, MR x1 at 3mins	0.1 mg/kg to max 5mg, MR x1 at 3mins	N/A	----
Riverside County	Yes	(Per Broselow)	(Per Broselow)	(Per Broselow)	cooling measures before benzos
		May substitute lorazepam or diazepam			
Sacramento County	Yes	0.2 mg/kg to max 6mg	0.1 mg/kg to max 4mg	0.1 mg/kg to max 4mg in 1-2mg increments	undress pt for cooling
		May substitute diazepam (in context of midazolam shortage) 0.1 mg/kg IM/IV/IO to max 5mg, MR IM x1			
San Benito County	Yes	0.1 mg/kg to max 3mg, additional per BH	0.2 mg/kg to max 3mg, additional per BH	0.1 mg/kg to max 3mg, additional per BH	----
San Diego County	No	(Per Broselow)	(Per Broselow)	(Per Broselow)	"Versed not required for simple febrile seizures"
San Francisco County	Yes	0.2 mg/kg total max dose 2mg*	0.1 mg/kg total max dose 2mg*	0.1 mg/kg total max dose 2mg* *may substitute Diastat rectal gel if available	"Cooling measures if fever present"
San Joaquin County	Yes	0.2 mg/kg to max 5mg	0.1 mg/kg to max 5mg	0.1 mg/kg to max 5mg	"initiate cooling if febrile"
San Luis Obispo County	No	0.1 mg/kg to max 5mg all routes MR x1 at 10min	0.1 mg/kg to max 5mg all routes MR x1 at 10min	0.1 mg/kg to max 5mg all routes MR x1 at 10min	----

BZD, benzodiazepine; *IN,* intranasal; *IM*, intramuscular; *IV/IO,* intravenous/interosseous; *mg,* milligram; *mg/kg,* milligram per kilogram; *MAX,* maximum; *MAG,* magnesium; *MR,* may repeat; *PRN,* as needed; *Q,* every; *BH,* base hospital; *MIN,* minute; *SZ*, seizure; *GTT,* drops; *BHO,* base hospital; *NTG,* nitroglycerin; *HTN,* hypertension; *BHPO*, base hospital physician; *EMT-II,* emergency medical technician; *DM,* diabetes mellitus; *CBG,* capillary blood glucose; *PR,* per rectum; *SMC,* San Mateo County

Table 2. Continued.

LEMSA	CBG Prior to 1st dose BZD	Midazolam			Febrile
		IN	IM	IV/IO	
San Mateo County	Yes	N/A	(Per SMC reference card to max 5mg)	(Per SMC reference card to max 5mg)	cooling before benzos
Santa Barbara County	If known h/o DM	N/A	0.1 mg/kg to max 5mg	0.1 mg/kg to max 1mg	passive cooling measures
Santa Clara County	Yes	0.1 mg/kg to max 5mg 2nd choice: diazepam IV 0.25 mg/kg to max 5mg age < 5y, max 10mg > 5y; PR 0.5 mg/kg to max 10mg; 3rd choice: lorazepam 0.1 mg/kg to max 2mg MR x1 at 5-10min to net max 4mg	0.1 mg/kg to max 5mg	0.1 mg/kg to max 5mg	remove clothing to address cooling
Santa Cruz County	Yes	N/A	0.2 mg/kg to max 3mg total	0.1 mg/kg to max 3mg total	remove clothing to address cooling
Sierra Sacramento Valley EMS	Yes	0.2 mg/kg to max 8mg MR x1 at 5min	0.2 mg/kg to max 8mg MR x1 at 5min	0.1 mg/kg in 1-2mg increments to max 4mg MR x1 at 5min	remove clothing to address cooling
Solano County	Yes	N/A	0.2 mg/kg to max 4mg	0.1 mg/kg titrated in 1mg increments Q3min to max 5mg	cooling if febrile
Tuolumne County	No	0.2 mg/kg to max 2mg	0.1 mg/kg to max 1mg	0.1 mg/kg to max 1mg	----
Ventura County	Yes	N/A	0.1 mg/kg to max 5mg	N/A	passive cooling measures
Yolo County	No	0.2 mg/kg to max 8mg MR x1 at 5min with BHO	0.2 mg/kg to max 8mg MR x1 at 5min with BHO	0.1 mg/kg in 1-2mg increments repeat Q5min, max single dose 4mg	cooling only AFTER seizures stop/controlled

BZD, benzodiazepine; *IN,* intranasal; *IM*, intramuscular; *IV/IO,* intravenous/interosseous; *mg,* milligram; *mg/kg,* milligram per kilogram; *MAX,* maximum; *MAG,* magnesium; *MR,* may repeat; *PRN,* as needed; *Q,* every; *BH,* base hospital; *MIN,* minute; *SZ*, seizure; *GTT,* drops; *BHO,* base hospital; *NTG,* nitroglycerin; *HTN,* hypertension; *BHPO*, base hospital physician; *EMT-II,* emergency medical technician; *DM,* diabetes mellitus; *CBG,* capillary blood glucose; *PR,* per rectum; *SMC,* San Mateo County

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The Efficacy of LUCAS in Prehospital Cardiac Arrest Scenarios: A Crossover Mannequin Study

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Introduction: High-quality cardiopulmonary resuscitation (CPR) is critical for successful cardiac arrest outcomes. Mechanical devices may improve CPR quality. We simulated a prehospital cardiac arrest, including patient transport, and compared the performance of the LUCAS™ device, a mechanical chest compression-decompression system, to manual CPR. We hypothesized that because of the movement involved in transporting the patient, LUCAS would provide chest compressions more consistent with high-quality CPR guidelines.

Methods: We performed a crossover-controlled study in which a recording mannequin was placed on the second floor of a building. An emergency medical services (EMS) crew responded, defibrillated, and provided either manual or LUCAS CPR. The team transported the mannequin through hallways and down stairs to an ambulance and drove to the hospital with CPR in progress. Critical events were manually timed while the mannequin recorded data on compressions.

Results: Twenty-three EMS providers participated. Median time to defibrillation was not different for LUCAS compared to manual CPR (p=0.97). LUCAS had a lower median number of compressions per minute (112/min vs. 125/min; IQR = 102-128 and 102-126 respectively; p<0.002), which was more consistent with current American Heart Association CPR guidelines, and percent adequate compression rate (71% vs. 40%; IQR = 21-93 and 12-88 respectively; p<0.002). In addition, LUCAS had a higher percent adequate depth (52% vs. 36%; IQR = 25-64 and 29-39 respectively; p<0.007) and lower percent total hands-off time (15% vs. 20%; IQR = 10-22 and 15-27 respectively; p<0.005). LUCAS performed no differently than manual CPR in median compression release depth, percent fully released compressions, median time hands off, or percent correct hand position.

Conclusion: In our simulation, LUCAS had a higher rate of adequate compressions and decreased total hands-off time as compared to manual CPR. Chest compression quality may be better when using a mechanical device during patient movement in prehospital cardiac arrest patient. [West J Emerg Med. 2017;18(3)437-445.]

INTRODUCTION

The survival rate for patients suffering prehospital cardiac arrest is extremely low, typically in the range of 5-8%.[1] While there are many reasons for low success rates in prehospital cardiac arrest, two of the most studied and most integral are the performance of proper chest compressions and amount of total hands-off time during cardiopulmonary resuscitation (CPR).

To perform high-quality chest compressions with a minimal amount of hands-off time, they must be done with an adequate depth and rate.[2] When a provider performs chest compressions on a patient in cardiac arrest, it takes multiple compressions to build up and maintain an adequate intravascular pressure to allow for proper perfusion of the tissues. Additionally, whenever there is a halt in compression application, that pressure is quickly lost and it once again takes time to build that pressure back, leading to large amounts of time with suboptimal perfusion of the heart and brain. Thus, it is critical that interruptions between times that compressions are being performed be kept to a minimum to help increase good patient outcomes. A variety of factors make it difficult to achieve uniformly perfect compressions with minimal hands-off time in the prehospital setting, including needing to move the patient around obstacles, maintaining balance in a moving vehicle, and attempting to perform other Advanced Cardiovascular Life Support (ACLS) measures.[2,3] These tasks can make adequate access to the patient's chest difficult, which greatly reduces the total number of proper chest compressions and causes large gaps where no compressions are being performed. Moreover, performance of chest compressions is exhausting and most providers will quickly begin to tire, resulting in a decrease in compression quality.[1]

Mechanical devices have been designed to perform automated CPR chest compressions on patients so that compressions are not being directly performed by health professionals.[4] One such device, the Lund University Cardiac Arrest System (LUCAS™), has been in use since the early 2000s. A photo of the device is shown in Figure 1.The debate as to whether the use of mechanical CPR devices results in better patient outcomes, as compared to manual CPR, is currently a heavily debated topic. A number of studies show good rates of return of spontaneous circulation (ROSC) in the field with increased desirable patient outcomes compared to manual CPR.[5-10] At the same time, there are a number of other studies that show no difference between mechanical devices and the efficacy of manual CPR.[11-18]

We hypothesized that the use of the LUCAS device in a realistic prehospital cardiac arrest scenario involving transport of the patient would lead to increased quality of CPR, i.e., more in line with American Heart Association (AHA) guidelines, as measured by consistent chest compression rate, a greater compression depth, an increased compression fraction, and full chest recoil as compared to CPR done manually ("manual CPR"). We also hypothesized that deployment of the LUCAS device would not significantly delay time until the first defibrillation of the patient.

Population Health Research Capsule

What do we already know about this issue?
Some studies suggest that LUCAS, a mechanical chest compression-decompression device, provides improved CPR in the lab and inpatient settings, but few studies have prospectively assessed prehospital LUCAS use.

What was the research question?
Does LUCAS use in typical prehospital conditions improve CPR and shorten time to critical resuscitation and transport events?

What was the major finding of the study?
LUCAS deployment resulted in improved compression rate and reduced hands-off time, while not delaying defibrillation.

How does this improve population health?
If CPR characteristics and resuscitation events in prehospital arrests are improved with LUCAS, patients may have lower morbidity and mortality following out-of-hospital cardiac arrest.

METHODS

The study was reviewed and approved by the Pennsylvania State University Institutional Review Board. We recruited subjects from a single hospital-operated advanced life support EMS program working under state-delineated treatment protocols. Teams were composed of one paramedic and one emergency medical technician (EMT). Primary outcomes for the study included time to first defibrillation and better CPR characteristics. For the purposes of power calculation, we based our definition of better CPR on chest compression rate. We expected that a delay of 30 seconds for defibrillation or a compression rate differing by more than 20/min would be clinically significant. Based on these factors, we calculated that enrolling at least 20 participants (10 teams) in the study would provide 80% power to detect a statistically significant difference at $\alpha = 0.05$.

Upon consenting to participate in the study, subjects were asked to complete a brief questionnaire to obtain demographic information regarding certification level, experience with CPR, and experience with LUCAS. They then completed a 15-minute orientation and training session

Figure 1. The LUCAS™ chest compression system, a device for mechanical chest compression-decompression. *LUCAS,* Lund University Cardiac Arrest System.

with the LUCAS device, in which its proper use was demonstrated and the subjects were then permitted to practice and ask any questions about using it.

The study was a crossover controlled mannequin study in which a resuscitation simulation mannequin (Laerdal *Resusci Anne* Simulator Model 150-00001) was fitted with CPR biophysical sensors and attached wirelessly to analytical software designed for the mannequin. This simulation mannequin weighed 36 kg; additionally, because its weight was certainly lighter than that of most real patients, a 14 kg weighted belt was placed around the mannequin to increase its weight during trials to a total of 50 kg. The mannequin was then programmed to present in ventricular fibrillation and was placed on the second floor of a building approximately five miles from the medical center. An EMS crew was asked to respond from the parking lot of the building up to the mannequin. The crew was instructed to go through the state-delineated protocol for cardiac arrest response, including defibrillation pad placement, rhythm identification, one defibrillation, one attempt at airway placement, and performance of manual CPR for at least two cycles prior to any other activity.[19,20]

The crew packaged the mannequin in a Reeves litter and carried the mannequin and all equipment down to the waiting ambulance. The path to the ambulance included two stairways, totaling approximately 15 steps, and three narrow hallways. Upon reaching the ambulance, the crew loaded the mannequin onto the ambulance litter and initiated transport to the medical center. The driver of the ambulance was standardized across all scenarios. The crew continued resuscitation efforts until the ambulance pulled into the parking lot of the medical center emergency department (ED). After completion of the scenario, the crew received a 30-minute rest period to recover from the first scenario. They were then instructed to repeat the same scenario, but with use of the LUCAS device in place of manual CPR. The order in which crews completed the two scenarios was randomized.

Mannequin software automatically recorded data on CPR compression rate, compression depth, compression release depth, correct hand position, and time hands off. Specifically, the software provided these data for each CPR characteristic for each compression in a given trial and then automatically calculated descriptive statistics for each trial from the data set. In addition, time elapsed to critical clinical and transport events were marked manually throughout the scenario by an investigator who monitored the conduct of each trial.

Statistical Analysis

We analyzed the demographic data collected from participants for descriptive statistics only. The descriptive statistics obtained from the mannequin software program were

analyzed and inferential statistics were obtained via STATA 9 statistical software (Statacorp, College Station, TX).

Because study data were nonparametric, we used median and percentile comparisons in the data analysis. LUCAS and manual CPR results were compared via the Wilcoxon signed-rank test.

RESULTS

Thirteen paramedics and 13 EMTs participated in the study. Table 1 summarizes the participant demographics. Table 2 shows the median times to completion of critical transport events for scenarios in which manual CPR and LUCAS CPR were administered. There was no statistically significant difference between the chest compression modalities for time to patient contact, time to CPR initiation, time to placement of the defibrillator pads, time to rhythm identification, or time to arrival at the ED. However, we found that LUCAS took a significantly longer time for arrival of the packaged patient at the litter, time of arrival at the ambulance, and time that transport to the hospital commenced. Median time to first defibrillation was not different for LUCAS compared to manual CPR (132 s vs. 123 s, p = 0.97).

LUCAS was found to perform no differently than manual CPR when analyzing median compression depth, median

Table 1. Demographic data of emergency medical services participants in a study of the use of a mechanical chest compression-decompression device vs. manual CPR.

Demographic	EMT-B (n=13)	EMT-P (n=13)
Mean number of years in EMS (range)	13.5 (6-27)	19.4 (4-47)
Number who received LUCAS training in CPR course	1	2
Current CPR instructor	2	4
Mean previous LUCAS training sessions (range)	2 (1-8)	2 (1-12)
Mean estimate of times performed manual CPR (range)	50 (10-100)	95 (15-230)
Mean estimate of times LUCAS used (range)	2 (0-15)	2 (0-10)

CPR, cardiopulmonary resuscitation; *EMS,* emergency medical services; *EMT-B,* emergency medical technician-basic; *EMT-P,* emergency medical technician-paramedic; *LUCAS,* Lund University Cardiac Arrest System.

Table 2. Median time to completion of critical transport events.

Time-stamped event	Median time with manual CPR (s) (IQR)	Median time with LUCAS (s) (IQR)	p-value
Patient contact	31 (29-33)	32 (31-34)	0.27
CPR initiation	66 (45-71)	62 (56-76)	1.0
Placement of defibrillator pads	100 (86-110)	105 (94-111)	0.22
Rhythm identification	106 (103-129)	120 (103-130)	0.97
Defibrillation performed	123 (108-135)	132 (113-141)	0.97
Arrival at litter	369 (338-412)	422 (312-493)	0.006*
Arrival at ambulance	538 (493-559)	622 (425-753)	0.06*
Begin transport	565 (517-610)	664 (454-805)	0.03*
Arrival at ED	1436 (1369-1468)	1411 (1353-1478)	0.21

CPR, cardiopulmonary resuscitation; *LUCAS,* Lund University Cardiac Arrest System*; ED,* emergency department.

Table 3. Analysis of chest compression characteristics between the LUCAS mechanical device and manual CPR.

Chest compression characteristic	LUCAS CPR (IQR)	Manual CPR (IQR)	p
Median compression depth (mm)	36 (35-38)	37 (35-48)	0.83
Compressions fully released (%)	93 (77-96)	78 (72-88)	0.67
Median duration of hands off event (s)	7 (5-9)	9 (7-12)	0.86
Compressions with correct hand position (%)	91 (78-100)	96 (88-99)	0.83

CPR, cardiopulmonary resuscitation; *LUCAS,* Lund University Cardiac Arrest System.

compression release depth, percent of compressions that were fully released, median time that was hands off in the scenario, and percent of compressions with a correct hand position on the chest. Analyses of these data can be found in Table 3.

It was found that median compression rate in the LUCAS scenario (112 compressions/min.) was significantly less than that in the manual CPR scenario (125 compressions/min IQR = 102-128 and 102-126 respectively; $p<0.002$). The percentage of compression that achieved an adequate rate in the LUCAS scenario (71%) was significantly greater than that achieved in the manual CPR scenario (40%, IQR = 12-93 and 21-88 respectively; $p<0.002$). Furthermore, the percentage of LUCAS compressions that achieved an adequate depth (52%) was significantly greater than that in the manual CPR scenario (36%; IQR = 29-74 and 25-64 respectively; $p<0.007$). Finally, the percent total time in the LUCAS scenario that was hands-off time (15%) was significantly decreased with that found in the manual CPR scenario (20%; IQR = 10-22 and 15-27 respectively; $p<0.005$). Figure 2 shows a graphical analysis of these data.

DISCUSSION

The AHA has placed a heavy emphasis on improving the quality of chest compressions during CPR; its stance is that while survival from cardiac arrest depends on early recognition of the event and immediate activation of the emergency response system, "equally critical is the quality of CPR delivered." Proper compressions have been found to lead to increased rates of ROSC both in the prehospital and hospital settings, as well as improved cerebral blood flow and better neurological outcome.[21-25] The increased quality of CPR via the LUCAS device has been already demonstrated in the laboratory and hospital settings. Studies have found that LUCAS provides a compression rate that is consistently able to meet or exceed AHA guidelines. The machine does not become fatigued like a human healthcare provider and so does not reduce its quality of compressions over time.[4,19] In addition, LUCAS allows for less hands-off time during compressions and allows for healthcare personnel to have free hands to perform other tasks such as airway management, IV access, and medications administration. Indeed, when the EMS crew is required to move the patient around tight corners, through narrow hallways, or down multiple stairwells, the device allows for continued compressions during situations in which a patient would almost certainly be receiving no compressions. As the device has continuous access to the patient, lack of provider access to the chest when in awkward locales in the field does not present a barrier to continued CPR. During performance of this study, 100% of crews during manual CPR either completely stopped compressions while moving the patient to the ambulance or else had to not perform compressions while moving the patient and halt transport multiple times to perform a round of compressions. These events were nonexistent when the LUCAS was deployed, with hands-off time occurring during LUCAS CPR only during application of the device and readjustment of the device during slippage. Thus, the patient received continued compression during transport, and the time of transport was not extended due to the crew having to stop movement for a round of compressions. Overall, this process is critical as it allows for a continued maintenance of adequate perfusion pressure to the patient's brain, heart, and other tissues and does not lead to a loss of that pressure. Most importantly for the EMS system, LUCAS has been shown to be a safe device to employ when on a moving vehicle during emergency transport and has also been shown to be more efficient and effective than manual CPR both in the field and during emergency medical transport, leading to better patient outcomes.[26-34]

We were not able to identify any simulation studies that have examined the efficacy of the LUCAS device in the prehospital settings when patients are being moved. The closest study to evaluating prehospital use of LUCAS in a more standard scenario was performed by Blomberg et al., who found that LUCAS did increase the quality of CPR so that compression rate, depth, and other CPR characteristics were in line with current guidelines.[35] However, this study did not involve movement of the patient, transport via ambulance or assessment of hands-off time, all of which are integral components of real cardiac arrest scenarios.

Importantly, in our study median time to first defibrillation was not significantly different between the two methods of chest compression. These data suggest that the LUCAS device does not delay defibrillation shocks compared to manual CPR; this is consistent with previous literature.[36-38] Compression depth, release depth, and hand position were also not different between the two methods of chest compression. However, when compared to manual CPR, LUCAS provided a compression rate more in line with AHA guidelines and had decreased total hands-off time. Interestingly, the compression rate during manual CPR was found to have a median that exceeded the recommended compression rate by the AHA. This result was surprising because we expected subjects to be more fatigued during manual CPR, resulting in a lower median rate than with LUCAS. The cause of this result is unclear, although it might be related to the Hawthorne effect or problems in original CPR training. More research into this area may be warranted in the future.

There were no significant differences among many of the marked critical times in transport of the patient to the ED. This suggests that LUCAS neither delays nor reduces a large fraction of the transport time compared to manual CPR. When considering time to arrival at the patient, CPR initiation, defibrillator placement, and rhythm recognition, these data intuitively make sense as they are not related directly to whether or when the LUCAS may be deployed in a scenario. Regarding final arrival at the ED, one would expect that the overall scenario would take a shorter time with the LUCAS device as the crew would not have to continually halt transport

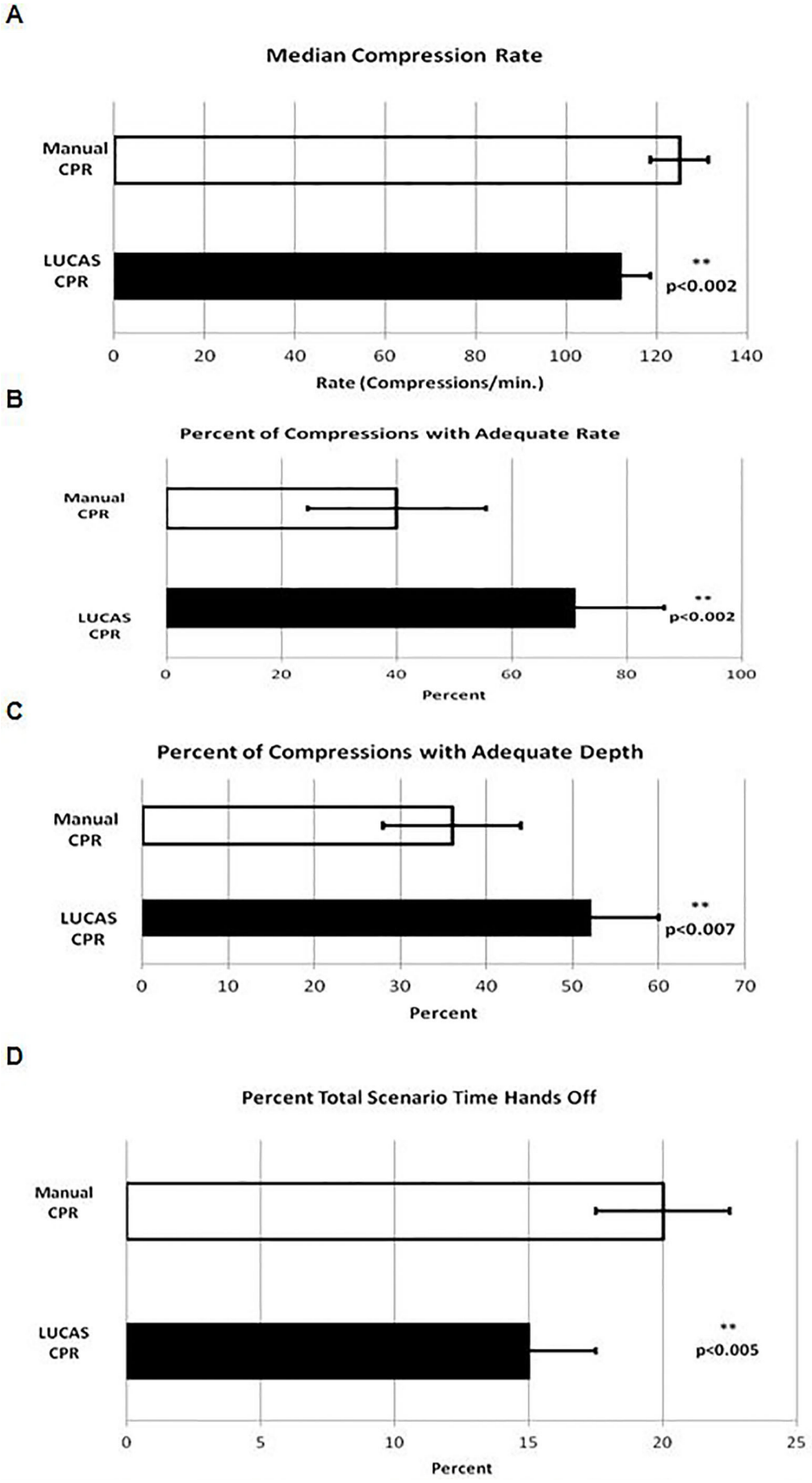

Figure 2A-D. CPR characteristics in which LUCAS performed more optimally than manual CPR.
CPR, cardiopulmonary resuscitation; *LUCAS,* Lund University Cardiac Arrest System.

for compression rounds; yet, no significant difference was found between the scenarios.

This finding is most likely related to three separate phenomena. First, the crews who were unfamiliar with the LUCAS device appeared to struggle with proper deployment and assembly around the patient; this delay, while not measured, may have offset any of the time saved during the rest of the transport. Another consideration is that some of the crews, during the manual CPR trials, chose not to halt transport to the litter multiple times to engage in CPR rounds as would normally be recommended. It was not measured how many crews transported in this manner, nor how long a delay was incurred for crews that did halt for CPR, but continuous transport down to the litter, though increasing scenario hands-off time, decreased total transport times in a manner that rivaled the time saved with LUCAS. Finally, all crews followed the Pennsylvania state EMS protocols, which required at least two full rounds of manual CPR prior to LUCAS deployment. While realistic and true to required standard of care for these crews, it certainly delayed transport time in the LUCAS trials that would likely not have been seen if LUCAS had been permitted to be deployed immediately. Indeed, many states would have allowed for immediate LUCAS deployment.

Further investigation into transport times without the prerequisite rounds of manual compressions is warranted. It is important to note that time to arrival at the litter and time to initiation of transport to the ED were found to be significantly increased when LUCAS was used. It may be that the aforementioned alleviation of needing to halt transport for a round of compressions makes it easier to transport the patient, but may not have been offset by the other variables as stated above. To better determine the full effects on critical transport events, further study will be required that can control for these variables. Whether either mode of chest compression delivery had a transport time difference that was of clinical significance is unclear.

The use of the LUCAS may contribute to improved safety. The most obvious example of this is that crew members were able to sit safely seat belted during transport when LUCAS compressions were being done, but had to stand in the moving ambulance while doing manual CPR. In addition, crews had time to perform other tasks during transport with LUCAS because their hands were not occupied with manual CPR. This extra time may allow providers the chance to complete such things as placing an advanced airway, starting additional intravenous lines, giving more timely medications, and contacting the receiving hospital to give a report. The crew members were able to perform these tasks in a calmer and less hurried manner with LUCAS compared to manual CPR, which might suggest that LUCAS allows for more time for crews to think clearly and perform optimally during patient care.

LIMITATIONS

There were several limitations to this study. First, due to time, resource, and financial constraints this study included a single EMT/paramedic team in the cardiac arrest response. While the use of LUCAS allowed for better CPR characteristics and increased opportunity for ACLS milestones, most real-world cardiac arrest responses will include either fire support or at least one other EMS team. Thus, it cannot be determined from this study that the increased ability of crews to complete ACLS milestones would be due solely to LUCAS in a real arrest response, as there would be more personnel available to perform compressions and would allow the EMS team to focus on activities not related to compression performance.

Most participants in the study had not received any training or practice on LUCAS prior to that given in the study. This inexperience may have led to uncertainty and hesitancy when using the LUCAS under pressure in the study scenario, which may have led to falsely increased overall scenario times due to the hesitancy and not to deployment of LUCAS itself. The skin of the mannequin did not consistently allow for realistic contact of the plunger of the LUCAS device, which led to some slippage of the device off of the midsternal region in a few scenarios.

In addition, during the LUCAS scenarios crews were highly variable in the amount of time before switching from the original rounds of manual CPR to compressions delivered by LUCAS (range: 136-378s); because this was not standardized among all crews, it added some additional variability to performance and may once again have increased overall scenario time in a way that had nothing to do with LUCAS. Additionally, the 30-minute rest period may not have been of sufficient length to allow for fatigue to be addressed between scenarios for crew members; there seemed to be some residual fatigue across several crews during the second scenario which would again have increased overall scenario time.

Another potential factor that may have increased overall scenario time not directly related to the LUCAS device was the use of the state of Pennsylvania EMS protocols for cardiac arrest response. To allow for realism in this study, the state protocols were adhered to as they should be in a real response; however, the state requires at least two rounds of manual CPR before LUCAS or another mechanical device may be deployed. This requirement may have falsely increased overall scenario time as it prescribed close to two full minutes in which the crew was not permitted to deploy LUCAS or focus on other activities other than compression performance. In other states, these requirements do not exist and LUCAS may be deployed immediately. Thus, the use of the Pennsylvania state protocols, while realistic, may have added extra time to the scenario that was not secondary to the actual LUCAS device.

Due to time, cost and safety, some realistic aspects of the scenario had to be sacrificed. These aspects included lack of lights and siren transport of the crew to the hospital and an

allowed pre-study walkthrough of the path from the ambulance to the mannequin for the crews. Moreover, the total weight of the mannequin and the weighted belt was 50 kg. While this additional weight was used to attempt to add a bit more realism to the study scenario, most patients that EMS will come in contact with are significantly heavier than this. Thus, the overall patient package may still have been significantly lighter than a real patient and may have made traversing the overall scenario less difficult than would be seen in a real response. Finally, due to the fact that this was a mannequin study, it is unclear what the real effects would be on patient outcomes. As such, while this study can speak to the physical parameters of completing an arrest scenario, it can only be used as a bridging study that will lead from isolated CPR-performance assessment without realistic arrest scenarios to studies assessing real deployment in patient care. Further research that includes deployment in real cardiac arrest scenarios will be imperative to determine patient outcomes.

CONCLUSION

As previously stated, there are data showing that LUCAS is very effective in prehospital cardiac arrest and patient outcomes and that the device is safe for patient use and does not lead to undue patient injury.[39-41] However, not enough data on real patients exist; thus, this area is clearly ripe for future work.

In this mannequin study attempting to assess the efficacy of the LUCAS device in a realistic prehospital cardiac arrest scenario, LUCAS provided chest compressions that were more consistent with AHA standards without creating delays to critical resuscitation tasks such as defibrillation. Moreover, total hands-off time was reduced in LUCAS scenarios, which would lead to maintenance of adequate perfusion pressures and may afford better overall patient outcomes. The effect of patient movement on chest compression quality must be considered as the use of mechanical CPR devices is deliberated by EMS agencies.

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Areas of Potential Impact of the Patient Protection and Affordable Care Act on EMS: A Synthesis of the Literature

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Introduction: This comprehensive review synthesizes the existing literature on the Patient Protection and Affordable Care Act (ACA) as it relates to emergency medical services (EMS) in order to provide guidance for navigating current and future healthcare changes.

Methods: We conducted a comprehensive review to identify all existing literature related to the ACA and EMS and all sections within the federal law pertaining to EMS.

Results: Many changes enacted by the ACA directly affect emergency care with potential indirect effects on EMS systems. New Medicaid enrollees and changes to existing coverage plans may alter EMS transport volumes. Reimbursement changes such as adjustments to the ambulance inflation factor (AIF) alter the yearly increases in EMS reimbursement by incorporating the multifactor productivity value into yearly reimbursement adjustments. New initiatives, funded by the Center for Medicare & Medicaid Innovation are exploring novel and cost-effective prehospital care delivery opportunities while EMS agencies individually explore partnerships with healthcare systems.

Conclusion: EMS systems should be aware of the direct and indirect impact of ACA on prehospital care due to the potential for changes in financial reimbursement, acuity and volume changes, and ongoing new care delivery initiatives.[West J Emerg Med. 2017;18(3)446-453.]

INTRODUCTION

Background and ACA History

In the United States, the Patient Protection and Affordable Care Act (ACA), signed into law on March 23, 2010, primarily aimed to expand health insurance coverage, improve quality reporting, and reduce overall costs by encouraging primary care.[1] The ACA is expected to improve access to healthcare by increasing health insurance enrollment by an estimated 30 million people by the year 2021 via both mandates and subsidies.[2-4] In 2011, emergency medical services (EMS) transported over 21 million people to emergency departments (ED). Of the 136.3 million ED visits, 15.7% arrived by ambulance.[5]

Areas of change in emergency medicine identified by a prior review included a greater proportion of Medicaid-insured patients, changes in patient volume, and variable increases in acuity.[6] Although these changes are directly studied in relation to patients presenting to the ED, EMS agencies have already begun to implement and propose adaptations that respond to these observed changes.[7-9] This comprehensive review synthesizes the existing literature regarding ACA-related changes in emergency care that impact EMS systems and specific measures within the ACA that have the potential to directly impact EMS systems.

MATERIALS AND METHODS

This comprehensive review was limited to the English language due to the nature of the subject matter. We searched databases PubMed, EMBASE, Ovid Healthstar, CINAHL and the Cochrane Library for articles published between January

2006 and March 2016 using the following search filter: ("Emergency Medical Services" OR "prehospital" OR "Hospital Emergency Service" OR "Medical Device Legislation" OR "Emergency Medical Service Communication Systems" OR "Emergency Medical Technicians" OR "paramedic" OR "paramedics" OR "paramedicine" OR "Ambulances" OR "ER" OR "EMS" OR "ED" OR "EMT" OR "helicopter" OR "HEMS") AND ("Patient Protection and Affordable Care Act" OR "affordable care act" OR "ACA"). We identified 435 publications on the subject matter after adding 30 additional citations discovered through a grey literature search.

The citations were combined in Refworks and reviewed manually, resulting in the exclusion of 90 duplicate articles. Of the remaining 345 articles, we excluded 259 after screening the titles and abstracts due to irrelevance to emergency care or EMS. The full text of all the remaining 86 articles was reviewed independently by three authors (DO, CB, and BF) and scored as eligible or ineligible for inclusion. Articles without unanimous approval were determined for inclusion by majority non-anonymous, in-person voting. We excluded six articles based on lack of applicability to emergency care and located six additional articles by reviewing the bibliographies of the included articles. In addition, the sections and provisions of the final publication of the ACA (Public Law 111-148) that directly apply to emergency services were identified via a free-text match using the same literature search terms.

Population Health Research Capsule

What do we already know about this issue?
Previously identified effects of the Affordable Care Act on emergency department care include a greater proportion of Medicaid-insured patients, changes in patient volume, and variable increases in acuity.

What was the research question?
What specific areas of emergency medical services are potentially impacted by the ACA?

What was the major finding of the study?
EMS may experience changes in volume and in reimbursement due to a new payer mix and revisions to the Ambulance Fee Schedule.

How does this improve population health?
As the health insurance landscape of the United States continues to evolve, these provisions within the ACA provide areas for future research and operational focus within EMS systems.

RESULTS

The final review included 86 publications (Figure 1). The review of the ACA identified the following sections that directly mention emergency care and EMS services (Table 1).

DISCUSSION

Patient Usage and Access to Care

A major goal of the ACA was to reduce the use of ED care for non-urgent conditions and promote primary care utilization.[10] Prior to ACA implementation, 15.4 – 16.3%[11-17] of ED patients arrived by ambulance. Data from states that have implemented Medicaid expansion and from those that had implemented similar health insurance reform programs prior to the ACA suggest that ED volume continues to increase despite expanded insurance.[18-20] The direct effects of healthcare expansion efforts on EMS usage have not been described, Due to lack of EMS-specific acuity and volume data, we used ED data as a surrogate for EMS acuity and volume when reviewing publications.

Medicaid Enrollees Acuity and Volume

Local changes in patient acuity may depend upon the proportions of new Medicaid recipients. New recipients of Medicaid may have a greater need for healthcare after previously deferring care due to lack of insurance.[19] Data from Oregon and Wisconsin, where Medicaid was expanded to a specific group of the population, demonstrated an increase in ED use of 40% and 46%, respectively.[21,22] The initial transient increase in ED utilization was shown to level off after 18 months during implementation of a program in California that expanded Medicaid early to future potential enrollees.[23] In areas with a similar Medicaid population, EMS transport volume as a percentage of overall ED volume may increase in the near future and may experience potentially larger than normal short-term increases followed by a gradual long-term taper.

A 10% increase in patient acuity, which was measured by resource needs and clinical complexity, and up to 13.2% increase in number of diagnoses have been noted during the first two quarters after newly enrolled Medicaid recipients gain access to care.[18] Early Medicaid expansion in California brought an increase in hospital admissions, with the most notable increase coming from those who did not use healthcare resources during the year prior.[23] Similar to volume, local acuity changes may change proportional to the quantity of new Medicaid enrollees who were previously underinsured.

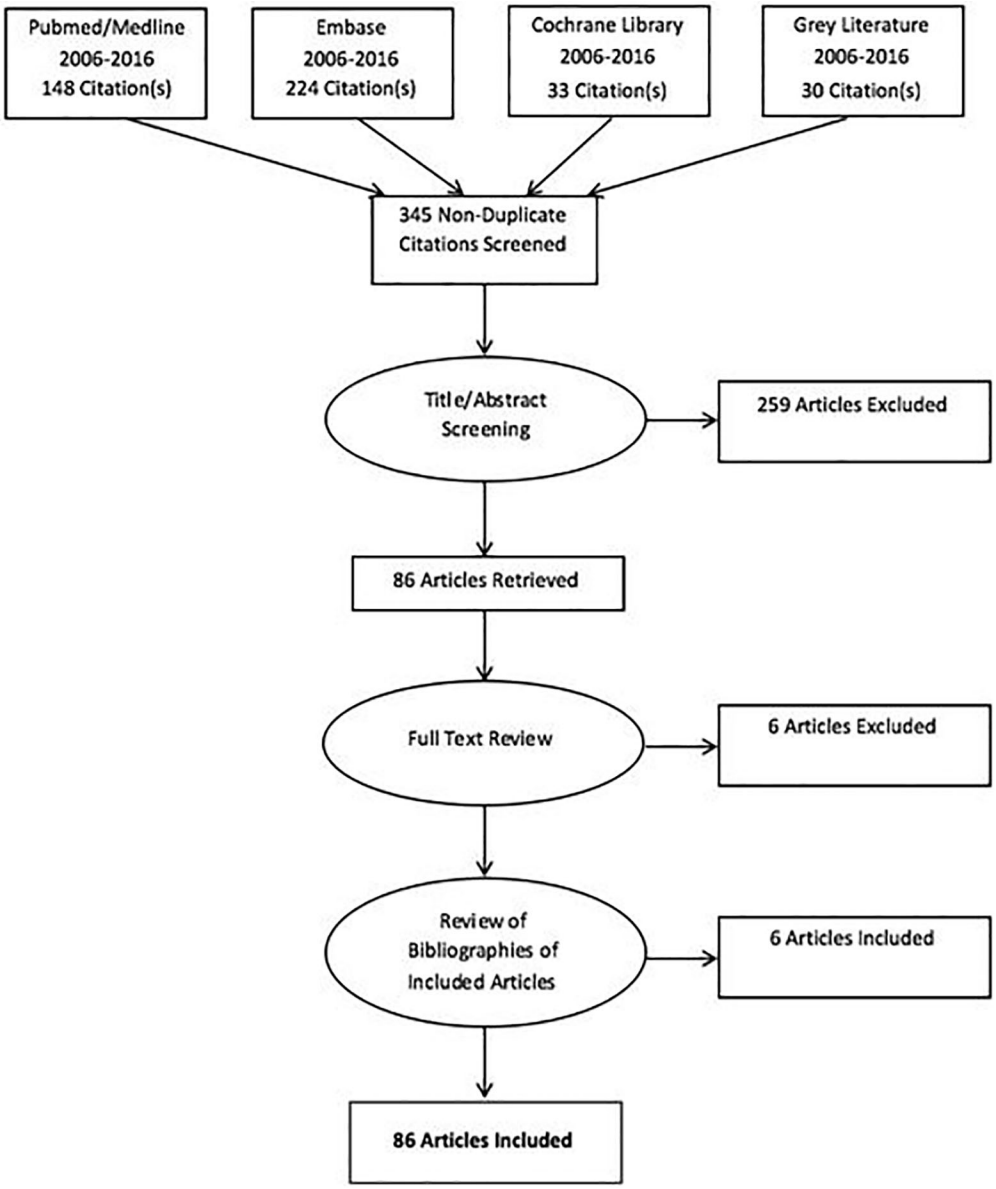

Figure 1. PRISMA flowchart of systematic literature review of changes to emergency care related to the Affordable Care Act that directly affect emergency medical services.

Deductible effects on usage

Up to 85% of the plans chosen in health exchanges now contain an increased deductible,[24] which may incentivize individuals to defer seeking care until an absolute emergency. Among individuals with lower socioeconomic status (SES) who purchased low premium, high-deductible plans, high-acuity ED visits decreased 24.5% in the first year after enrollment and decreased another 7.4% in the second year. Similarly, hospitalizations among those with lower SES dropped by 23% in the first year but increased the need for subsequent hospitalizations. This is in contrast to individuals of high SES with high-deductible plans who had no significant change in ED visits or hospitalizations.[25] As such, the usage of ambulance services as a proportion of patients seeking emergency care should change based on the proportion of SES individuals in the EMS catchment area who have purchased high-deductible health insurance plans.

HEALTHCARE QUALITY ASSESSMENTS

Readmissions

In an attempt to improve the quality of healthcare, the Centers for Medicaid and Medicare Services (CMS) began allocating additional funds to hospitals in 2013 for those meeting a set of quality standards. Hospitals are graded on standards that

Table 1. Sections in the Patient Protection and Affordable Care Act identified via systematic search that relate to EMS.

Section	Provision	Summary
1281	Grants to states for trauma service availability	Sub-section 4 awards funding for enhanced collaboration between trauma centers and EMS services
1302	Inclusion of emergency services as Essential Health Benefits for exchange-based health plans	Emergency department services are declared core elements of health insurance and insurance coverage is essential
3021	Establishment of the Center for Medicare and Medicaid Innovation (CMMI)	Test innovative payment and service delivery models that decrease cost and improve quality
3024	Independence at home demonstration program	Testing of payment incentives and delivery models for home based care to reduce emergency department visits, improve outcomes, and prevent readmissions and hospitalizations
3101	Increase in physician payment update	Continued yearly update of the ambulance fee schedule
3105	Ambulance Fee Schedule add on payment extension	Extension through January 1, 2011, of the rural bonus for ground ambulance transport
3401	Revision of market-based productivity increases for the ambulance fee schedule	The Consumer Price Index (CPI) is adjusted downward by the Multifactor Productivity score (MFP) to calculate the new Ambulance Inflation Factor (AIF)
3504/1204	Design and Implementation of regionalized systems for emergency care	Grant awards for trauma systems, EMS systems and comprehensive care systems
5603	Reauthorization of the Wakefield Emergency Medical Services for Children Program (EMSC)	Authorized funding of EMSC activities per congressional appropriation
4304	Epidemiology-Laboratory Capacity (ELC) grants from the Centers for Disease Control and Prevention, Division of Vector-borne Diseases	Establishment of grants for surveillance and threat detection for biologic events
498D	Support for emergency medicine research	Support for NIH-funded emergency medicine research
5101	National health care workforce commission	Recognition of the EMS providers as part of the healthcare workforce
5210	Ready Reserve Corps	Establishment of the Ready Reserve Corps for emergency service

EMS, emergency medical services; *NIH,* National Institutes of Health.

include health outcomes, patient safety, efficiency, equity, and patient satisfaction. Section 3025 of the ACA established the Hospital Readmissions Reduction Program (HRRP) to penalize reimbursement based on readmissions for a specific set of diagnoses (Table 2). The diagnoses have expanded since 2013 and the percentages of the penalties are also increasing.[26,27] Again, like many other measures, the HRRP applies only to hospitals and does not change EMS reimbursement, but it has offered some new opportunities for EMS to partner with hospital systems in the implementation of readmission reduction programs.

Mobile Integrated Healthcare and Community Paramedicine (MIH-CP) programs are being implemented and evaluated by some EMS systems as a viable option for reducing readmissions and EMS transports.[28] These programs offer opportunities for EMS to provide healthcare in non-traditional roles using knowledge that is standard among EMS personnel and critical care nursing.[29] Such models offer unique funding mechanisms such as those demonstrated by MedStar Mobile Healthcare, in which a portion of hospital savings is passed back as reimbursement to an EMS agency if a readmission was prevented within 30 days.[30]

As an example, Medstar performs house visits to educate patients on management of chronic conditions and evaluate for opportunities to decrease unnecessary transports to EDs.[31] Over a five-year period, this program prevented 1,893 transports to the ED due to 911 calls. The estimates in Medicare savings, however, are small at $21,627.[31] Another similar program in California at 12 statewide sites uses paramedics working under physician supervision to provide services that include transportation to mental health or urgent care clinics, follow-up care for individuals recently released from the hospital, hospice care, and assistance to frequent EMS utilizers.[32] Long-term funding and sustainability of these and other similar programs is both uncertain and currently unpublished.

REIMBURSMENT CHANGES

Ambulance Fee Schedule

The Centers for Medicare and Medicaid Services (CMS)

Table 2. Diagnoses tracked for the Hospital Readmission Reduction Program (HRRP).

Year in effect	Diagnosis
2013-2014	Myocardial infarction
	Congestive heart failure
	Pneumonia
2015	Elective hip arthroplasty
	Elective total knee arthroplasty
	Chronic obstructive pulmonary disease
2016	Stroke
2017	Coronary artery bypass graft

established a fee schedule for EMS reimbursement in 2002. The established ground-service fee schedule consists of seven levels of services in which a relative value unit (RVU) was established for each level of transport. These RVU values are multiplied by a conversion factor to correlate reimbursement with level of care. There is also an additional mileage fee and adjustment factors that are dependent on the location of service (Figure 2).[33] The rural bonus, which provides additional reimbursement for rural transport, was extended until 2011 in section 3105 and later extended by Section 104(a) of the Protecting Access to Medicare Act of 2014 to March 31, 2015, and further extended via Section 203 of the Medicare Access and CHIP Reauthorization ACT of 2015 (MACRA) until December 31, 2017. [34,35]

Prior to the ACA, the price increases for ambulance payments were equal to a percentage increase in the urban Consumer Price Index (CPI). Going forward, the Ambulance Inflation Factor (AIF) will subtract the nonfarm Multifactor Productivity (MFP) value from the CPI. The nonfarm MFP accounts for economy productivity based on the labor outputs and capital invested. The value incorporates technological innovation and new efficiencies while the CPI simply accounted for price inflation of services. For the first time since the enactment of the ACA, the AIF will be negative. Specifically, the MFP is 0.5 and the CPI is 0.1 so the AIF is adjusted down -0.4 percent.[36] The overall implication is encouragement to improve productivity along with the remainder of the economy regardless of inflation rates. The main potential issue with the new AIF calculation is that EMS costs are mainly personnel not technological, and the resulting MFP adjustment on an annual basis could negatively impact reimbursement as the productivity of the U.S. economy increases relative to EMS costs and inflation.

Payer Mix

Based on CMS estimates, the uninsured population in the U.S. is estimated to decrease by 33.8 million people by 2019.[37] The number of Medicaid patients, however, is estimated to increase, especially in states that have adopted the Medicaid expansion. An analysis including 465 hospitals in 30 different states found a 25% decline in self-pay status.[18] These changes correlate with the increases in Medicaid and may not occur in non-expansion states.[38] Under CMS guidelines, which are also frequently followed by private insurance companies, EMS services must transport patients to a hospital to receive reimbursement for their care.[39] The median cost of EMS transport was $429 in 2010, with median Medicare reimbursement for those transports $464.[40] It should be expected that these small margins on Medicaid patients will continue and may even shrink based on Ambulance Inflation Factor (AIF) changes. The continued low margins could be offset by the increasing payments from a greater percentage of insured patients, but ultimately depend on the local payer mix.[41]

NEW INNOVATIONS

CMMI Awards

Section 3021 of the ACA established the Center of Medicare and Medicaid Innovation (CMMI) to test innovative payment and service-delivery models that aim to reduce expenses and improve costs. A few EMS agencies are currently taking advantage of the grants offered from the CMMI in the form of community paramedicine and mobile integrated healthcare and alternative healthcare destination

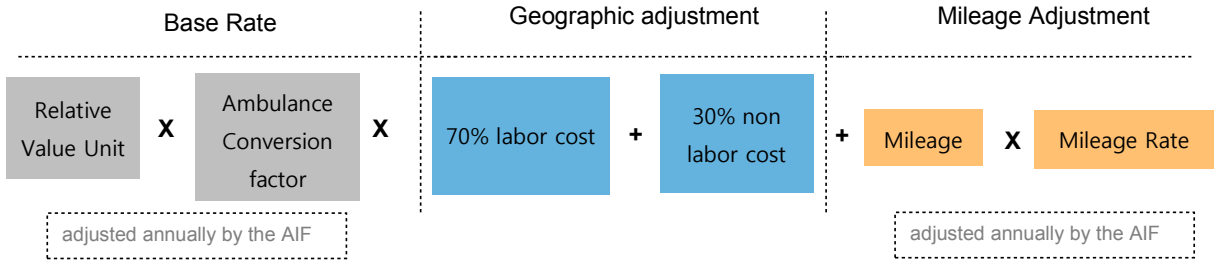

Figure 2. Ambulance fee schedule reimbursement calculation.
AIF, ambulance inflation factor.

programs.[42] Other hospital systems are implementing mobile healthcare without partnering with an EMS agency in order to reduce readmission rates for diseases on the HRRP list. For example, the Icahn School of Medicine at Mount Sinai Mobile Acute Care Team (MACT) received funding to pilot a program using community paramedics, nurses, and physicians to perform home treatment for recently discharged patients in order to reduce 30-day readmission rates.[43] Such hospital-based MIH-CP programs may also fulfill the community outreach requirements for maintenance of hospital non-profit status.[44,45]

Alternative Destinations

Although EMS is currently reimbursed by Medicare Part B as a transportation service to the nearest healthcare facility, agencies are exploring alternative transport destinations options for 911 calls. Mesa Arizona Fire and Medical Department, a recipient of a CMMI award, is testing a model that involves paramedic and nurse practitioner- or physician assistant-staffed response vehicles. In addition to field treatment and release, the system can divert patients from the ED to alternative transport destinations.[46] Although controversial, it is estimated through Medicare claims data from 2005 to 2009, that 12.9-16.2% of EMS transports covered by Medicare may have been comprised of patients whose chief complaints could have been treated in a primary care facility. This may have resulted in a $283-$560 million per year savings.[9,47-50] The ACA does not provide a means for EMS agencies to receive reimbursement for the emergent transport of patients to a non-emergent care facility. Overall, the financial stability of alternative destination programs remains unknown as most are funded by "add-on" programs or grants until future Medicare and private insurance change reimbursement requirements.[7,39]

OTHER MEASURES

In addition to the previously highlighted changes, multiple sections of the ACA (1204, 1281, 3504, and 5603 and 498D) provide for continued support of EMSC and trauma center funding and research. For the first time in U.S. EMS history, providers are now recognized officially as part of the healthcare workforce via Section 5105. Section 5210 amended Section 203 of the Public Health Service Act (PHSA) to establish the U.S. Public Health Service Ready Reserve Corps (RRC) to provide additional volunteer member availability for response in foreign or domestic public health emergencies. The RRC provides additional resources if needed to assist the regular USPHS Commissioned Corps personnel. The existing PHSA was further amended to establish an Epidemiology and Laboratory Capacity grant program from the Centers for Disease Control and Prevention Division of Vector-borne Diseases. The state- and local government-awarded laboratories will serve to assist public health agencies in the surveillance of infectious disease and biological threats.[1,45]

CURRENT LIMITATIONS AND FURTHER RESEARCH

A major limitation of this review is lack of directly published literature regarding the financial, operational, and clinical effects of the ACA on EMS systems. The majority of published literature relates to ED care and as such was used as a surrogate for predictions related to EMS changes. Future research is needed regarding the long-term effects of healthcare reimbursement and patient insurance changes on EMS systems. Regionalized and national data will allow for more specific conclusions regarding impacts on prehospital care from current healthcare changes and new innovations.

CONCLUSION

In the wake of the current healthcare reforms initiated in the U.S. by the ACA, potential changes to EMS are largely side effects of inpatient and ED changes. Although EMS and emergency care is directly addressed by the ACA, changes to transport destinations and operations remain unchanged. Modifications to the ambulance fee schedule will impact EMS departments and potentially place negative pressure on revenue. Alternative sources of funding being supported by CMMI grants, such as MIH-CP, may provide future opportunities, although long-term sustainability is uncertain. EMS agencies that partner with hospital systems may benefit from the continued emphasis on patient- and system-centered healthcare quality metrics. Volume and acuity increases will depend upon state Medicaid expansions, local insurance coverage, and socioeconomic demographics.

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"Choosing Wisely" Imaging Recommendations: Initial Implementation in New England Emergency Departments

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Introduction: In June 2016, the American College of Emergency Physicians (ACEP) Emergency Quality Network began its *Reduce Avoidable Imaging Initiative*, designed to "reduce testing and imaging with low risk patients through the implementation of *Choosing Wisely r*ecommendations." However, it is unknown whether New England emergency departments (ED) have already implemented evidence-based interventions to improve adherence to ACEP *Choosing Wisely* recommendations related to imaging after their initial release in 2013. Our objective was to determine this, as well as whether provider-specific audit and feedback for imaging had been implemented in these EDs.

Methods: This survey study was exempt from institutional review board review. In 2015, we mailed surveys to 195 hospital-affiliated EDs in all six New England states to determine whether they had implemented *Choosing Wisely*-focused interventions in 2014. Initial mailings included cover letters denoting the endorsement of each state's ACEP chapter, and we followed up twice with repeat mailings to non-responders. Data analysis included descriptive statistics and a comparison of state differences using Fisher's exact test.

Results: A total of 169/195 (87%) of New England EDs responded, with all individual state response rates >80%. Overall, 101 (60%) of responding EDs had implemented an intervention for at least one *Choosing Wisely* imaging scenario; 57% reported implementing a specific guideline/policy/clinical pathway and 28% reported implementing a computerized decision support system. The most common interventions were for chest computed tomography (CT) in patients at low risk of pulmonary embolism (47% of EDs) and head CT in patients with minor trauma (45% of EDs). In addition, 40% of EDs had implemented provider-specific audit and feedback, without significant interstate variation (range: 29-55%).

Conclusion: One year after release of the ACEP *Choosing Wisely r*ecommendations, most New England EDs had a guideline/policy/clinical pathway related to at least one of the recommendations. However, only a minority of them were using provider-specific audit and feedback or computerized decision support. Few EDs have embraced the opportunity to implement the multiple evidence-based interventions likely to advance the national goals of improving patient-centered and resource-efficient care. [West J Emerg Med.2017;18(3)454-458.]

INTRODUCTION

In 2013,the American College of Emergency Physicians (ACEP) published 10 evidence-based *Choosing Wisely*® recommendations for emergency department (ED) use of diagnostic tests and treatments,[1] which patients and their providers were encouraged to discuss in order to reduce low-value care. Five of these focused on high-cost imaging. Since the publication of the *Choosing Wisely* recommendations, a number of tools, including clinical pathways,[2] computerized decision support (CDS),[3] and provider-specific audit and feedback[4] have focused on improving emergency physicians' adherence to evidence-based imaging guidelines.

In June 2016, ACEP's Emergency Quality Network (E-QUAL) began its *Reduce Avoidable Imaging Initiative*[5] as part of the Centers for Medicare and Medicaid Services (CMS) Transforming Clinical Practice Initiative, designed to "reduce testing and imaging with low risk patients through the implementation of *Choosing Wisely r*ecommendations." The initiative is a laudable endeavor meant to emphasize the many tools available to assist with adherence to these recommendations. However, there are sparse data on whether EDs have implemented any interventions to improve adherence to guidelines since their initial publication in 2013. Our objective was to investigate whether New England EDs implemented evidence-based interventions to improve adherence to ACEP *Choosing Wisely* recommendations after their release, and also whether provider-specific audit and feedback for imaging had been implemented in these EDs.

Population Health Research Capsule

What do we already know about this issue?
ACEP has recommended a number of tests that can be avoided as part of the Choosing Wisely initiative.

What was the research question?
Do EDs have guidelines, policies, pathways, decision support, or feedback regarding ACEP Choosing Wisely Initiatives?

What was the major finding of the study?
57% have guidelines, policies, or pathways, 40% have decision support, and only 28% provide feedback regarding Choosing Wisely.

How does this improve population health?
Adherence to Choosing Wisely requires more than just education - the use of the evidence-based tools we studied should improve adherence to Choosing Wisely.

METHODS

Study Settings

This survey study was exempt from institutional review board review. In 2015 we used the 2012 National Emergency Department Inventory[6] to identify 195 hospital-affiliated EDs in the six New England states of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island and Vermont. We mailed surveys to their ED directors to assess several structural and process measures of each ED including capabilities, characteristics and policies in 2014 (the year after the release of ACEP's *Choosing Wisely* recommendations). These initial mailings included cover letters denoting the endorsement of each state's ACEP chapter, and were followed up twice with repeat mailings to non-responders.

Survey Questions

The survey included a total of 30 questions, of which two focused on interventions that EDs had implemented targeting the five *Choosing Wisely* imaging scenarios: head computed tomography (CT) studies (for minor traumatic brain injury [MTBI] and in asymptomatic adults with syncope); chest CT for low-risk pulmonary embolism (PE); lumbar spine magnetic resonance imaging (MRI) for atraumatic low back pain; and abdominal CT for renal colic. For each of the scenarios, respondents were asked dichotomous yes/no subquestions regarding whether they had implemented either a guideline/policy/clinical pathway and/or computerized decision support. Pediatric EDs and EDs without CT/MRI capability to which individual questions might not apply were asked to indicate "NA" (not applicable). "Guideline/policy/clinical pathway" and "computerized decision support" were not further defined to allow respondents flexibility in deciding which of their interventions fell into each category. Respondents were also asked whether their clinicians received provider-specific audit and feedback regarding use of advanced imaging (e.g., their utilization compared to other clinicians in their ED).

Outcome Measures and Statistical Analyses

The outcomes were the presence or absence of at least one reported intervention for each of the five *Choosing Wisely* imaging scenarios, as well as the use of provider-specific audit and feedback. Data analysis included descriptive statistics and a comparison of state differences using Fisher's exact test.

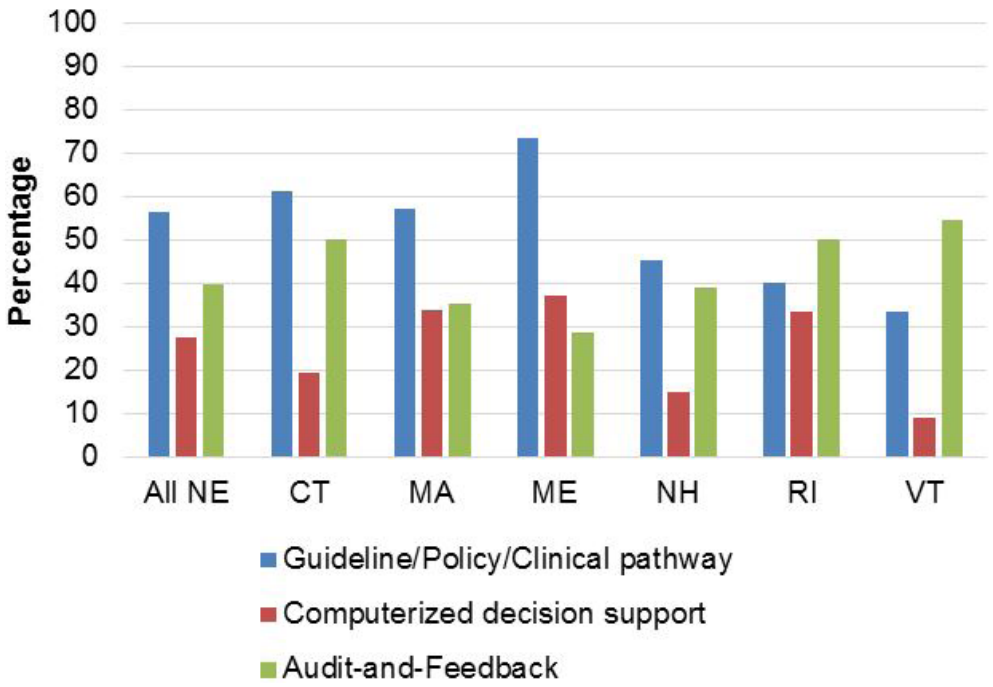

Figure 1. Interventions to reduce avoidable emergency department imaging in six New England states, in a study of the implementation of evidence-based *Choosing Wisely* recommendations.
NE, New England; *CT,* Connecticut; *MA,* Massachusetts; *ME,* Maine; *NH,* New Hampshire; *RI,* Rhode Island; *VT,* Vermont.

RESULTS

Responses were received from 169/195 (87%) of New England EDs; all individual state response rates were >80%. Overall, 101 (60%) of responding EDs had implemented an intervention for at least one *Choosing Wisely* imaging scenario; a guideline/policy/clinical pathway (57% of EDs) was more frequently reported than CDS (28%) (Figure 1). In addition, 40% of EDs had implemented provider-specific audit and feedback, without significant interstate variation (range: 29-55%).

The most common interventions were for chest CT in patients at low risk of PE (47% of EDs), and head CT in patients with MBTI (45% of EDs) (Figure 2). By state, 63% of Maine EDs had implemented an intervention for head CT in patients with MTBI and 58% of Connecticut EDs had one for PE CT; interventions for the other three scenarios were observed less frequently (≤33% of responding EDs). Interventions were least commonly reported for abdominal CT for renal colic (21% of responding EDs); e.g., only one (8%) Vermont ED reported a policy for this scenario. There were no significant interstate differences in which *Choosing Wisely* targets had interventions implemented for them.

DISCUSSION

One year after release of the ACEP *Choosing* Wisely recommendations, most New England EDs focused their interventions on only two imaging scenarios: patients with suspected PE and those with MTBI. While most EDs had a guideline/policy/clinical pathway related to at least one of the *Choosing Wisely* recommendations, only a minority had implemented CDS related to one of the recommendations. In addition, fewer than half of New England EDs were providing provider-specific audit and feedback about imaging utilization to their clinicians.

The *Choosing Wisely* recommendations are largely evidence-based and meant to target likely unnecessary and overused imaging studies. Translating these recommendations into clinical practice to reduce low-value care is the next needed step. A recent analysis of the effectiveness of the publication of several *Choosing Wisely* recommendations on outcomes (including head and lumbar spine imaging) found mixed results.[7] The engagement of EDs in interventions beyond basic education through the 2016 *Reduce Avoidable Imaging Initiative* will be key to broad implementation of tools targeting the established *Choosing Wisely* targets.

For campaigns such as the E-QUAL *Reducing Avoidable Imaging Initiative* to succeed, understanding current ED interest and practice in imaging re-education is essential to guiding future efforts. From our data, it is evident that a number of EDs, at least in New England, are already focusing on reducing imaging in patients with suspected PE and suspected MTBI. Both conditions have a broader evidence base to guide imaging decisions, including widely disseminated ACEP clinical

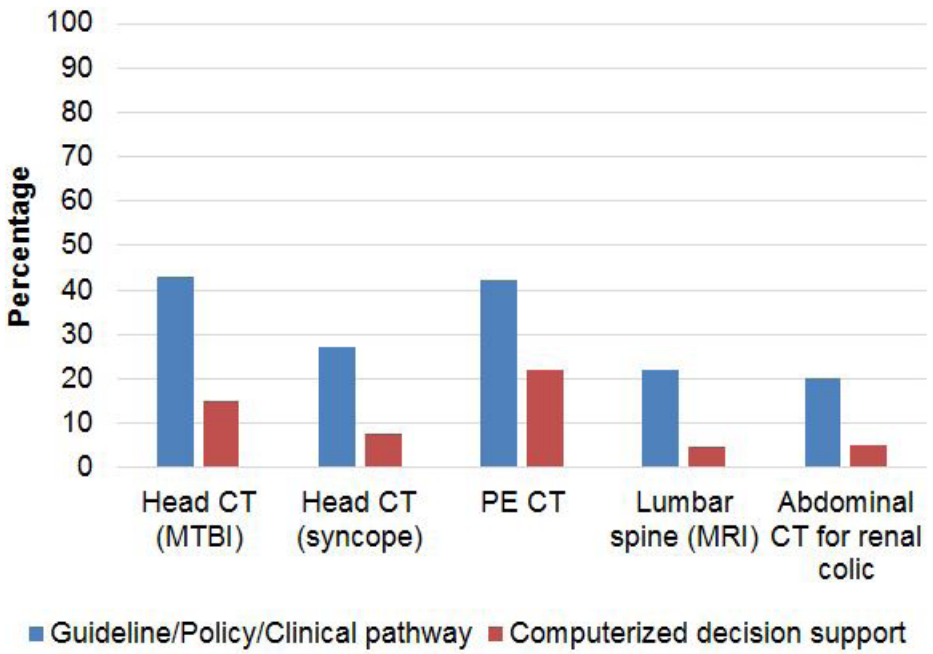

Figure 2. Interventions for *Choosing Wisely* clinical scenarios.
CT, computed tomography; *MTBI,* mild traumatic brain injury; *PE,* pulmonary embolism; *MRI,* magnetic resonance imaging.

policies, likely making provider engagement in quality improvement (QI) easier. Conversely, clear evidence gaps remain for two of the other targets —CT for syncope and abdominal CT for renal colic —for which no clinical practice guidelines or many large clinical trials exist. In the case of lumbar spine MRI for back pain, which is supported by the *Choosing Wisely* campaigns of numerous medical specialty societies and clinical practice guidelines, lower rates of ED QI interventions may reflect that many of the guidelines are still based on expert consensus rather than evidence-based decision instruments. As national efforts such as E-QUAL continue to expand, resources must be dedicated to developing an evidence base and the associated clinical practice guidelines necessary to engender physician trust in recommendations to reduce imaging use historically considered necessary to exclude high-risk, life-threatening diagnoses.

Our work also demonstrates wide variability in the implementation of evidence-based QI strategies, with a notable lack of CDS and provider-specific audit and feedback. There is evidence that both of these interventions can improve the appropriateness of imaging use in the ED[3,4,8,9] – specifically in the scenarios targeted by ACEP's E-QUAL – and both tools should be considered by EDs looking to improve performance for *Choosing Wisely* recommendations. Poor adoption of CDS is surprising given the rapid adoption of electronic health records (EHR) in the ED as a result of the CMS Meaningful Use program. However, not all EHRs have easily-customized CDS capabilities, and ED staff may not have had the opportunity to readily implement CDS to address *Choosing Wisely* recommendations. As our survey preceded implementation of the 2014 Protecting Access to Medicare Act (PAMA) that mandates physician use of CDS, increased adoption of CDS is likely to be reflected in future surveys of EDs.

LIMITATIONS

This study has two main limitations. The first is that it was conducted only in New England, and therefore results may not generalize nationally. We used a survey methodology that relies on self-reporting and we did not assess any potential differences in actual "on the ground" implementation. However, we have no reason to believe that respondents were untruthful, particularly as they were told in the survey instructions that no identifying information would be used and responses would be reported only in aggregate.

CONCLUSION

Our assessment of initial ED efforts undertaken after publication of the *Choosing Wisely* recommendations shows broad interest in reducing avoidable imaging. However, the QI practices are largely limited to select interventions and certain clinical scenarios. Few EDs have embraced the opportunity to implement multiple evidence-based interventions likely to yield synergistic gains necessary for emergency care to advance the national goals of improving patient-centered and resource-efficient care.[10]

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Improved Accuracy and Quality of Information During Emergency Department Care Transitions

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Introduction: Suboptimal communication during emergency department (ED) care transitions has been shown to contribute to medical errors, sometimes resulting in patient injury and litigation. The study objective was to determine whether a standardized checkout process would decrease the number of relevant missed clinical items (MCI).

Methods: In this prospective pre- and post-intervention study conducted in an urban academic ED, we collected data on omitted or inaccurately conveyed medical information before and after the initiation of a standardized checkout process. The intervention included group checkout in an optimal location, review of electronic medical records, case discussion and assigned roles. MCI were considered relevant if they resulted in a delay or alteration in disposition or treatment plan. The primary outcome was the change in the number of MCI. Secondary outcomes were duration of checkout and physician satisfaction with the intervention.

Results: Pre-intervention, there were 94 relevant MCI during 164 care transitions. Post-intervention, there were 36 MCI in 157 transitions. The mean MCI per transition decreased by 58% from 0.57 (95% confidence interval [CI] [0.41, 0.73]) to 0.23 (95% CI [0.11-0.35]). Instituting the intervention did not lengthen checkout duration, which was 15 minutes (95% CI [13.81-16.19]) pre-intervention and 14 minutes (95% CI [12.99-15.01]) post-intervention. The majority of participants (73.4%) felt that the process decreased MCI, and 89.5% reported that the new process had a positive or neutral effect on their satisfaction with care transitions.

Conclusion: The adoption of a standardized care transition process markedly decreased clinically relevant communication errors without lengthening checkout duration. [West J Emerg Med. 2017;18(3)459-465.]

INTRODUCTION

Background

Patient care transitions, handoffs, or checkouts are defined as a transfer of information, professional responsibility, and the authority to act for a patient. Emergency department (ED) care transitions are generally regarded as one of the most error-prone events within the routine ED workflow.[1] The ED is an inherently chaotic environment in which patient care transitions typically occur in an informal manner. Due to a lack of standardization, checkout process variation is ubiquitous in emergency medicine.[1]

Importance

A Joint Commission statement on sentinel events found that 84% involved a breakdown in communication, usually between physicians, with 62% relating to continuum of care

issues.[2] In addition, one study found that 24% of liability claims against ED providers included care transitions as a contributing factor.[3] Previous studies have described a subjective decrease in the handoff error rate and an increase in physician satisfaction with the use of standardized transfer of care processes. Despite these results, there has been little consensus regarding the most valuable components of standardization. Research is limited due to a lack of objective measurements of error reduction after the implementation of checklists or other standard processes. Multiple sources including the Joint Commission, American College of Emergency Physicians (ACEP), and a survey of emergency medicine (EM) residency directors have noted the need for improved standardization of patient checkout for a more complete transfer of information.

At our institution, the need to improve our ED checkout process was identified through quality assurance review of error incidents that revealed care transitions-related communication gaps as significant contributing factors. Observation of EM resident care transitions revealed that wide variation occurs, which has been reported at other institutions as well.[4]

Resident care transitions were highly dependent on individual physician preferences and the state of the department at shift change. Resident handoffs did not occur as a group or in a standard location, were often interrupted by the nursing staff, and did not routinely involve supervising faculty. Patient data were typically reviewed after, rather than during, the care transition.

Goals of This Investigation

We hypothesized that initiating a standardized group checkout process that included review of pertinent patient data would decrease the amount of relevant clinical information that was either omitted or inaccurately transferred. Further, we hypothesized that this intervention would not lengthen the duration of ED care transitions and that it would improve physician satisfaction.

Population Health Research Capsule

What do we already know about this issue?
Turning over patients is a high-risk event that can lead to medical errors. 84% of sentinel events involved a breakdown in communication, and 25% of liability cases in EM included transfer of care.

What was the research question?
Whether a standardized checkout process, compared to an unstructured one, would decrease the number of relevant miscommunications, defined as delay or change in patient management or disposition. Missed or poorly communicated items were counted and categorized, giving an objective primary outcome measure.

What was the major finding of the study?
The multifactorial change in the sign-out process led to fewer missed or inaccurately conveyed items of information, without prolonging checkout, and most providers judged it superior to unstructured care transitions.

How does this improve population health?
Emergency department crowding is frequent, and emergency physicians turn over boarding patients to colleagues commonly. Miscommunication is a documented problem, especially with critical illness or multiple active problems. Communication errors were decreased with a standardized checkout process, lowering the risk of delays and suboptimal care.

METHODS

Study Design

We used an interventional study design to evaluate the impact of a standardized process for EM resident care transitions. No protected health information was used in the study, which met criteria for exemption from review by the University of Texas at Houston Institutional Review Board.

The primary outcome of interest was the change in the number of missed clinical items (MCI) pre and post-intervention. MCI were defined as relevant clinical items that were omitted or inaccurately conveyed and which resulted in a delay or alteration in the patient's disposition or treatment plan. Secondary outcomes of interest were the types of MCI, checkout duration, and provider satisfaction with the process change.

A data form (Appendix 1) was used during the care transition to record the checkout start and end time and the number of patients signed out. The data form was also used during the course of the shift to document the number and type of MCI.

During the study's two-month pre-intervention phase, ED care transitions were conducted in accordance with previous practice patterns.

Prior to the initiation of the intervention, residents and faculty received instructions about the standardized care

transition process at the weekly educational conference and through presentations transmitted via email. Additionally, during the first few days of the intervention, providers received in-person guidance from study personnel.

Study Setting and Population

We conducted the study between February and May 2012 in an urban tertiary care Level 1 trauma center with 60,000 annual ED patient visits and an EM residency program. The pre-intervention phase occurred during February and March. The post-intervention phase directly followed during April and May.

The study subjects were the EM residents and faculty who participated in care transitions during EM resident shift change, which occurred daily at 0700 and 1900 in two care areas. One area included primarily major and minor medical complaints. The second is designated primarily, but not exclusively, for major and minor traumatic chief complaints. The patient volume and resident staffing was approximately equal in the two areas. Resident staff included EM residents at post-graduate year (PGY) 1, 2, and 3. At times, there were also off-service residents rotating in the treatment areas. There were at least two residents per area during a shift. In general, residents signed out to residents of similar experience; however, at times staffing required patients to be transferred to a resident of different training and experience. For example, a PGY-2 might sign out to a PGY-3 or PG-1. Of note, there were never two PGY-1 residents stationed in either treatment area alone; there was always at least one EM PGY-2 or -3 per side. Each part of the ED had a dedicated faculty member to supervise the two to three residents in that section.

All care transitions between ED residents were included in the study. We excluded care transitions that did not contain resident-to-resident patient checkouts. Twice per day (at 1500 and 2300), ED faculty changed shift without an associated change of resident staffing, and those transitions were not studied. Once per week, advanced practice professionals (APP) worked while EM residents were at the educational conference. Coverage by APP resulted in two care transitions per week (at 0700 and 1300 on Thursdays) between residents and APP. We also excluded those from the intervention and study.

The rationale for excluding non-resident-to-resident care transitions was multifactorial. First, ED faculty and APP did not work principally at the study hospital during the study period. As a result, their sign-out process may have had more variation and their training on the intervention may not have been as comprehensive as the residents' instruction was. Secondly, the intervention was designed such that some recorded data were always entered by the senior resident whose role made him or her responsible for the data form during care transitions. Additionally, we agreed with physician investigators who believe it is essential to adopt a culture that encourages review of prior ED care during the care transition with the intent of identifying errors and optimizing care,[5] and residents play a key role in any initiative to produce a culture change within an academic department.[6] Finally, according to a study of closed malpractice claims, resident care transitions are higher risk than those not involving physicians in training.[7]

Intervention

Incorporating published suggestions, the standardized care transition process included six features: Outgoing and incoming emergency physicians were encouraged to 1) openly discuss the care being delivered with the goal of identifying errors and optimizing patient safety and ensure that 2) care transitions were performed in a standard location, as a group, to allow the necessary information review with limited interruptions; and 3) an incoming senior resident was designated as the care transition "data resident" who was tasked with reviewing each patient's electronic medical record (EMR) data (nursing notes, laboratory data, imaging, pending orders and vital signs). The data resident was accountable (by signature) for identifying inaccurately reported data. (All incoming residents and faculty were asked to document MCI that were identified later during the course of their shift.) 4) Both incoming and outgoing residents and faculty were encouraged to review each patient's EMR data during the care transition to identify inaccuracies. 5) The incoming residents and faculty were given the opportunity to ask additional questions at the end of each patient-care transition report and were queried regarding comprehension of the report.(6) The outgoing faculty or most senior outgoing resident was designated the "interruption manager" and was responsible for handling ongoing ED issues to minimize interruptions of the care transition process.

Outcome Measures

The primary outcome measure was the number of missed clinical items. We defined MCI as items not properly communicated during checkout that resulted in a delay or change in disposition or treatment plan. There were six MCI categories: 1) vital signs; 2) laboratory data; 3) radiology data; 4) ancillary data such as ECG; 5) consultant information; and 6) an "other" category for miscellaneous information such as history of present illness element or physical exam finding.

Secondary outcome measures were the mean duration of the care transition and physician satisfaction with the intervention.

Data analysis

The completed care transition data forms were stored in a secure folder in a standard location in the department and were collected weekly by study investigators. A single study investigator performed transcription of the data forms into a data worksheet in Microsoft® Excel 2011 (Microsoft Corporation, Richmond, VA), which was used for analysis. The numbers and types of MCI, the care transition time duration, and the number of patients signed out are presented as totals

and means with associated 95% confidence intervals (CI).

We developed an online survey using SurveyMonkey®. The survey items were reviewed using an iterative process of focus group feedback to validate the survey instrument. Upon completion of the post-intervention phase, we sent the survey to the ED residents and faculty who participated in the study. Their perceptions of the intervention and their satisfaction with the new process are presented as percentages.

RESULTS

Of the 448 resident-to-resident care transitions eligible for study inclusion, 321 (72%) had data forms submitted. During the pre-intervention phase, data from 164 (74 %) of the possible 222 care transitions were captured. Post-intervention, 157 (69 %) of the eligible 226 care transitions were included.

As shown in Table 1, 94 MCI were reported during the pre-intervention phase, and 36 during the post-intervention phase. Significant reductions in MCI were noted in the laboratory, radiology and "other" categories. There were no noticeable reductions in the ancillary data or consultant information categories. The mean MCI per care transition decreased by 58% from 0.57 (95% CI [0.41-0.73]) to 0.23 (95% CI [0.11-0.35]) as shown in Table 2.

The following are examples of MCI designated as clinically relevant. In the case of laboratory values, a patient with dizziness in whom discharge was planned was noted to have a markedly elevated blood urea nitrogen concentration that was suggestive of gastrointestinal (GI) bleeding. A GI bleed was confirmed, and the patient was admitted for observation. During the patient's course there was a significant drop in hemoglobin and a volume loss that required crystalloid replacement. An example of a relevant MCI in the "other" category was when a patient's past medical history was found to include AIDS, which the primary resident had not noted. The discovery led to a change in the differential and workup to include pneumocystis pneumonia and led to a change in therapy.

In the "vital signs" category of MCI, the heart rate of a patient awaiting a bed rose to 150 beats per minute. She was in atrial fibrillation with rapid ventricular response (RVR). Looking back at the electronic medical record (EMR,) it was noted that the abnormal vitals had already crossed over and were available at the time of sign-out, but since this was pre-intervention, the EMR review was not performed. The elevated heart rate was noted by nursing 45 minutes after sign-out when an inpatient bed was available. The RVR was treated and controlled, but led to a delay in transport to the inpatient bed of approximately 1.5 hours. Also in boarding patients, the systematic care transition process allowed detection of the need for re-dosing of antibiotics. Pre-intervention, re-dosing of antibiotics occurred at random and sometimes not at all, which was considered a clinically relevant MCI for patients who were being admitted and treated for active infections. We noted that pre-intervention, active secondary diagnoses needing management were also sometimes discovered at random during the shift, occasionally hours after the patient had been signed out. For example, there was a diabetic patient with a non-diabetic primary problem, but in whom hyperglycemia was worsening. During the non-systematic transition of care, the hyperglycemia was not communicated or noted, which led to a delay in the administration of insulin therapy and increased ED length of stay.

During the pre-intervention phase, the care transition start and end times were documented on 132 (80%) of the data forms, and the number of patients involved in the care transition was documented on 136 (83%). The mean and standard deviation of the care transition duration during the pre-intervention phase was 15 (95% CI 13.81, 16.19) minutes while the number of patients involved in the care transition was 9.3 (95% CI 8.69, 9.91) patients. Post-intervention, the care transition duration was documented on 124 (80%) of the data forms, and the number of patients involved in the care transition was documented on 153 (97%). The care transition duration and number of patients checked out during the post-intervention phase was similar to the pre-intervention phase, 14 (95% CI 12.99, 15.01) minutes and 9.3 (95% CI 8.73, 9.87) patients respectively.

As presented in Table 3, the majority (89.5%) of residents and faculty surveyed felt the change in the care transition process had either a positive impact or no impact. Most residents (85.7%) reported the desire to continue use of a standardized checkout process after graduation. Both residents and faculty felt the intervention decreased the number of MCI.

LIMITATIONS

Although the participants were technically blinded to the hypothesis and outcome measures, they could have inferred this

Table 1. Missed-clinical-item totals by category before and after the intervention implementing a standardized sign-out checklist for patient care transitions.

Missed clinical items	Pre-intervention	Post-intervention
Vital signs	7	3
Laboratory data	37	2
Radiology data	15	9
Ancillary data	6	9
Consultant information	7	7
Other	22	6
Total	94	36

Table 2. Mean missed clinical item (MCI) per transition before and after the intervention.

MCI per care transition	Pre-intervention	Post-intervention
Mean (95% CI)	0.57 (0.41-0.73)	0.23 (0.11-0.35)

information from the data collection form and pre-intervention training. This may have resulted in a Hawthorne effect in which participants altered their behavior in an attempt to decrease MCI during care transitions. As such, the number of MCI may have been lower during the study period, which could have resulted in an underestimate of the benefit of the intervention. Participants may also have failed to either recognize or record an MCI, which could have led to underreporting.

Specific details about the circumstances leading to the MCI were not always collected and may have been helpful; whether an MCI was an omission or whether the information conveyed was deemed inaccurate was not captured, nor was the justification for considering the missed information relevant.

Instituting a verification process to assess the thoroughness and accuracy of MCI reporting would have strengthened the study and could have been achieved by having trained impartial observers identify and record MCI during the care transition and subsequent shift. However, it wasn't feasible to have study personnel present during each shift for the four-month study period.

The study also doesn't address whether continued long-term use of the intervention in regular clinical practice results in sustained reduction of communication errors. As the standardized process is still being used, a new phase of the investigation is planned to evaluate the intervention again and determine the current rate of MCI per care transition.

Table 3. Post-intervention survey results of 17 emergency medicine faculty and 21 residents.

Questions	Responses
1. What percentage of the time is the standardized care transition protocol being used?	
<25%	12.1%
25-50%	11.7%
50-75%	30.7%
75-99%	35%
100%	2.6%
2. Has the new care transition process decreased the amount of MCI during care transition?	
Yes	73.5%
No	15.9%
3. How has the revised care transition process impacted your overall satisfaction with care transition?	
Negatively	0.0%
Unchanged	41.9%
Positively	47.6%
4. In your first job as an attending, if no formal care transition process were in place, would you either use or implement our revised care transition process? (Residents only)	
Yes	85.7%
No	14.3%
5. With the implementation of the revised care transition process, do you feel that interruptions have a smaller impact on overall care transition? (Faculty only)	
Yes	47.1%
No	52.9%

MCI, mild cognitive impairment

DISCUSSION

From 1993 to 2003, ED visits in the U.S. grew by 26% while the number of EDs declined by 425 and the number of hospital beds declined by 198,000.[8] As ED length of stay increases, mortality increases.[9] ED crowding and boarding will likely continue to rise, subjecting patients to more physician sign-outs.

The ED transition of care is well known to be an error-prone event because pertinent patient information is often not conveyed correctly or in full. The recognized need for process improvement has led to a variety of recommendations within the medical literature. Our study evaluated a standardized care-transition process that incorporated six key elements from published suggestions.[4,10,11,12]

In a 2011 observational study, investigators reported that certain care-transition characteristics were associated with communication errors including un-ideal location of care transition, interruptions, and lack of access to support materials including labs and images.[10] Taking this into account, our intervention required checkout to take place in a designated area with adequate room and a sufficient number of EMR computer kiosks for the process. An interruption manager was assigned to decrease the impact of disruptions. The outgoing faculty or most-senior outgoing resident acted as interruption manager because the role required a clinician who understood the current state of the ED and possessed the knowledge to manage any acute issues.

Current literature suggests that actively using the EMR during transfer of care improves communication at care transition.[4,10,12,13] A senior resident was responsible for reviewing all available EMR data and providing up-to-date patient information on demand. Not surprisingly, the biggest post-intervention decrease in MCI were in the categories found in the EMR, such as vital signs, laboratory data, and radiology data. Of note, ECG and consultant data, which were typically not available for review in the EMR at the time of care transitions, were categories that showed no post-intervention improvement. These findings suggest that clinically relevant data not available in the EMR should be gathered and reviewed during the care transition.

There was no attempt to standardize or script the verbal content of care transitions in our intervention because there was

concern that complex cases might warrant a more detailed presentation than scripting would allow. However, recent studies suggest that a standardized checklist is an effective communication tool during care transitions, resulting in statistically significant improvements in accuracy and completeness of information transferred.[14] A 2010 study evaluated a mnemonic checklist to standardize and shorten the amount of information that was transferred. The result was a decrease in checkout duration, an improvement in the perception of the quality of the process, and a decline in the amount of missing or wrong information.[12] Incorporating a checklist is a process change that is being considered for the future.

Very few resources are needed to implement a care-transition protocol like the one we studied. At our institution, after a brief in-service, most providers were able to implement the protocol on their next shift without further instruction. Four years after the study, the intervention is still being used and no further education has been required. Since the habits formed in residency are often maintained in future practice, this type of intervention might benefit training programs. A study of academic EM training programs found that only 10.5% have a written policy regarding care transitions in their department and almost 75% of programs don't provide formal didactic training sessions on the checkout process.[4]

Prolonging the duration of transfer of care was a concern for providers when the process change was proposed. Our data suggest that there is no difference in duration with the implementation of the standardized process at our institution. This is consistent with prior studies with care transition interventions.[12,14] In addition to the benefit of having an assigned interruptions manager, the more organized care-transition structure may have increased the providers' focus and limited unnecessary discussion.

We recognize that board-certified EPs signing out to each other in the community are not likely to have a large team in which they will have the luxury of an interruptions manager. They may, therefore, only make use of part of the systematic sign-out process. We do strongly feel that training residents to review their patient's EMR at checkout provides a good foundation for their future practice, particularly when there are complicated patients boarding in the ED. It is very easy to overlook the re-dosing of antibiotics, the administration of insulin, venous-thromboembolism prophylaxis and other clinically relevant therapies. Our systematic care-transition process has made checking for these things a matter of routine.

CONCLUSION

We studied 321 care transitions, accounting for the transfer of information on roughly 3,000 patients. A strength of our study was that, in contrast to many others of its type which only used subjective measures to determine outcomes, we used an objective measurement for error. We found that the intervention, a standardized checkout process with six elements, reduced the communication error rate by 58%. The new process also improved physician satisfaction without increasing the length of time spent transferring care. As a result, our department continues to use the standardized process to this day.

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Security, Violent Events, and Anticipated Surge Capabilities of Emergency Departments in Washington State

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Introduction: Over the past 15 years, violent threats and acts against hospital patients, staff, and providers have increased and escalated. The leading area for violence is the emergency department (ED) given its 24/7 operations, role in patient care, admissions gateway, and center for influxes during acute surge events. This investigation had three objectives: to assess the current security of Washington State EDs; to estimate the prevalence of and response to threats and violence in Washington State EDs; and to appraise the Washington State ED security capability to respond to acute influxes of patients, bystanders, and media during acute surge events.

Methods: A voluntary, blinded, 28-question Web-based survey developed by emergency physicians was electronically delivered to all 87 Washington State ED directors in January 2013. We evaluated responses by descriptive statistical analyses.

Results: Analyses occurred after 90% (78/87) of ED directors responded. Annual censuses of the EDs ranged from < 20,000 to 100,000 patients and represented the entire spectrum of practice environments, including critical access hospitals and a regional quaternary referral medical center. Thirty-four of 75 (45%) reported the current level of security was inadequate, based on the general consensus of their ED staff. Nearly two-thirds (63%) of EDs had 24-hour security personnel coverage, while 28% reported no assigned security personnel. Security personnel training was provided by 45% of hospitals or healthcare systems. Sixty-nine of 78 (88%) respondents witnessed or heard about violent threats or acts occurring in their ED. Of these, 93% were directed towards nursing staff, 90% towards physicians, 74% towards security personnel, and 51% towards administrative personnel. Nearly half (48%) noted incidents directed towards another patient, and 50% towards a patient's family or friend. These events were variably reported to the hospital administration. After an acute surge event, 35% believed the initial additional security response would not be adequate, with 26% reporting no additional security would be available within 15 minutes.

Conclusion: Our study reveals the variability of ED security staffing and a heterogeneity of capabilities throughout Washington State. These deficiencies and vulnerabilities highlight the need for other EDs and regional emergency preparedness planners to conduct their own readiness assessments. [West J Emerg Med. 2017;18(3)466-473.]

INTRODUCTION

Background and Importance

Over the past 15 years, violent threats and acts against hospital patients, staff, and providers have increased and escalated.[1] The non-fatal assault rate of healthcare workers has been reported to be up to four times the rate for all private–sector industries.[2] Hospital-based shootings nearly doubled from 2000-2011.[3] Within the hospital, the leading area for violence is the emergency department (ED) given its 24/7 operations in patient care and as the admissions gateway,[4] with assault rates as high as 1.1 per 100,000 ED employee hours per year.[5] A study of EDs in Cincinnati reported 98% of nurses and 96% of physicians had been verbally abused, and 67% of nurses and 51% of physicians had been physically abused while at work.[6] Another study in Michigan found the average ED healthcare worker was physically threatened four times per year and assaulted at least once per year.[7]

Concurrently, EDs are often the center for influxes of patients, crowds, media, and traffic during mass casualty events that include natural disasters and terrorist attacks. Violent incidents, such as in 2009 at Fort Hood, 2012 in Aurora, CO, in New York City during Hurricane Sandy, and during the 2013 Boston Marathon, accentuate the importance of ED and hospital campus-specific plans to rapidly augment hospital security and operations. Although accredited hospitals are required to have an emergency management plan, because of costs and a lack of standardization, EDs and hospitals employ a variety of security protocols ranging from in-house "rapid response teams" to reliance on local law enforcement.[8] No standardized requirements or recommendations for emergency planning exist, and anecdotal lack of familiarity with ED and hospital security plans further complicate ED personnel safety and operations, which may be magnified during an acute surge or mass casualty event.

Population Health Research Capsule

What do we already know about this issue?
Over the past 15 years, violence within hospitals and the frequency of mass casualty events has increased and escalated. The emergency department is the leading area for this violence and influx.

What was the research question?
Within Washington State EDs, what are the frequencies of violent events, basic response protocols, and surge capabilities?

What was the major finding of the study?
Our study reveals the variability of ED security staffing and a heterogeneity of capabilities throughout WA State.

How does this improve population health?
This initial and unprecedented survey highlights the need for other EDs and regional emergency preparedness planners to conduct their own readiness assessments and examine their protocols.

Goals of This Investigation

Growing research in ED violence exists, yet there is an absence of detailed statewide or comprehensive characterization of ED security and resources for normal operations and mass casualty event response. This investigation had three objectives: to assess the current security of Washington State EDs; to estimate the prevalence of and response to day-to-day threats and violence in Washington State EDs; and to appraise the Washington State ED security capability to respond to a mass casualty event.

MATERIALS AND METHODS

Study Design

A voluntary, blinded, 28-question Web-based survey developed by emergency physicians was electronically delivered to all 87 Washington State ED directors in January 2013 (Appendix). Two senior physician-authors, with disaster medicine focus and publications, created the survey based on observations and reports of numerous hospital emergency management plans, which was to serve as an initial assessment of a potentially overlooked topic. As a result, the survey did undergo a formal validation phase. Review and approval by the Washington State American College of Emergency Physicians (ACEP) and local institutional review board were obtained. Multiple-choice questions pertained to basic ED demographics, current security protocols and resources, estimated prevalence and types of threats and violent incidents, and ability of security to respond to acute events (Table 1). Four subsequent monthly email participation reminders were sent and final responses collected in June 2013.

Data Collection and Processing

ED directors were aware that their responses would remain anonymous via the Web-based survey collection tool. Missing survey item answers were treated as no responses. We evaluated data using univariate descriptive statistical analyses. The data were based solely on the responses of the ED directors and were not compared to police or hospital reports.

Table 1. Demographics of 78 EDs (emergency departments) that responded to a survey on security and preparedness for an acute surge or mass casualty event.

	n	%
Annual census	78	
<20,000	20	26
20,000-39,999	29	37
40,000-59,999	9	12
60,000-79,999	17	22
80,000-99,999	3	4
Practice environment	78	
Rural/critical access	24	31
Suburban 1-2k/mi^2	11	14
Suburban 2-3k/mi^2	19	24
Urban	24	31
Trauma level designation	78	
Level 1	1	1
Level 2	14	18
Level 3	23	29
Level 4	29	37
"Not Applicable"	11	14
# of Security personnel assigned to ED each shift	75	
"Not Applicable"	21	28
1	34	45
2	14	19
3	3	4
4	1	1
≥5	2	3
Timing of ED security coverage	75	
Never/not applicable	18	24
Special events	0	0
Daytime	4	5
Evenings	1	1
Nights/weekends	5	7
24-hour coverage	47	63
Source of security personnel	75	
"Not Applicable"	10	13
Hospital	45	60
Private/contracted company	13	17
Local law enforcement agency	7	9
Regional/state law enforcement agency	0	0
Training of security personnel assigned to ED	75	
"Not Applicable"	17	23
No formal or prior training	3	4
Prior security/law enforcement experience	11	15
By hospital/healthcare system	34	45
Agency or contractor sponsored course	8	11
Non-employer sponsored training course	2	3

RESULTS

Demographics

Seventy-eight of 87 (90%) Washington State ED directors responded between January and June 2013 (Table 1). A majority reported one (45%) or two (19%) security personnel on duty. Twenty-one (28%) responded zero or "not applicable." Nearly two-thirds (63%) had 24-hour security coverage. Security personnel were provided to 60% of EDs by the hospital, 17% by private companies, and 9% by local law enforcement agencies. Security personnel training was provided by 45% of hospitals or healthcare systems, while 11% used an agency or contractor-sponsored course, 15% relied on prior training, and 3% used a non-employer sponsored training course. Three (4%) reported no prior or formal training for security personnel.

Prevalence of and Response to Threats and Violence

Sixty-nine of 78 (88%) ED directors witnessed or heard violent threats or acts occurring in their ED. Of these respondents, 93% had witnessed these threats/acts directed towards nursing staff, 90% towards physicians, 74% towards security personnel, and 51% towards administrative personnel. Nearly half (48%) noted incidents directed towards another patient, and 50% towards a patient's family or friend (Figure 1). These events were variably reported, according to ED directors' recollection, to the hospital administration—most often for incidents involving nurses (89%) and providers (83%). Incident reporting rates were lower for administrative staff (77%) and security personnel (71%), and lowest when directed towards another patient (62%) and or their family or friends (58%) (Figure 1).

Fifty-nine of 75 (79%) EDs had plans to notify and receive additional security personnel. Twenty-three (31%) would be able to receive additional security personnel from within the hospital in under five minutes, 35% within 5-15 minutes, and 8% within 16-30 minutes. Five (7%) EDs would have to wait for 30 or more minutes. Thirty-four of 75 (45%) EDs reported that the general consensus of their ED staff was that the current level of their security was inadequate.

Response to an Acute Surge or Mass Casualty Event

After an acute surge or mass casualty event, 18 of 69 (26%) respondents believed the availability and size of the initial additional security response would be adequate, while 35% did not, and 39% were unsure. The number of security personnel that could present within 15 and 30 minutes upon activation of their hospital's emergency management plan varied (Figure 2), including 26% reporting no additional security would be available within 15 minutes and 25% reporting additional personnel within 30 minutes.

The ED security personnel source during normal operations and responding to an acute surge event varied. Additional security personnel would be provided by 24 of 61 (39%) hospitals, while 8% would receive support from a private or contracted company and 46% depended on local law enforcement. When asked about the highest level of assurance that additional security personnel would be available and respond to an acute surge or mass casualty event, 38% reported additional security was already present on the hospital campus, arranged through a formal contract, or coordinated via a memorandum of understanding or agreement. Twelve (20%) reported reliance on an unwritten agreement, and 41% did not know.

Thirty-nine of 61 (64%) ED directors reported that points of entry and egress from the hospital could be secured within 15 minutes (Table 2). When asked about specific scenario response effectiveness, 57% believed that their security would be able to handle a violent criminal or terrorist in the ED, and 59% and 56% felt security could handle a surge of patients and of patients' family and friends, respectively, arriving within one hour. If an acute surge of patients greater than the current capacity of the ED and its waiting room occurred within an hour, 61% reported planned policies to limit access of visitors. Thirty-eight (62%) did not know of or have a security protocol to control traffic for incoming patients, additional hospital personnel, medical equipment suppliers, responding agencies, and media. Fifteen (25%) did not know of or have a security plan to enforce the quarantine of contaminated and contagious patients. Nineteen (31%) respondents did not have or know of a security protocol to secure contaminated items, high-value possessions, or firearms.

Table 2. ED directors' responses to a survey regarding response times and protocols during an acute surge or mass casualty event.

Question asked	Responded yes (%)	Responded no (%)
Could entry/egress from the hospital be secured in 15 minutes?	64%	36%
Could your security handle a violent criminal/terrorist?	57%	43%
Could your ED handle a surge of patients?	59%	41%
Could your ED handle a surge of patients' family/friends?	56%	44%
In an acute surge of patients greater than the ED/waiting room capacity, does your ED have planned policies to limit visitors?	61%	39%
Does your ED have a protocol to control traffic for incoming patients, personnel, and supplies?	38%	62%

ED, emergency department

Seventeen (28%) were unaware of securing and maintaining a chain of custody for potential forensic evidence (Figure 2).

DISCUSSION

A 2011 ACEP policy statement advocated that hospitals have a responsibility to "provide a best-practices security system, including adequate security personnel, sufficient training of personnel, physical barriers, surveillance equipment, and other security components, coordinate … with local law enforcement agencies, [and] develop written ED protocols for violent situations occurring in the ED to ensure the safety of patients and health care workers alike."[9] Our study reveals variable ED security staffing and training and a heterogeneous collection of plans and capabilities throughout Washington State. Although disaster plans exist, a number of common potential deficiencies were apparent, such as uniformity of security training, reporting of violent acts, and specific protocols for securing firearms, hospital resources, and forensic evidence. Concerning vulnerabilities exist including lack of additional and readily-available security, capability to rapidly secure access to EDs, and crowd and traffic control.

Demographics

While nearly two-thirds (63%) of EDs had 24-hour security personnel coverage, 28% reported no assigned security personnel. A 2012 study in New Jersey found that small-town hospitals in areas with low crime indices or violent crime rates implemented the fewest security features. Despite hypotheses that small EDs in low crime areas would need less security protection, these facilities had more violent acts than large hospitals in areas of low and high crime rates.[5] In Washington State, we found that lower census EDs more often have no or only part-time security presence. We recommend full-time dedicated security presence for all EDs, or at least full-time hospital security that can quickly be activated to the ED and planned coordination with local law enforcement.

Prevalence of and Response to Violent Threats and Acts

Congruent with past investigations, we found ED personnel are likely to witness or experience workplace violence. We also found that violence was common against other patients and their families and friends as well. This reinforces that improved security measures are needed not just to protect those who work in EDs, but the patients and other visitors who seek care and safety in EDs.

Another intriguing finding was the gap between violent threats and acts witnessed or heard about and the subsequent reporting rate to administration. Several previous studies have reported similar patterns, including a 2006 study that found only 26% of ED providers and 45% of ED employees in general filed formal reports after experiencing a spectrum of violent acts.[6] Another study in 2011 found only 35% of violence by patients and 55% by visitors were reported.[10] We recommend that ED supervisors support a culture of reporting and an easy method to file reports without punitive consequences. Having accurate data regarding the locations, times, and natures of these events

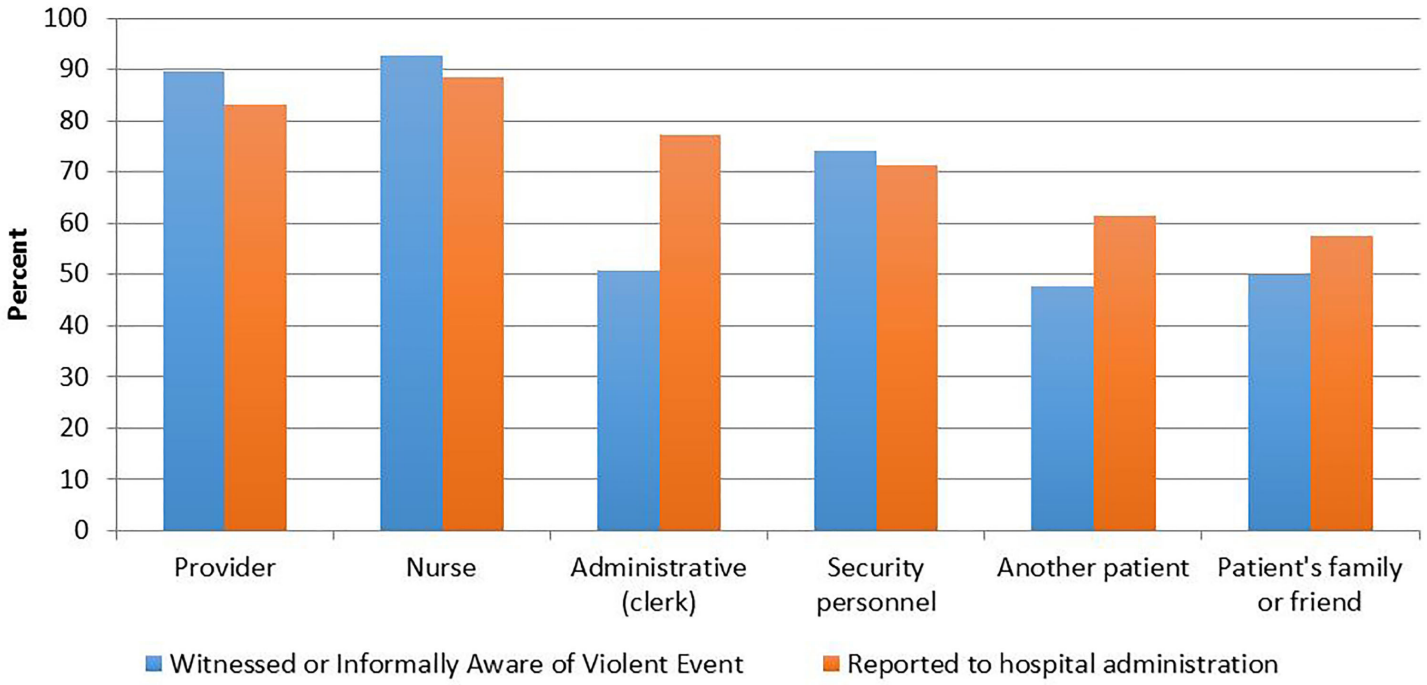

Figure 1. Percent distributions of violent threats or acts witnessed by or reported to emergency department (ED) directors and reported to hospital administration.

will help hospitals and government systems to further secure the workplaces and healthcare settings for staff and patients alike and to identify problems and gain resources in this effort.

Response to an Acute Surge or Mass Casualty Event

The increased national incidence of ED and hospital-based shootings reinforce the importance of hospital security, which may deter or rapidly respond to "active shooters" or other imminent threats. A 2008 study identified that, despite having a disaster plan and conducting disaster drills, one out of six Los Angeles County 911-receiving hospitals did not have a protocol for hospital lockdown or involved the local police department.[11]

Of concern in Washington State as well, we found nearly half (43%) of ED directors believed security would be unable to control violent criminals or terrorists. Nearly half (41%) of directors also doubted that their security could handle an acute surge of patients and visitors greater than the ED and waiting room capacity; more than one-third (36%) reported that it was unlikely all points of hospital entry and egress could be secured within 15 minutes; and nearly two-thirds (62%) did not believe security protocols would be able to control traffic of incoming patients, additional hospital personnel, medical equipment suppliers, responding agencies, and media. Additionally, nearly one-third (31%) of respondents did not know of or have a security protocol to secure contaminated items, high-value possessions, or firearms, and 28% similarly did not know about the ability or use of a chain of custody for potential forensic evidence. These results highlight a huge vulnerability in homeland security and safety of hospital staff and patients. We recommend that all hospitals, regardless of size, develop protocols to ensure adequate resources for security in surge events and terrorist or imminent-threat events. These should be practiced routinely in drills and staff awareness of these plans should be promoted through easy access and frequent reinforcement.

Terrorist and mass casualty events are rare, and there have been multiple examples regarding how hospitals have been ill prepared to handle these surges. However, the well-run response after the Boston Marathon bombings in 2013 demonstrates a major event where protocols, coordinated efforts between different agencies, and disaster drills paid off.[12] The Oso landslide that occurred outside a rural town in Washington in 2014 highlights that surge events can occur anywhere and all levels of hospitals must be prepared.

A national escalation of violent threats and acts against ED patients, visitors, and staff, coupled with increases in acute surge and mass casualty events, underscores the need to reevaluate and improve existing ED security capabilities. Results from this assessment highlight multiple shortcomings in ED security protocols and capabilities. These deficiencies are likely common outside of Washington as well and further research is needed to better describe the incidence of ED violence and security capabilities, ideally prospectively, in Washington and other states.

With the implementation of the Emergency Medical Treatment and Labor Act EMTALA in 1986, EDs must evaluate and stabilize all patients; however, they are not given adequate government resources for the protection of their staff. Smaller hospitals and communities may not have the resources to provide the same security measures that larger hospitals can afford, but

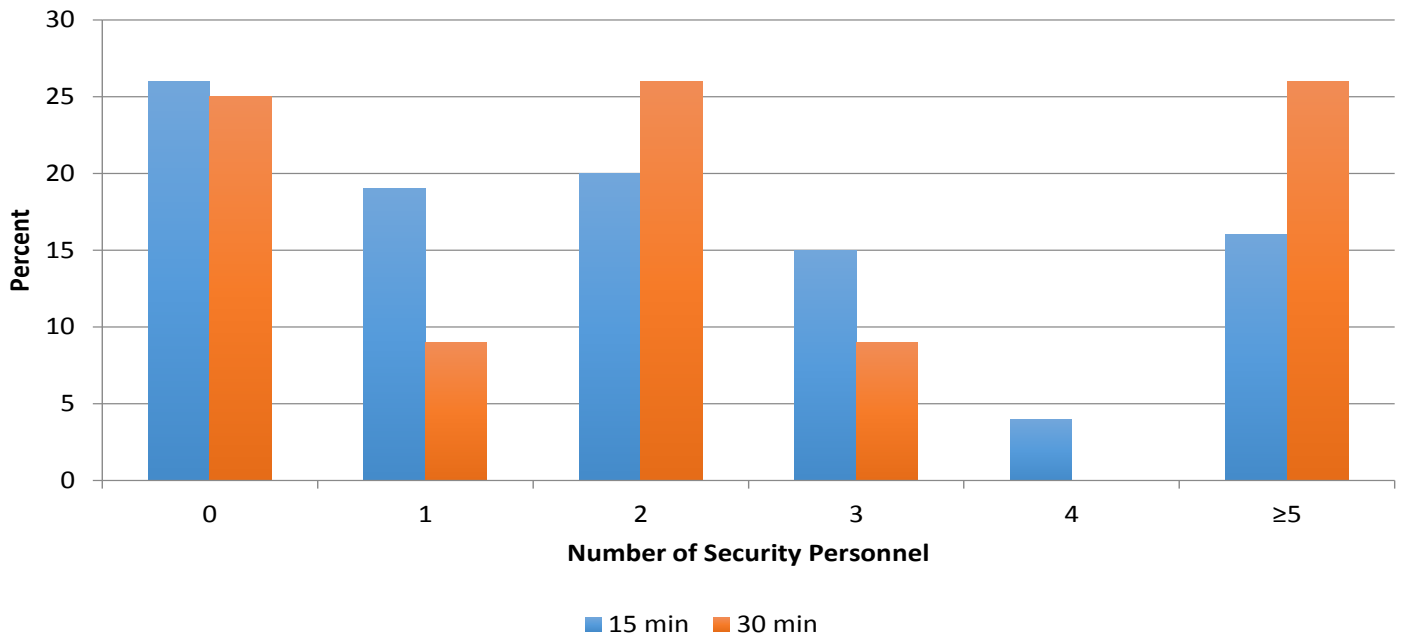

Figure 2. Number of security personnel that could respond within 15 and 30 minutes of activation of the hospital emergency management plan.

these critical access hospitals are important resources themselves and their staff and patients are just as important to protect. Each community must create its own security and disaster plans and coordinate them with their local police forces. On a statewide basis, minimum security standards for daily operations and for mass security threats should be set and supported. Furthermore, it would be less costly and more efficient to create standard operating procedures for all hospitals within a state so that training could be more uniform, operations would be easier to coordinate during a disaster, and appropriate resource allocation could be ensured. Hospitals are a key resource for homeland security, and government financial resources should support protecting these facilities, staff, and patients.

LIMITATIONS

Firstly, this was a survey instrument and we only collected data for a single state. This study relied on the knowledge, access to local records, and recollection of the Washington State ED directors without confirming response accuracy and with potential bias from the perception of local security resources and plans. Also, multiple interpretations of survey questions may have occurred and some questions were not answered by all respondents. For instance, we did not specify between types of mass disaster events. Finally, results have uncertain generalizability beyond Washington State. Due to anonymity we did not track dates of responses, and demographic data could not be analyzed alongside corresponding prevalence and response to threats or events.

CONCLUSION

Our study reveals variable ED security staffing and training and a heterogeneous collection of plans and capabilities throughout Washington State. Although disaster plans exist, a number of common potential deficiencies are apparent, such as uniformity of security training, reporting frequency of violent acts, and specific protocols for securing firearms, high-value items, and forensic evidence. Concerning vulnerabilities exist including lack of readily available additional security, capability to rapidly secure access to EDs, and crowd and traffic control ability, and two-thirds of the ED directors we surveyed responded that resources were inadequate for day-to-day operations and surge events

ED security is increasingly critical given the progressive frequency of violent, acute surge, and mass casualty events. Although specific to Washington State, identified security deficiencies and vulnerabilities are likely shared and additional research should be considered by other EDs and regional emergency preparedness planners.

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The Fast and the Furious: Low-Risk Chest Pain and the Rapid Rule-Out Protocol

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Accelerated diagnostic pathways (ADP) have been designed to identify low-risk chest pain patients in the emergency department. This review article discusses the Asia-Pacific Evaluation of Chest Pain Trial (ASPECT) score, the Accelerated Diagnostic Protocol for Chest Pain Trial (ADAPT) score, the Emergency Department Assessment of Chest Pain Score (EDACS), the HEARTScore and the HEART pathway. These ADPs have been validated in various studies and aid the emergency provider with identifying the low-risk chest pain patient who is appropriate for discharge home, while at the same time highlighting those patients who would benefit from further in-patient work up. These approaches should be paired with patient input and shared decision-making strategies. [West J Emerg Med. 2017;18(3)474-478.]

INTRODUCTION

Chest pain is one of the most frequent complaints of patients presenting to the emergency department (ED). Approximately 10-20% of patients who present to the ED with chest pain are suffering from an acute coronary syndrome (ACS), requiring early intervention and treatment.[1] In the remaining 80% of patients chest pain symptoms are explained by other, often not life-threatening, conditions. Distinguishing patients suffering from ACS from those who are not based on their chest pain history and physical examination is difficult as no history or examination variables have sufficient predictive value to rule in or rule out ACS, if considered in isolation. Admission for further workup of chest pain patients for the evaluation of ACS is costly, time consuming and places patients at risk of adverse events during their evaluation. Early discharge is also not without risk, as up to 2-5% of patients with ACS are inappropriately discharged from the ED every year.[2] Missed ACS remains a top malpractice claim in the United States. These current care patterns of over- and under-testing demonstrate that the low-risk chest pain evaluation is a diagnostic dilemma for emergency clinicians.

The American College of Cardiology and American Heart Association (ACC/AHA) have developed guidelines in an attempt to standardize the approach to patients with chest pain. The 2010 and 2014 guidelines recommend the use of the Global Registry of Acute Coronary Events (GRACE) score or thrombolysis in myocardial infarction (TIMI) risk score as part of the initial evaluation for possible ACS. However, neither TIMI nor GRACE was designed for ED chest pain risk stratification. The TIMI score was designed to be applied to patients with unstable angina or non ST-elevation myocardial infection (NSTEMI) to determine their risk for 14-day mortality, new or recurrent acute myocardial infarct (AMI) or severe recurrent ischemia requiring urgent revascularization.[3] The GRACE score was developed to risk stratify patients with confirmed ACS to estimate their in-hospital, six-month and three-year mortality.[4] While these scores were subsequently validated in an ED setting, they lack the sensitivity needed to

Table 1. Low-risk patients as classified in the ASPECT, ADAPT and APACE trial.[6,7,8]

ASPECT	ADAPT	Modified ADAPT
Contemporary troponin, myoglobin and CK-MB negative at 0 and 2 hours	Contemporary troponin negative at 0 & 2 hours	High sensitive troponin negative at 0 & 2 hours
ECG without new ischemic changes	ECG without new ischemic changes	ECG without new ischemic changes
TIMI score 0	TIMI score 0	TIMI score 0 or 1

ASPECT, Asia-Pacific Evaluation of Chest Pain Trial; *ADAPT,* Accelerated Diagnostic Protocol for Chest Pain Trial; *APACE,* Advantageous Predictors of Acute Coronary Syndrome Evaluation; *CK-MB,* creatine kinase-MB; *ECG,* electrocardiogram; *TIMI,* thrombolysis in myocardial infarction.

identify a low-risk population capable of safe early discharge from the ED.[5]

Accelerated diagnostic pathways (ADP) were developed to provide guidance to emergency clinicians to determine the level of risk for patients with possible ACS and support appropriate testing for each patient with chest pain. The goal of ADPs is to identify the very low-risk patients for early discharge, while at the same time identifying those patients more likely to benefit from stress testing and angiography. ADPs are starting to appear in ACC/AHA guideline updates. A more detailed description of the most commonly used ADPs is found below.

ACCLERATED DIAGNOSTIC PATHWAYS

ASPECT

The ASia-Pacific Evaluation of Chest Pain Trial (ASPECT) aimed to prospectively validate the safety of a predefined two-hour ADP to identify ACS patients. The study was conducted in 14 EDs in nine countries in the Asia-Pacific region.[6]

Those with a TIMI risk score of 0, no new ischemic changes on the electrocardiogram (ECG) and a negative 0- and 2-hour point-of-care biomarker results were deemed low risk and eligible for early discharge. Primary endpoint was major adverse cardiac events (MACE) within 30 days. MACE was defined as death (not clearly non-cardiac), cardiac arrest, an emergency revascularization procedure, cardiogenic shock, ventricular arrhythmia needing intervention, high-degree atrioventricular block needing intervention and acute myocardial infarction. A total of 3,582 patients were enrolled, of which 352 (10%) were considered low risk. Within the low-risk group there were three (0.85%) MACE. The ASPECT ADP had a 99.3% (95% confidence interval [CI] [97.9 – 99.8]) sensitivity with a negative predictive value of 99.1% (95% CI 98-100) for MACE.

Table 2. TIMI score.[3]

Age ≥ 65	+ 1
≥ 3 CAD (coronary artery disease) risk factors	+ 1
Known CAD (stenosis ≥ 50%)	+ 1
Aspirin use in past 7 days	+ 1
Severe angina (≥ 2 episodes in 24 hours)	+ 1
ECG ST changes ≥ 0.5mm	+ 1
Positive cardiac marker	+ 1

TIMI, thrombolysis in myocardial infarction; *ECG,* electrocardiogram

ADAPT

The Accelerated Diagnostic Protocol for Chest Pain (ADAPT) trial was a prospective observational study from the same investigators as the ASPECT trial.[7] In this trial, 1,975 patients were enrolled in two of the ASPECT centers to identify low-risk patients suitable for discharge after application of an ADP incorporating sensitive/contemporary troponin assay results, with TIMI score and ECGs (Tables 1 and 2). The investigators found that 392 patients (20%) were classified as low risk. One of 392 patients (0.25%) had a MACE. The ADAPT score was found to have a sensitivity of 99.7%, specificity of 23.4%, negative predictive value of 99.7% and positive predictive value of 19% for MACE.

In the Advantageous Predictors of Acute Coronary Syndrome Evaluation (APACE) validation study, patients were classified as low risk if they had a TIMI score of 0 or 1 (0 only in the ADAPT trial), a non-ischemic ECG and normal 0- and 2-hour high sensitivity troponin measures (Table 1).[8] Of the 909 patients enrolled, 40% were identified as low risk. This validation study found a sensitivity of 99.4% (95% CI [96.5 – 100]), NPV 99.7% (95% CI [98.4 – 100]).

EDACS

The Emergency Department Assessment of Chest Pain Score (EDACS) is the first emergency medicine-based risk score derived from clinical data and was developed as a chest pain score to identify patients safe for early discharge. The derivation cohort consisted of patients enrolled in the ADAPT study.

The EDACS score was incorporated into an ADP, where low risk was identified as an EDACS score < 16, no new ischemia on ECG and a negative 0- and 2-hour troponin. In this observational cohort patients who met these criteria were identified who would have been safe for discharge home without further workup. The derivation cohort (1,974 patients) and the validation cohort (608 patients) identified 40-50% of patients as low risk. The sensitivity was 99% (95% CI [96.9–99.7]) for MACE. EDACS has been

Table 3. Emergency Department Assessment of Chest Pain Score (EDACS).

Clinical characteristics	Score
Age	
18 – 45	+ 2
46 – 50	+ 4
51 – 55	+ 6
56 – 60	+ 8
61 – 65	+ 10
66 – 70	+ 12
71 – 75	+ 14
76 – 80	+ 16
81 – 55	+ 18
86 +	+ 20
Male sex	+ 6
Aged 18 – 50 years and either:	+ 4
known coronary artery disease or	
≥3 risk factors	
Symptoms and signs	
Diaphoresis	+ 3
Radiates to arm or shoulders	+ 5
Pain occurred/worsened by inspiration	- 4
Pain is reproduced by palpation	- 6

Table 4. The HEARTScore for chest pain patients in the emergency department.[11]

HEARTScore		
History	Highly suspicious	2 points
	Moderately suspicious	1 point
	Slightly or non suspicious	0 points
ECG	Significant ST-depression	2 points
	Nonspecific repolarization	1 point
	Normal	0 points
Age	>= 65 years	2 points
	> 45 - <65 years	1 point
	<= 45 years	0 points
Risk factors*	>= 3 risk factors or history of CAD	2 points
	1 or 2 risk factors	1 point
	No risk factors	0 points
Troponin	>= 3x normal limit	2 points
	>1 - <3 normal limit	1 point
	<= normal limit	0 points

* Risk factors: diabetes mellitus, current or recent (<one month) smoker, diagnosed hypertension, diagnosed hypercholesterolemia, family history of coronary artery disease and obesity.

validated in a randomized trial comparing EDACS to ADAPT.[9] In this study more patients were identified as low risk by EDACS compared to ADAPT, and no patients identified as low risk had a 30-day MACE event. However, in the first U.S. validation study EDACS had lower sensitivity for MACE.[10]

HEARTScore

The HEARTScore was developed to score predictors of primary end points based on clinical experience and previous medical literature.[11] Predictors included history (H), electrocardiography (ECG) (E), Age (A), Risk factors (R) and Troponin (T), forming the HEART score. Each of the five factors is scored with 0, 1, or 2 points (Table 4). Patients were followed for six weeks for a primary end point of major adverse cardiac event (MACE), including AMI, primary coronary intervention (PCI), coronary artery bypass graft (CABG) or death.

In the first retrospective validation study 122 patients presented to the ED with chest pain. Results are presented in Table 5. One (2.5%) of the 39 patients with a low HeartScore (0-3) had a MACE, requiring CABG. This was compared to 12 of 59 (20.3%) patients with a HeartScore of 4-6, and 16 of 22 (72.7%) of patients with a HeartScore of 7-10 points that reached an endpoint. Two deaths occurred in the study; both patients had a HeartScore of eight. After this small retrospective study, a multicenter retrospective study was performed.[2] In this study 34% of patients were identified as low risk, with a risk of MACE of 0.99%. The results of this study are presented in Table 5. Both studies, however, were limited by their observational, retrospective design. Further validation was needed, and the same authors provided a prospective multicenter study.[5] In this study the HeartScore was compared to the TIMI and GRACE scores. A total of 2,440 patients who presented to the ED with chest pain were enrolled in 10 Dutch hospitals. Outcomes measures were the same as the retrospective studies. The results of the HeartScore original study and validation studies are presented in Table 5.

Sixteen patients died (0.7%), 13 of whom died of a cardiac cause. One of these patients was in the low-risk HeartScore group, five were in the intermediate-risk group and seven in the high-risk HeartScore group. The C-statistics of the HeartScore when compared to TIMI and GRACE were as follows: HEART 0.83, TIMI 0.75, GRACE 0.70 ($p<0.0001$). This study provided additional support for use of the HeartScore as an ADP for low risk chest pain patients.

HEART Pathway

While the HeartScore is predictive of MACE, many clinicians consider the 1.7% risk of MACE in a patient identified

Table 5. HeartScore, risk of MACE within six weeks from ED presentation.

	Risk of MACE at 6 weeks in original study[11]	Risk of MACE at 6 weeks in validation study[5]
Low HeartScore (0 – 3)	2.5 % (1/39)	1.7% (15/870)
Intermediate HeartScore (4 – 6)	20.3 % (12/59)	16.6 % (183/1101)
High HeartScore (7 – 10)	72.7 % (16/22)	50.1 % (209/417)

HeartScore (history, ECG, age, risk factors, troponin); *MACE*, major adverse cardiac event; *ED,* emergency department

as low risk by the HeartScore to be too high. Furthermore, with the HeartScore it is possible to have a patient with a low-risk HeartScore, despite a positive troponin. The Heart pathway was designed to lower the missed MACE rate of the HeartScore below 1%, by separating the troponin results from the remaining "Hear" score and using two troponin measures (at 0 and 3 hours) instead of one. To be considered low-risk using the HeartScore pathway you must have a Hear(t) score of 0-3 and have both serial troponin measures less than the 99th percentile upper-reference limit.

The first study to validate the HeartScore in the U.S. enrolled 1,070 chest pain patients in an observation unit and revealed that five patients with an NSTEMI had low-risk HeartScore.[13] However, all of these patients had positive serial troponins. Use of the Heart pathway, with its serial troponins, was 100% sensitive for ACS and could have decreased observation stays by 80%. A secondary analysis performed on 1,005 participants in the Myeloperoxide in the Diagnosis of Acute Coronary Syndromes Study (MIDAS) found the Heart pathway to identify 20% of patients for early discharge with a 99% (95% CI [97%-100%]) sensitivity for ACS.[14] The Heart Pathway Randomized Controlled Trial evaluated 282 patients and randomized them to the Heart pathway or usual care. Use of the Heart pathway increased early discharge by 21% (p=0.0002), median length of stay was decreased by 12 hours (p=0.013), and objective cardiac testing at 30 days was decreased by 12% (p=0.048), without any MACE events among patients identified as low risk.

SHARED DECISION-MAKING

In recent years there has been growing attention to shared decision-making. Shared decision-making involves educating patients on their health risks, as well as the risks of testing, and discussing their treatment options. This is often done using a pictogram developed at the Mayo Clinic called the Chest Pain Choice.[15] In the Chest Pain Choice Trial, a single-center randomized controlled trial, patients enrolled in the shared decision-making arm reported greater knowledge, less decisional conflict and feeling more engaged in the decision-making process when compared to those receiving usual care. Patients also decided less frequently to be admitted for further testing, with a 19% absolute difference (95% CI [6%-31%]).

SUMMARY

The low-risk patient with chest pain can be a high-risk scenario for the emergency physician. Accelerated decision protocols have been designed to aid the emergency physician in decision-making with regards to assessment of these patients. The use of these ADPs can reduce cost, length of stay and risk of unnecessary testing in chest pain patients. It is important for all emergency physicians to be familiar with different ADPs, and to know their benefits and limitations. All of the above-described ADPs are validated choices for risk assessment of low-risk chest pain patients in the ED. UsTe of any of these ADPs should be considered within standard of care. The choice to select a specific ADP for use in the ED can be done on an institutional level or can be the choice of the individual practitioner. Within the authors' (MH, AM, ZD) institution, the Heart pathway was implemented alongside a shared decision model for its high sensitivity, negative predictive value and ease of use. Shared decision-making tools may assist patients with acute chest pain and their providers to navigate difficult disposition decisions.

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Skin to Intramuscular Compartment Thigh Measurement by Ultrasound in Pediatric Population

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Introduction: Pediatric obesity threatens the efficacy of medications given intramuscularly. In anaphylactic patients, epinephrine auto-injector needle lengths are potentially too short to reach the muscle compartment in patients with elevated body habitus. The objective of the study was to determine needle-length requirements for intramuscular injections in pediatric patients.

Methods: We used ultrasound to measure the distance from skin to muscle compartment of the thigh in 200 pediatric patients of various weight and body mass index who presented to the emergency department.

Results: Patients with higher body mass index had an increased distance to muscle and bone. If current recommendations were followed, 5% of patients within the EpiPen adult weight category and 11% of patients within the Centers for Disease Control and Prevention weight category would have potentially used a needle inadequate in length for intramuscular injections.

Conclusion: With the increase in childhood obesity, needle lengths may be too short to effectively deliver medications to the intramuscular compartment. Needle length should be evaluated to accommodate pediatric patients with increased skin to muscle distance. [West J Emerg Med. 2017;18(3)479-486.]

INTRODUCTION

During a severe allergic reaction, anaphylaxis, certain life-saving medications such as epinephrine have a quicker onset of action if given intramuscularly.[1,2] In response to allergen exposure, mast cells and basophils release inflammatory mediators, which promote a systemic reaction with potential respiratory and cardiovascular consequences.[3-11] Epinephrine, an adrenergic receptor agonist, increases vasoconstriction and peripheral vascular resistance through the alpha-1 receptor, elevates inotrophy and chronotrophy through the beta-1 receptor, and promotes bronchodilation and vasodilation via the beta-2 receptor to reduce anaphylactic symptoms and promote a homeostatic state.[12,13] The National Institute of Allergy and Infectious Diseases recommends epinephrine be given intramuscularly as the first line of therapy to rapidly treat anaphylaxis. Auto-injector needles that facilitate the intramuscular injection should be adequate in length to reach between the subcutaneous adipose tissue and vastus lateralis muscle.[14] If treatment is injected intramuscularly to the anterolateral aspect of the thigh, blood levels of epinephrine are therapeutic at eight minutes. However, if treatment is given subcutaneously, therapeutic levels of epinephrine are not reached until 22 minutes, extending exposure of potentially life-threatening symptoms and therefore increasing morbidity and mortality risk.[2]

It is well known that obesity is a growing issue in the

pediatric population in the United States (U.S.), with obesity statistics more than doubling in children over the past 30 years.[15,16] In 2012, 16.9% of 2-19 year olds were considered obese, with obesity defined as body mass index (BMI) at or above the 95th percentile of the sex-specific BMI-for-age-growth charts.[15,17] With the increase in body habitus, problems of appropriate intramuscular medication delivery via standard needle lengths to these children is a great concern. The EpiPen and EpiPen Jr cartridge-based epinephrine auto-injector devices approved in the U.S. have an activated needle length of 1.6 centimeters (cm) and 1.3cm, respectively.[18,19] For children 3-18 years old, the Centers for Disease Control and Prevention (CDC) recommends using a 2.54cm needle for intramuscular injection into the vastus lateralis muscle. A 2.54-3.81cm needle is recommended for those whose weight falls between 69-118 kilograms (kg).[20]

In 2009, a study including 256 children 1-12 years of age found that BMI significantly influenced distance from skin to vastus lateralis muscle when measured by ultrasound (US). The skin to muscle distance of 12% of the children who weighed less than 30kg and 30% of children who weighed greater than 30kg exceeded auto-injector needle length. Epinephrine auto-injector needle lengths are potentially too short to reach the muscle compartment for most pediatric patients.[21] A graphical reference of BMI versus distance to the muscle compartment that physicians can use to select appropriate needle lengths for intramuscular injections is needed. The objective of this study was to determine needle-length requirements for intramuscular injections of medication or vaccines by using US to measure the distance from skin to muscle compartment of the thigh in pediatric patients of various weight and BMI. We hypothesized that distance from skin to muscle would correlate with BMI.

Population Health Research Capsule

What do we already know about this issue?
Needle lengths used for pediatric intramuscular injections are potentially too short to reach the muscle compartment in patients with elevated body mass index.

What was the research question?
What needle lengths are required for successful intramuscular injection in a sample of 200 pediatric patients?

What was the major finding of the study?
A small percentage of patients fell outside EpiPen and CDC needle lengths for intramuscular injection.

How does this improve population health?
Assessing skin to intramuscular distance is needed in specific pediatric populations to determine needle length and improve intramuscular medication delivery.

METHODS

This was a prospective study that used convenience sampling of 200 pediatric patients less than 18 years of age who presented to the emergency department (ED). The study was conducted between October 2013 and August 2014. The institutional review board at the authors' institution approved this research project and the research was conducted according to federal research guidelines.

We excluded patients if a chronic illness was present, which could have impeded normal growth or development. Other exclusion criteria included the presence of cystic fibrosis, congenital heart disease, autoimmune disorders, failure to thrive and medical resuscitation. Pediatric patients were approached to participate in the study in the ED. If they were interested in participating the study, informed consent was obtained from the child's guardian and assent was obtained from patients older than six years of age.

An US certified pediatric emergency physician performed the ultrasounds. Depth measurement was taken at the midpoint between the superior aspects of the anterior superior iliac spine to the superior aspect of the patella, on the lateral aspect of the right thigh. Minimal but sufficient pressure on the probe was applied to get adequate US imaging. Sagittal images were obtained for measurements from the skin to the fascial layer and mid-depth of the muscle mass. Study staff recorded the measurement. Once the US measurements were made, a still US picture was obtained. The whole measurement procedure took five minutes to perform.

Patient's age (months), height (cm) and weight (kg) were recorded to calculate each patient's BMI. These measurements are done routinely by triage staff while the patient is in the waiting room, but if they were not done prior to patient enrollment in the study, study investigators obtained them. Other patient information collected included gender and ethnicity, which was used to determine if other factors may be good predictors for increased depth to the muscle compartment. We executed a distribution graph for BMI versus skin to muscle and bone compartment depth, measured in centimeters. Data were collected using paper forms and then uploaded into an electronic data file using Microsoft Excel (Redmond, WA). We performed Pearson correlation coefficient and linear regression in SAS version 9.4 (Cary, NC) to determine significance.

RESULTS

Gender distribution was proportionate, with 99/200 male subjects (49.5%) and 101/200 female subjects (50.5%). Caucasian, African-American, and Hispanic subjects represented 55%, 44.5% and 0.5% of the subject population, respectively.

The mean BMI for all subjects combined averaged to 19 with standard deviation of +/- 5.3. The mean depth to muscle was 0.72cm. Regression analysis determined that BMI significantly predicted the distance to muscle and that subjects with higher BMI tended to have a greater distance to muscle, with an R^2 value, which indicates how well the linear model fits the data, of 0.3515 and a p-value of <0.001 or Pearson correlation coefficient of 0.6 (Figure 1). Additionally, regression analysis determined that BMI significantly predicted the distance to bone and that subjects with higher BMI tended to have greater distance to bone, with an R^2 value of 0.6429 and a p-value of <0.001 or a Pearson correlation coefficient of 0.8. The mean depth to bone was 3.84cm (Figure 2). When analyzed by gender and ethnicity, female and African-American patients had higher trends in BMI and distance to muscle and distance to bone compared to white males. The Hispanic population included less than five patients (Figures 1-2).

The relationship between distance to muscle and distance to bone was compared to EpiPen and CDC-recommended needle lengths to determine how many patients could have potentially received an inadequate intramuscular injection. Out of 110 patients who fell within the 7.5kg-25kg EpiPen Jr weight range, 0.9% (1/110) had a distance to muscle and distance to bone that was not in range with the recommended 1.3cm needle length (Figure 3A). Out of the 77 patients who fell within the ≥25kg EpiPen adult weight range, 5% (4/77) had a distance to muscle and distance to bone that was not in range with the recommended 1.6cm needle length (Figure 3B). Out of the 169 patients who fell within the CDC-recommended needle-length weight category of

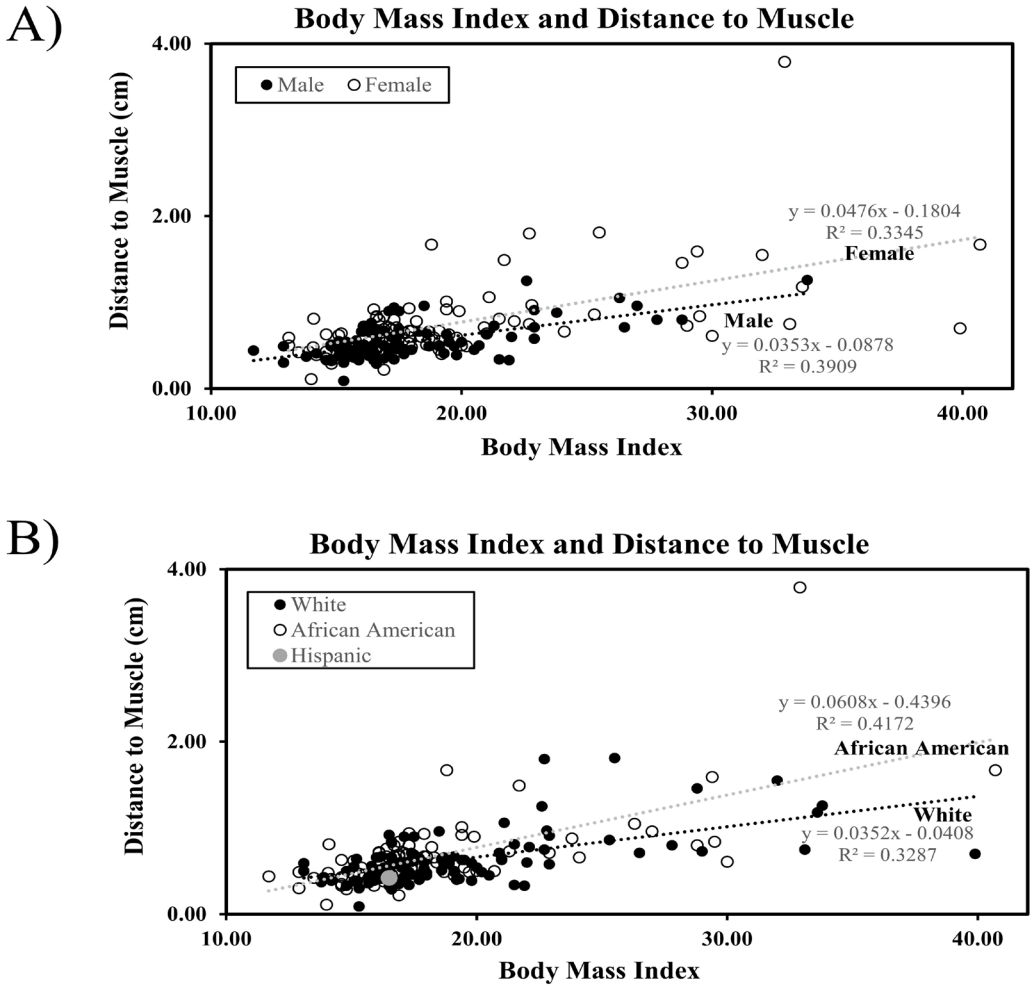

Figure 1. Body mass index predicts distance to muscle. Regression analysis was performed from ultrasound measurements from skin to muscle and analyzed by gender (A) and ethnicity (B). Best fit regression lines are represented for gender and ethnicity. The equation of the line for total patients was Y=0.046x-0.2142, R^2=0.3515.

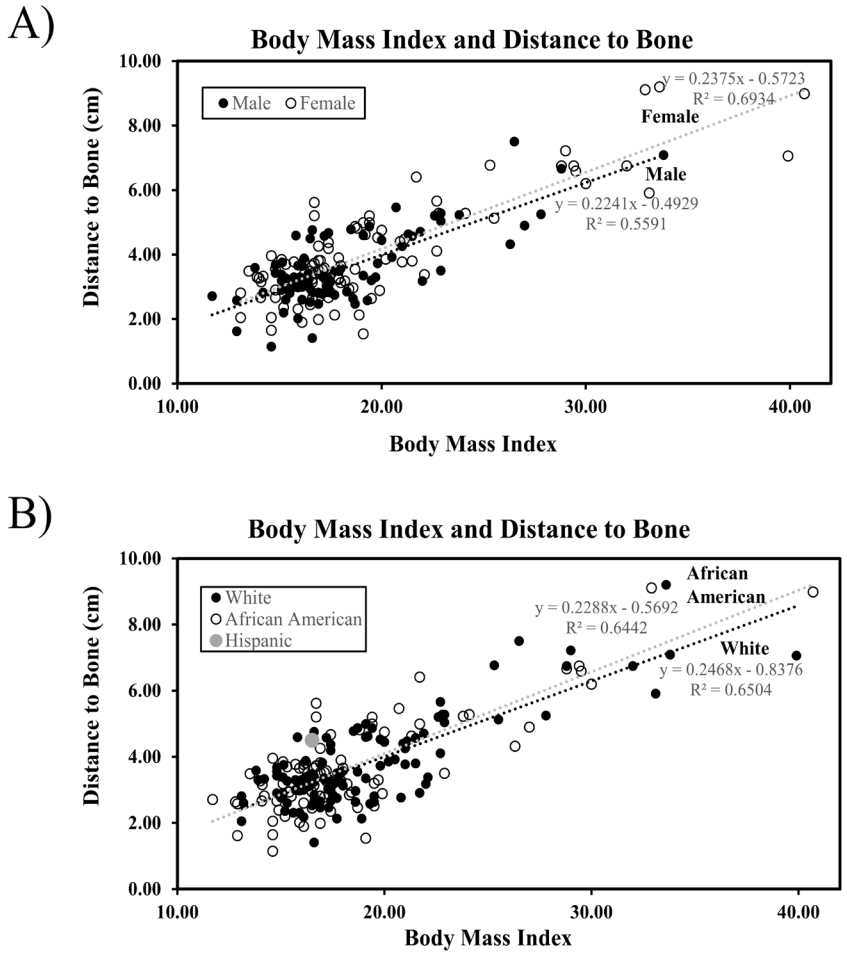

Figure 2. Body mass index predicts distance to bone. Regression analysis was performed from ultrasound measurements from skin to bone and analyzed by gender (A) and ethnicity (B). Best fit regression lines are represented for gender and ethnicity. The equation of the line for total patients was Y=0.2356x-0.664, R^2=0.6429.

<69kg, 11% (19/169) had a distance to muscle and distance to bone that was not in range with the recommended 2.54cm needle length (Figure 4A). None of the 15 patients who fell within the CDC-recommended needle-length weight category of >69kg had a distance to muscle and distance to bone that was out of needle-length range (Figure 4B).

DISCUSSION

Intramuscular injection of epinephrine during anaphylaxis allows medication to rapidly alleviate anaphylactic symptoms such as hypotension, bronchial airway constriction, and decreased cardiac output.[1,2,12,13,22] Auto-injector needles should be adequate in length to reach between the subcutaneous adipose tissue and vastus lateralis muscle for blood levels of epinephrine to reach therapeutic levels approximately eight minutes after injection.[14,2] Obesity continues to burden the pediatric population, potentially preventing appropriate intramuscular medication delivery when standard auto-injector needle lengths are used.[3,15,16]

In the current study, US measurements were performed to determine distance from skin to muscle and skin to bone in 200 subjects ranging from 0.13 to 17 years in age. BMI was determined from subject's age (months), height (cm) and weight (kg). Subjects with higher BMI tended to have greater distance to muscle and bone. When distance to muscle and distance to bone was compared to weight-dependent needle recommendations, 5% of patients within the EpiPen adult weight category and 11% of patients within the CDC weight category could have potentially used a needle inadequate in length (Figures 3-4).

Variability of distance between skin and muscle exists within the literature. In 2008, a study measured thickness of subcutaneous fat tissue and muscle in 100 children aged two months to six years using magnetic resonance imaging (MRI) and computed tomography (CT). Average depth from skin to muscle was ~1.2cm. However, neither MRI nor CT apply pressure to the skin during measurement, which may not accurately represent auto-injector instructions for EpiPen use.

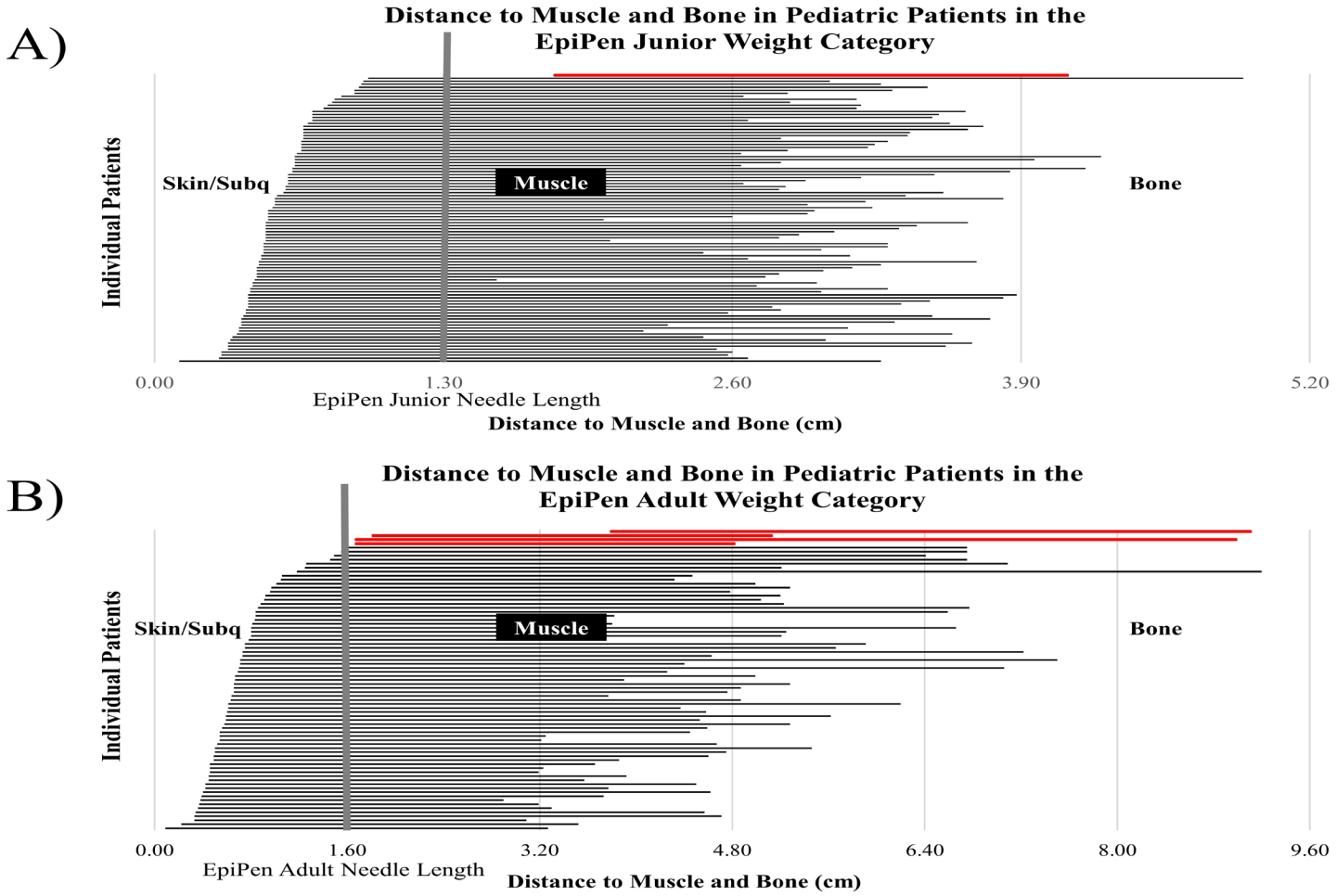

Figure 3. Distance to muscle and distance to bone of pediatric patients in the EpiPen Jr (A) and EpiPen adult (B) weight categories. Left end of horizontal bars represent the beginning of the vastus lateralis muscle. Right end of horizontal bars represent beginning of greater tuberosity of femur. Vertical bar represents 1.3cm (panel A) and 1.6cm (panel B) needle distance of EpiPen Jr and EpiPen adult auto-injectors, respectively. Horizontal red bars represent patients with distance from skin to muscle larger than the recommended needle length.

Additionally, the study population's weight and age distribution may not have represented the general population.[23] In the current study, US measurements were obtained while the child was in a supine position with legs in extension. Since procedural EpiPen instructions recommend the user lie down with their legs slightly elevated, protocols were similar but not exact, which may have influenced needle-length estimations.[18]

In 2009, Stecher et al. used US to measure the depth from the skin to vastus lateralis muscle in 256 subjects between 1-12 years of age and reported that BMI and age were good predictors for increased depth to muscle compartment.[21] Additionally, when depth from skin to muscle was measured in 120 adults 18-55 years old, 31% were at risk for potential undersized auto-injector needle length. Potential inadequate needle length correlated with higher BMI.[24]

It is important to note that many other medications administered in the pediatric healthcare setting require intramuscular injection to be effective. Vaccines in the outpatient setting and procedural sedation agents particularly in the ED setting are two categories of medications in which intramuscular administration is of utmost importance. In 2002, Cook et al. used US to determine needle length for intramuscular vaccinations in two-, four-, six-, and 18-month-old patients. Although needle length aligned with the World Health Organization and the National Health and Medical Research Council, it was dependent on the injecting angle technique (90 degrees versus 45 degrees).[25] In 1997, Groswasser et al. used a high-frequency, real-time ultrasonograph to measure subcutaneous tissue and muscular layer thickness in children at the ages when common vaccinations are given. The authors reported needle length could be determined by ultrasonographic measurements and

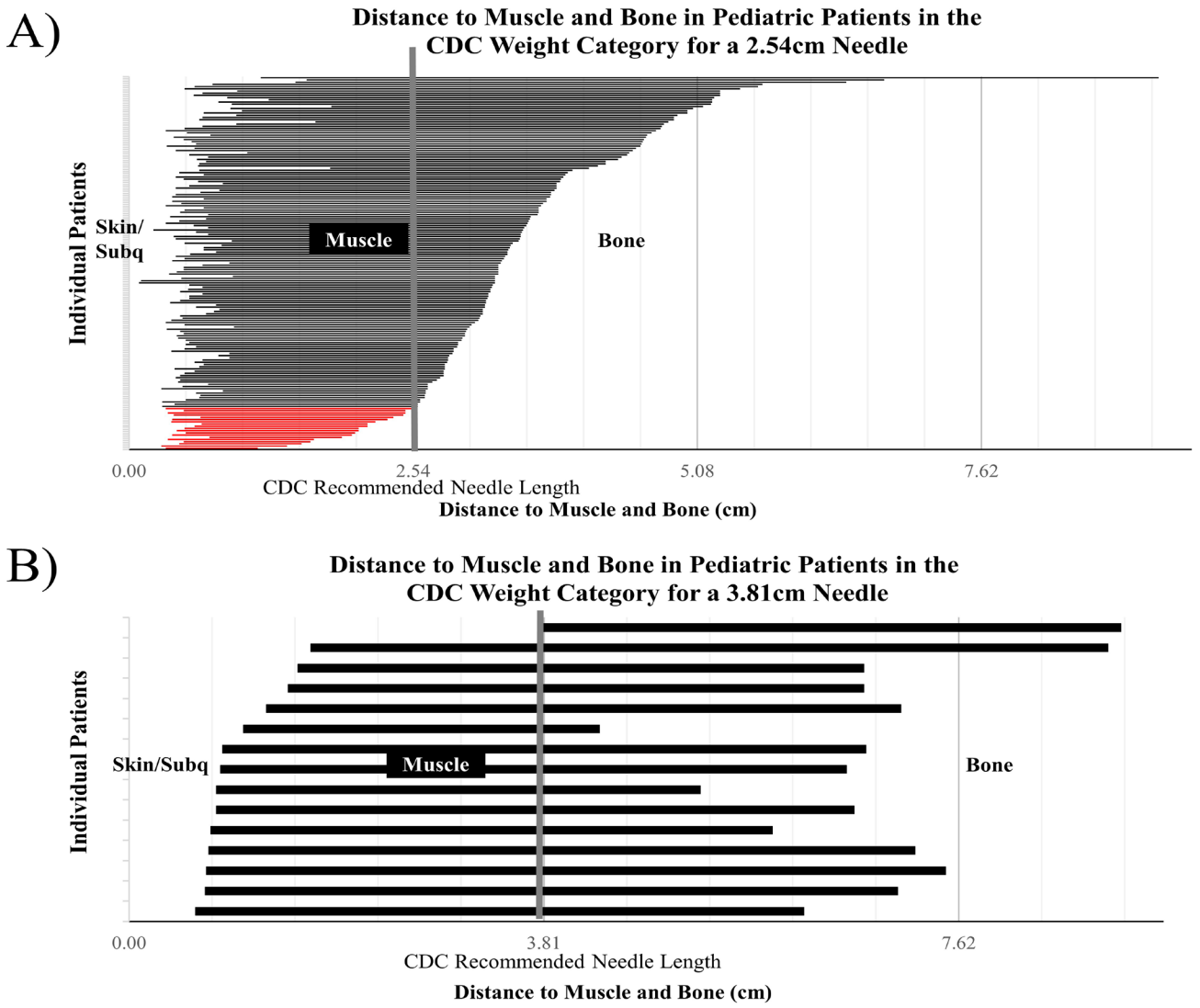

Figure 4. Distance to muscle and distance to bone of pediatric patients in the 2.54cm CDC needle-length range (A) and 3.81cm CDC needle-length range (B) weight categories. Left end of horizontal bars represent the beginning of the vastus lateralis muscle. Right end of horizontal bars represent beginning of greater tuberosity of femur. Vertical bar represents 2.54cm (panel A) and 3.81cm (panel B) CDC-recommended needle length. Horizontal red bars represent patients with distance from skin to muscle outside the recommended needle length.
CDC, Centers for Disease Control and Prevention.

that successful injection depended on injection technique.[26] Ipp et al. compared adverse reactions in children vaccinated with intramuscular needle lengths of either 1.6cm or 2.5cm. Redness and swelling was more common in children vaccinated with the 1.6cm needle.[27] Additionally, in 2006 a randomized controlled trial examined reactions in infants vaccinated using either 1.6cm or 2.5cm length needles. Infants vaccinated with the longer needle had significantly less severe local reactions.[28] Data from this and other studies suggest there are specific pediatric populations where assessing for skin to intramuscular distance needs to be performed to identify adequate needle lengths for administration.[21] Bedside ultrasonography has a role in assessing for this distance until more data are available to create more generalizable regression models for needle-length requirements.

Clinicians and auto-injector manufactures should continue to evaluate contributing factors such as age, demographics, and BMI to work toward use of the safest and most effective needle length. Currently, nurses at our institution select intramuscular needle length based on recommendations and body habitus. The authors advocate the use of US, if cost and urgency of the procedure permits, and development of a pediatric guide that determines appropriate needle-length sizes for BMI. Specific needle-length guidelines have the potential to improve intramuscular injections not only for auto-injectors but for other pediatric vaccinations and emergency procedures requiring effective intramuscular medication delivery.

LIMITATIONS

The average BMI for all subjects combined was 19 with standard deviation of +/- 5.3, suggesting that the majority of subjects fell into the normal or healthy weight category and the population may not have been representative of obesity prevalence (Figure 1-2).[17] Future studies with increased sample size would likely increase the number of subjects with a BMI that falls into the overweight or obese category and increase R^2 values to obtain a closer linear model fit. Although there was a linear correlation between skin to muscle and bone depth with BMI, with more data a non-linear curve may be more apparent.

A limitation of the current study was that intramuscular injections were not performed to record needle length used and success of the injection. Additionally, convenience sampling may not accurately represent the whole population. However, linear regression analysis determined that BMI significantly correlated with US measurement of depth of skin to muscle and skin to bone. Generation of a graph with representative demographics would be useful in determining appropriate size needles required for patients of variable BMI to ensure intramuscular administration of medications or vaccines.

CONCLUSION

Distance from skin to muscle compartment of the thigh was measured by ultrasound in 200 pediatric patients of various weight and BMI who presented to the ED. Linear regression analysis determined that BMI significantly correlated with ultrasound measurement of depth of skin to muscle and skin to bone. When distance to muscle and distance to bone was compared to weight-dependent needle recommendations, 5% of patients within the EpiPen adult weight category and 11% of patients within the CDC weight category could have potentially used a needle inadequate in length.

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Impact of Clinical Decision Support on Radiography for Acute Ankle Injuries: A Randomized Trial

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Introduction: While only 15-20% of patients with foot and ankle injuries presenting to urgent care centers have clinically significant fractures, most undergo radiography. We examined the impact of electronic point-of-care clinical decision support (CDS) on adherence to the Ottawa Ankle Rules (OAR), as well as use and yield of foot and ankle radiographs in patients with acute ankle injury.

Methods: We obtained institutional review board approval for this randomized controlled study performed April 18, 2012—December 15, 2013. All ordering providers credentialed at an urgent care affiliated with a quaternary care academic hospital were randomized to either receive or not receive CDS, based on the OAR and integrated into the physician order-entry system, with feedback at the time of imaging order. If the patient met OAR low-risk criteria, providers were advised against imaging and could either cancel the order or ignore the alert. We identified patients with foot and ankle complaints via ICD-9 billing codes and electronic health records and radiology reports reviewed for those who were eligible. Chi-square was used to compare adherence to the OAR (primary outcome), radiography utilization rate and radiography yield of foot and ankle imaging (secondary outcomes) between the intervention and control groups.

Results: Of 14,642 patients seen at urgent care during the study period, 613 (4.2%, representing 632 visits) presented with acute ankle injury and were eligible for application of the OAR; 374 (59.2%) of these were seen by control-group providers. In the intervention group, CDS adherence was higher for both ankle (239/258=92.6% vs. 231/374=61.8%, p=0.02) and foot radiography (209/258=81.0% vs. 238/374=63.6%; p<0.01). However, ankle radiography use was higher in the intervention group (166/258=64.3% vs. 183/374=48.9%; p<0.01), while foot radiography use (141/258=54.6% vs. 202/374=54.0%; p=0.95) was not. Radiography yield was also higher in the intervention group (26/307=8.5% vs. 18/385=4.7%; p=0.04).

Conclusion: Clinical decision support, previously demonstrated to improve guideline adherence for high-cost imaging, can also improve guideline adherence for radiography – as demonstrated by increased OAR adherence and increased imaging yield. [West J Emerg Med. 2017;18(3)487-495.]

INTRODUCTION

Patients with foot and ankle pain often present to emergency departments (ED) and urgent care centers, accounting for nearly 2.8 million visits in 2010 (7.6% of all injury visits).[1] Despite this frequency, clinically significant fractures are only found in 15-20% of cases.[2] Validated, high quality, evidence-based guidelines for imaging patients with suspected ankle fracture (the Ottawa Ankle Rules [OAR]),[3,4,2] have been available for almost 20 years. However, their widespread adoption into practice has been suboptimal. In 2001, 96% of United States (U.S.) physicians reported familiarity with the rules; however, only 31% reported using them "always" or "most of the time."[5] In the same study, Canadian physicians reported using the rules 89% of the time. However, despite this, an analysis in Ontario showed that ED foot and ankle radiography still increased 1% annually from 2001-2007.[6]

The federal Health Information Technology and Economic Health (HITECH) Act of 2009 aims to improve quality of healthcare and reduce waste through meaningful use of health IT, including a major focus on clinical decision support (CDS).[7,8] Imaging CDS and CDS-enabled interventions have been reported to improve adherence to evidence[9,10,11] and to reduce unnecessary imaging and increase its yield.[12–16,17,18] Imaging CDS is most effective when based on high-quality evidence and embedded in provider workflow.[19] However, most prior reports have focused on impact of CDS on "high cost" imaging (e.g., computed tomography, magnetic resonance imaging) with sparse use of a randomized controlled study design.[20] Despite the emphasis on high-cost imaging, low-cost imaging examinations are the most common diagnostic imaging examinations performed in the U.S. and may be overused[21,22], expose the patient to unnecessary ionizing radiation,[23,24], may result in longer length of stay in the ED,[25,26] and result in incidental or ambiguous findings that lead to additional high-cost imaging.[27] However, it remains unclear whether CDS will have a similar impact in low-cost as in high-cost imaging.

Thus, the purpose of this study was to assess the impact of CDS on radiography for acute ankle and foot injuries. More specifically, we evaluated the impact of a CDS tool on physician-documented adherence to the OAR in the evaluation of acute ankle injury in the urgent care setting. We chose the urgent care setting, as such centers are typically designed to handle relatively low acuity injuries (e.g., acute ankle and foot injuries). We hypothesized that such CDS, integrated into provider workflow, would increase adherence to the OAR.

Population Health Research Capsule

What do we already know about this issue?
Clinical decision support (CDS) has been effective for improving the appropriateness of high-cost imaging, but its effect on low-cost imaging remains unclear.

What was the research question?
What was the impact of randomized CDS on adherence to the Ottawa Ankle Rules (OAR)?

What was the major finding of the study?
While adherence to the OAR increased with CDS, use of ankle radiographs was also higher in the CDS group.

How does this improve population health?
Evidence-based CDS can be successfully implemented for both low- and high-cost imaging in the ED.

METHODS

Study Setting and Subjects

We obtained institutional review board approval for this Health Insurance Portability and Accountability Act-compliant randomized controlled study, performed between April 18, 2012, and December 15, 2013, at an urgent care center affiliated with a quaternary care, academic hospital. All providers (medical doctors and physician assistants) credentialed at the urgent care center, stratified by title, were randomized to either receive the CDS intervention at the time of ordering a foot or ankle radiograph (intervention group) or not (control group). Providers who began working at the urgent care center after the randomization period were excluded from the study.

Data Collection

Although providers were prospectively randomized, we collected data retrospectively. Data were captured concurrently with patient care, including in the CDS system for providers randomized to receive it. Therefore, we waited until all study data accrued and then collected it. Using International Classification of Diseases, Ninth Revision (ICD-9) codes, we queried the billing database for all unique patients presenting to the urgent care center during the study period with a discharge diagnosis code for a foot or ankle complaint (719.47, 824.x, 825.x, 826.x, 829.x, 837.0, 838.0, 845.x, 924.2x, and 928.2x; see Supplemental eTable 1). A subsequent review of each patient's electronic health record (EHR) was performed using an explicit chart review data collection form. Data collected included patient age, chief complaint, mechanism of injury, presence of any of the exclusion criteria from the OAR (injury greater than 10 days

DECISION SUPPORT **1A. Initial Screen**

Is this x-ray being requested to evaluate an acute ankle injury?

- ○ **Yes - Injury within 10 days**
- ○ **No**

DECISION SUPPORT **1B. Ankle radiography screen**

With reference to the diagram below, please answer the following questions.

Does the patient have pain near the malleoli AND one or more of the following:

- ☐ **Bony tenderness on the posterior medial malleolus?**
- ☐ **Bony tenderness on the posterior lateral malleolus?**
- ☐ **Unable to bear weight BOTH immediately and in the ED for 4 steps (unable to transfer weight onto each lower limb twice, regardless of limping)?**

☐ **None of the Above**

DECISION SUPPORT **1C. Foot radiography screen**

With reference to the diagram below, please answer the following questions.

Does the patient have pain in the midfoot zone AND one or more of the following:

- ☐ **Bony tenderness at the navicular?**
- ☐ **Bony tenderness at the base of the 5th metatarsal?**
- ☐ **Unable to bear weight BOTH immediately and in the ED for 4 steps (unable to transfer weight onto each lower limb twice, regardless of limping)?**

☐ **None of the Above**

1D. Ottawa tenderness sites

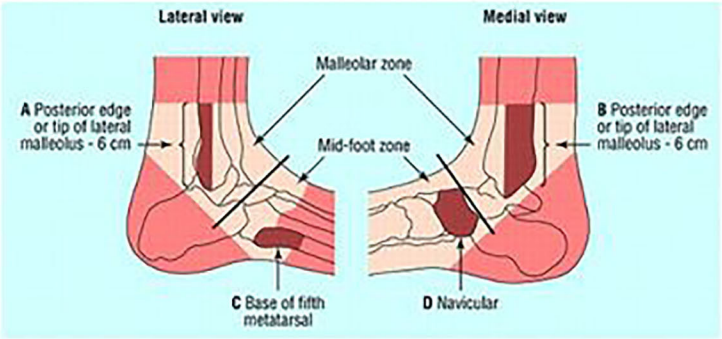

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Figure 1A-E. Clinical decision support screens for the Ottawa ankle rule integrated in the computerized physician order-entry system. *ED,* emergency department

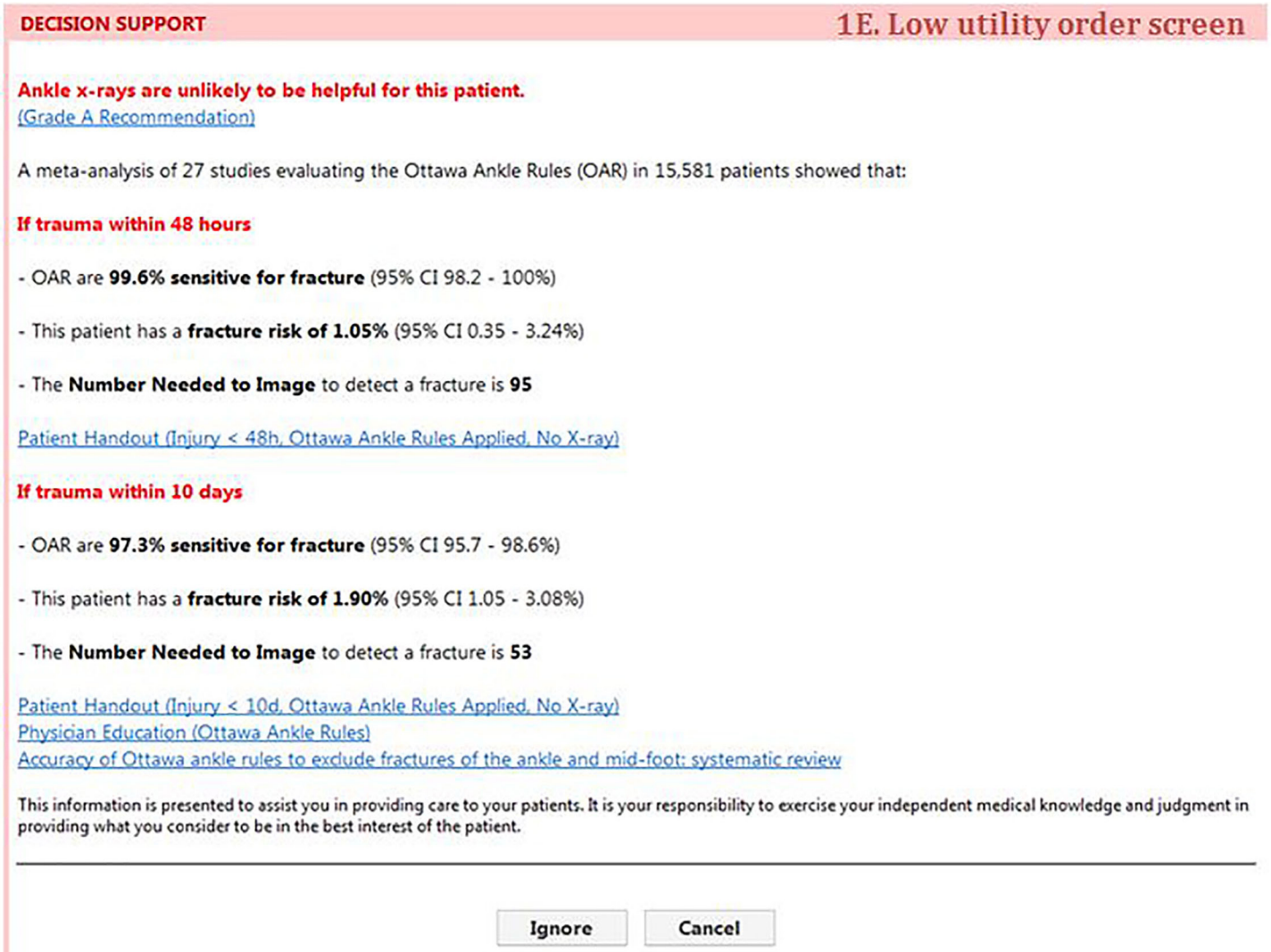

Figure 1A-E. Continued.

prior to presentation, altered level of consciousness, multiple trauma, pregnancy, penetrating or open wounds, patients with isolated superficial skin complaints, and patients < 18 years old), tenderness over the malleoli or midfoot, and radiography utilization (eTable 2). We reviewed radiology reports to determine whether a fracture was noted and, if so, what type. Patients with chief complaints not pertaining to the foot or ankle were excluded. After chart review, patients with one or more OAR exclusion criterion were removed from the study cohort. We included only the first patient visit for each trauma episode; patient visits for re-assessment of the same ankle or foot injury were excluded.

Intervention

Providers were clustered into two subsets based on their titles (physician [MD] or physician assistant [PA]). In April 2012, providers in each subset were randomly assigned to the intervention or control groups using a random number generator function. Intervention group urgent care providers were exposed to CDS based on the OAR integrated into the computerized physician order entry (CPOE) system (Percipio; Medicalis, San Francisco CA). The CDS intervention consisted of four successive screens to capture data to determine the utility of the study according to the OAR (Figure 1A-D), and one educational screen (Figure 1E). If the utility of the study was low, the provider was exposed to the educational screen informing him/her of such, and s/he could either cancel or proceed with the imaging order.

To determine whether any differences observed in adherence were simply a result of "gaming" the system, which we defined as inaccurate data entry into the CPOE system to avoid potentially onerous CDS interactions, one investigator (IKI) performed manual chart reviews of 158 randomly sampled charts in the CDS group, based on power calculation with alpha of 0.05,

Table 1. Provider characteristics by group and total in study of efficacy of clinical decision support, based on the Ottawa Ankle Rules, to curb unnecessary foot and ankle radiography.

	CDS		Control		Overall	
	N	%	N	%	N	%
Initial randomization						
MD	23		24		47	
Physician assistant	9		10		19	
Total randomized	32		34		66	100.0%
Providers who saw patients*						
MD	4		12		16	
Physician assistant	6		4		10	
Total at end of study	10	38.5%	16	61.5%	26	100.0%
Patient distribution						
MD	162		265		427	
Physician assistant	96		109		205	
Total patients seen	258	40.8%	374	59.2%	632	100.0%
Provider characteristics						
Average years of experience	13		16			
MD	19		18.5			
PA	10		9.3			
Gender (% male)		50%		56%		
MD		75%		75%		
PA		43%		0%		

CDS, clinical decision support.
*Providers randomized to each group who actually evaluated enrolled patients during the study.

power of 0.8, and confidence interval of 15%. We calculated the concordance and discordance rates between data in the physician note and data entered into the order entry screen (electronic orders consisting of the data entered in CPOE and CDS). Visits are concordant when the data in the visit note and the CPOE and/or CDS system matched (based on adherence to the evidence-based guideline). They are discordant when data are conflicting. If data entered in the CPOE and/or CDS system did not have corresponding entry in the physician note, we considered the visit to have incomplete documentation in the physician note rather than as discordant.

Outcome Measures

The primary outcome measure was adherence to the OAR, defined as the number of eligible patients with acute ankle and foot injuries whose workup was consistent with the OAR, whether or not they were imaged. We calculated the adherence rate for each group.

Secondary outcome measures were radiography utilization and fracture rates (radiography yield) among patients with acute ankle injuries. Ankle fracture, foot fracture, and clinically significant fracture rates were calculated. We defined clinically significant fractures as those with fracture displacement greater than 3 $mm^{2–4}$. Radiography yield was calculated as the number of foot (or ankle) radiographs that detected a clinically significant fracture divided by the total number of foot (or ankle) radiographs in each group. We calculated radiography utilization rate as the number of foot (or ankle) radiographs performed divided by the total number of patient visits for acute ankle injury in each group.

Power calculation based on the rate of adherence to OAR estimated that a sample size of 334 patient visits (167 in each arm) was needed to detect a relative difference of 15% between the intervention and control groups (baseline adherence of 0.5[10,14], alpha = .05, power = 0.8).

Statistical Analysis

We descriptively analyzed provider demographics. Chi-square was used to compare adherence to the OAR, radiography utilization rate and radiography yield of foot and ankle imaging between the intervention and control groups. We considered a two-tailed p-value of <0.05 statistically significant. All analyses were conducted using JMP Pro 11.0 (SAS Institute, Cary, NC).

RESULTS

Provider and Patient Characteristics

A total of 66 providers were randomized to either the

Table 2. Adherence to Ottawa Ankle Rules (OAR) and radiography use by group.

Adherence	CDS intervention group			Control group			
	Workups consistent with OAR	N	Adherence	Workups consistent with OAR	N	Adherence	p-value
Ankle	239	258	92.6%	231	374	61.8%	0.0155*
Foot	209	258	81.0%	238	374	63.6%	0.0001*
Use	CDS intervention group			Control group			
	No. exams performed	Patients seen	Use	No. exams performed	Patients seen	Use	p-value
Ankle only	101	258	39.1%	124	374	33.2%	0.1375
Foot only	76	258	29.5%	143	374	38.2%	0.0194
Ankle and Foot	65	258	25.2%	59	374	15.8%	0.0039
No radiography	17	258	6.6%	47	374	12.6%	0.0134
Total Ankle	166	258	64.3%	183	374	48.9%	0.0002*
Total Foot	141	258	54.6%	202	374	54.0%	0.95

CDS, clinical decision support; OAR, Ottawa Ankle Rules.
*Values are statistically significant.

intervention (n=32) or control (n=34) groups; 26 of them (10 intervention, 16 control) saw eligible patients during the study period (Table 1). There were 22,982 total visits (14,642 unique patients) to the urgent care center during the 20-month study period. Of these, 988 patients were identified by the ICD-9 codes pertaining to acute ankle and foot injuries, representing 6.7% of all patients seen. We excluded 356 visits (1.5%) identified by ICD-9 codes as foot and ankle related: 177 visits were not associated with an ankle injury, 7 were multi-trauma, 26 were isolated injuries to the skin, 13 were referred with radiographs, 81 were injuries that happened more than 10 days previously, 44 were reassessment of the same injury, and 8 were associated with pregnant patients. After applying exclusion criteria, 613 patients (4.2% of all patients) representing 632 patient visits (2.7% of all patient visits) were clinically eligible for application of the OAR, of which 258 patient visits (40.8% of eligible visits) were seen by a provider in the intervention group.

Discordance between EHR and order requisition was 0% in the control and 1.3% in the intervention group while concordance was 48% and 10.7%, respectively. In the remaining cases, EHR documentation of discrete clinical information entered in CPOE was incomplete to unambiguously assess adherence to OAR.

Adherence to Evidence-based Guidelines

Rate of adherence to the OAR was higher for ankle radiography (92.6% vs. 61.8%, p=0.015) and foot radiography (81.0% vs. 63.6%, p<0.001) in the intervention group as compared to the control group (Table 2).

Radiography Use

Ankle radiography use was higher in the intervention group (64.3% vs. 48.9%, p<0.001), but foot radiography use (54.6% vs. 54.0%, p=0.950) was not significantly different (Table 3). Ankle and foot radiography was performed in 25.2% of patient visits in the intervention group compared to 15.8% in the controls (p<0.01. Only 6.6% of patient visits in the intervention group had no radiography, compared to 12.6% in the control group (p=0.0136)

Fracture Prevalence

Prevalence of clinically significant fractures in the study was 8.7% (44/632), 2.1-fold higher in the intervention group (10.1% vs. 4.8%, p<0.02). Significant ankle fractures were 1.9-fold higher in the intervention group (4.7% vs. 2.4%, p=0.122) while significant foot fractures were 2.3-fold higher in the intervention

Table 3. Radiography combinations by group.

	Clinical decision support intervention group			Control group			
	No. exams performed	Patients seen	%	No. of exams performed	Patients seen	%	p-value
Ankle only	101	258	39.1%	124	374	33.2%	0.1375
Foot only	76	258	29.5%	143	374	38.2%	0.0194
Ankle and foot	65	258	25.2%	59	374	15.8%	0.0039
None	17	258	6.6%	47	374	12.6%	0.0134

Table 4. Radiography yield and fractures per patient visit of ankle and foot radiography by group.

	CDS intervention group					Control						
	Fractures	Total exams	Yield	# Patient visits	Fractures per Patient visit	Fractures	Total exams	Yield	# Patient visits	Fractures per patient visit	Yield p-values	Patient visit p-values
Clinically significant fractures	26	307	8.7%	258	10.1%	18	385	4.7%	374	4.8%	0.0421	0.0165
Ankle	12	166	7.2%	258	4.7%	9	183	4.9%	374	2.4%	0.364	0.122
Foot	14	141	9.9%	258	5.4%	9	202	4.5%	374	2.4%	0.0461	0.0463
Avulsion fractures	23	307	7.5%	258	8.9%	17	385	4.4%	374	4.5%	0.0849	0.0266
Ankle	15	166	9.0%	258	5.8%	12	183	6.6%	374	3.2%	0.389	0.111
Foot	8	141	5.7%	258	3.1%	5	202	2.5%	374	1.3%	0.127	0.125
All fractures	49	307	16.0%	258	19.0%	35	385	9.1%	374	9.4%	0.0060	0.0004
Ankle	27	166	16.2%	258	10.5%	21	183	11.5%	374	5.6%	0.195	0.0237
Foot	22	141	15.6%	258	8.5%	14	202	6.9%	374	3.7%	0.0099	0.0108

CDS, clinical decision support.

group (5.4% vs. 2.4%, p<0.05).

Prevalence of all fractures in the study was 13.3% (84/632), twofold higher in the intervention group (19.0% vs. 9.4%, p<0.01). A total of 48 ankle fractures were identified in the cohort (7.59%). The prevalence rate of all ankle fractures was 1.9-fold higher in the intervention group (10.5% vs. 5.6%, p<0.02). A total of 36 foot fractures (5.70%) were identified in the cohort. The prevalence rate of all foot fractures was 2.3-fold higher in the intervention group (8.5% vs. 3.7%, p<0.01; Table 4).

Radiography Yield

For clinically significant fractures, the radiography yield was 1.8-fold higher in the intervention group (overall 26/307=8.5% vs. 18/385=4.7%, p=0.0421). Foot radiography yield was 2.2-fold higher (14/141=9.9% vs. 9/202=4.5%, p=0.0461). Ankle radiography yield was 1.5-fold higher but did not reach significance (12/166=7.2% vs. 9/183=4.9%, p=0.354).

For all fractures, the radiography yield was 1.8-fold higher in the intervention group (overall 49/307=16.0% vs. 35/385=9.1%, p=0.0060). Foot radiography yield was 2.3-fold higher (22/141=15.6% vs. 14/202=6.9%, p=0.0099). Ankle radiography yield was 1.4-fold higher but did not reach significance (27/166=16.2% vs. 21/183=11.5%, p=0.195; Table 4).

DISCUSSION

Foot and ankle radiography represent low-cost, high-volume tests that – when used inappropriately – create waste, unnecessary radiation exposure, and likely increased lengths of stay in the ED/urgent care center.[4] Similar to concerns regarding inappropriate use of high-cost imaging, if radiography imaging results are ambiguous or if incidental findings are discovered, potentially unnecessary downstream diagnostic and therapeutic procedures (with their associated costs and risks) may result.

We found that the implementation of a CDS tool at an urgent care center resulted in a significant increase in documented adherence to OAR, improving adherence to 93% for ankle and 81% for foot radiography for acute ankle injuries. Although we did not quantitatively compare the effort required to implement and sustain OAR deployment, associated data capture, and unambiguous calculation of adherence to OAR when using CDS compared to paper-based interventions, the relative ease of performing our experiment may encourage implementation of other decision rules using CDS infrastructure. Moreover, prior reports highlight the need for chart review when using paper forms to complete data extraction from the patient's chart as nearly 23% of data capture forms were incomplete.[4,28] When using CDS, providers were required to complete entry of required data elements to place orders for imaging. Quality improvement strategies using CDS may thus provide near real-time measure of provider's adoption of evidence without the need for time-intensive retrospective chart review.

We also found that implementation of CDS reduced unnecessary foot radiography. Although the prevalence of clinically significant foot fractures was 2.3-fold higher in the CDS group, foot radiography use was similar to the control group, resulting in a higher foot radiography yield in the CDS group.

Our findings suggest overutilization of radiography even post CDS. Prior studies have reported approximately 16%

prevalence of significant fractures, and 4% prevalence of avulsion fractures in an ED cohort of patients with acute ankle injuries[4,28]. The intervention group in our urgent care had a 10% prevalence of significant fractures (with a nearly equal proportion of avulsion injuries), reflecting the diagnosis of less severe injuries compared to the ED. However, despite these less severe injuries, patients in our CDS group were imaged more frequently than prior reports. Stiell et al. reported that 20% of patients were spared imaging, with 10% having both ankle and foot imaging after implementation of OAR. Conversely, in our CDS cohort, only 6.6% of patients were spared imaging and 25% had both ankle and foot imaging (see eTable 4 for comparisons to previously published data). In our intervention group, 241 patients were imaged to identify 12 clinically significant ankle and another 14 clinically significant foot fractures. The overuse of imaging was even more dramatic in the control group: 327 patients were imaged to diagnose nine clinically significant ankle and another nine clinically significant foot fractures.

Our results suggest that despite the existence of a well-known, validated decision rule, use of radiography for the evaluation of acute ankle trauma in the urgent care setting is suboptimal. Moreover, we found that although implementation of CDS based on OAR resulted in modest improvement in use of radiography in these patients, radiography use was not optimized. This overuse of imaging may be due to a number of factors. Patients' preferences for imaging may have been a contributing factor when evidence-based guidelines were not followed; while patients are becoming aware of the risks of high cost high-radiation imaging, extremity radiographs carry a much less negative connotation. In addition, the OAR may have been suboptimally applied. Future studies would be needed to assess whether additional teaching, to both patients and providers, on use of OAR might reduce unnecessary utilization of radiography in patients with acute ankle injuries in urgent care centers.

The lower concordance between CDS-documented clinical attributes and the physician note found in the CDS group is expected. CDS required explicit documentation of relevant discrete clinical attributes, a capability absent in narrative documentation in the physician notes. This limitation of physician notes highlights the shortcomings of some current strategies for data collection (which rely on automated data extraction strategies from EHRs) as information may not be well documented and will thus often not be discoverable.

LIMITATIONS

There were a number of limitations to our study. We were unable to assess impact of OAR embedded in CDS on use and yield of radiography for evaluation of ankle fractures. The prevalence of significant fractures of ankle and foot differed significantly (near twofold) between control and intervention groups. Thus, our observed higher imaging yield of significant fractures, and higher use of radiography in the intervention group may simply reflect the higher prevalence of fractures in the intervention group. This in turn suggests that our randomization might not have been effective, with the intervention group consisting of providers evaluating patients with more significant fractures. An alternative explanation would be that a substantial number of significant fractures were missed in the control group, a very unlikely scenario, as 90% of the patients enrolled in the study were imaged, and we found no missed fractures re-presenting to the urgent care center. Secondly, we randomized on an intent-to-treat basis. As all clinicians were randomized based on being credentialed to practice at the urgent care, not every physician and PA may have worked there during the study period. Thirdly, our data was all obtained from a single site and thus may not be generalizable. Finally, we did not train our providers in interpreting OAR, which may have contributed to overuse of radiography.

CONCLUSION

We found that implementation of the Ottawa Ankle Rules embedded in clinical decision support significantly improved documented adherence to the OAR, and modestly improved use of foot radiography. The relative ease of implementation, data capture, and unambiguous measurement of provider adherence to OAR, without the need for time-consuming chart review, suggests CDS can efficiently deliver complex imaging-related decision rules embedded in provider workflow. Despite more than 20 years of experience with OAR,[4,28], we found radiography likely remains overused in patients with acute ankle injury in urgent care centers. Future studies would be needed to assess whether additional training about the Ottawa Ankle Rules for providers and patients, or more stringent CDS-enabled interventions, can help reduce unnecessary radiography in these patients.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. The authors disclosed none.

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Inferior Vena Cava Measurement with Ultrasound: What Is the Best View and Best Mode?

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Introduction: Intravascular volume status is an important clinical consideration in the management of the critically ill. Point-of-care ultrasonography (POCUS) has gained popularity as a non-invasive means of intravascular volume assessment via examination of the inferior vena cava (IVC). However, there are limited data comparing different acquisition techniques for IVC measurement by POCUS. The goal of this evaluation was to determine the reliability of three IVC acquisition techniques for volume assessment: sub-xiphoid transabdominal long axis (LA), transabdominal short axis (SA), and right lateral transabdominal coronal long axis (CLA) (aka "rescue view").

Methods: Volunteers were evaluated by three experienced emergency physician sonographers (EP). Gray scale (B-mode) and motion-mode (M-mode) diameters were measured and IVC collapsibility index (IVCCI) calculated for three anatomic views (LA, SA, CLA). For each IVC measurement, we calculated descriptive statistics, intra-class correlation coefficients (ICC), and two-way univariate analyses of variance.

Results: EPs evaluated 39 volunteers, yielding 351 total US measurements. Measurements of the three views had similar means (LA 1.9 ± 0.4cm; SA 1.9 ± 0.4cm; CLA 2.0 ± 0.5cm). For B-Mode, LA had the highest ICC (0.86, 95% CI [0.76-0.92]) while CLA had the poorest ICC (0.74, 95% CI [0.56-0.85]). ICCs for all M-mode IVCCI were low. Significant interaction effects between anatomical view and EP were observed for B-mode and M-mode measurements. Post-hoc analyses revealed difficulty in consistent view acquisition between EPs.

Conclusion: Inter-rater reliability of the IVC by EPs was highest for B-mode LA and poorest for all M-Mode IVC collapsibility indices (IVCCI). These results suggest that B-mode LA holds the most promise to deliver reliable measures of IVC diameter. Future studies may focus on validation in a clinical setting as well as comparison to a reference standard. [West J Emerg Med. 2017;18(3)496-501.]

INTRODUCTION

Intravenous fluid resuscitation is vital in the critically ill;[1] however, excessive fluid administration has been shown to contribute to mortality.[2,3] Rapid assessment of volume status may reduce over-resuscitation and improve outcomes. As it has been established that clinical examination alone is unreliable, more objective means of intravascular volume assessment have arisen.[4-6] Of those, point-of-care ultrasound (POCUS) of the inferior vena cava (IVC) has gained popularity as a noninvasive, easily obtainable, and rapid means of intravascular

volume assessment.[7-10] Various techniques for IVC assessment have emerged but vary in populations studied, anatomical approach, and sonographic methodology.[7,8,11-14] Currently there is no standardized approach for intravascular volume assessment by POCUS of the IVC, which may contribute to current controversies regarding its usefulness.[15,16] The objective of this study was to quantify the difference between three approaches to IVC diameter measurement.

Population Health Research Capsule

What do we already know about this issue?
Though point-of-care ultrasound has gained popularity as a non-invasive means of intravascular volume assessment, there is no standardized approach to inferior vena cava measurement.

What was the research question?
Which anatomical view and imaging modality of the inferior vena cava has the highest inter-rater reliability?

What was the major finding of the study?
The sub-xiphoid transabdominal long axis view in gray scale (B-mode) demonstrated the highest inter-rater reliability.

How does this improve population health?
A standardized approach to non-invasive volume assessment may reduce discrepancies and variability in the acute healthcare of various populations.

METHODS

Design

This was a prospective evaluation of 39 healthy adults approved by the hospital's institutional review board.

Setting and Population

Medical students from The Ohio State University College of Medicine participating in the Trained Simulated Ultrasound Patients (TSUP) program were enrolled on a volunteer basis and consented for participation in this study. Participating medical students serve as trained simulated ultrasound patients and are a volunteer group that fulfills the need for normal anatomic models for ultrasound education.[17] Exclusion criteria included inability to lie flat and inability by the ultrasonographer to adequately visualize and measure the IVC.

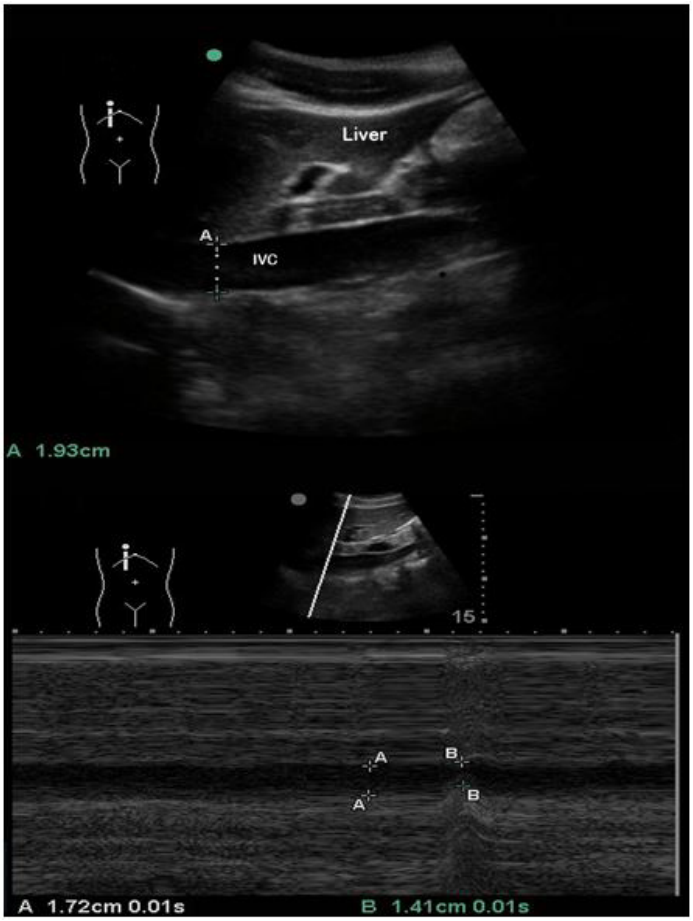

Figure 1. Sub-xyphoid transabdominal long axis (LA) in B-mode (top) and M-mode with respiratory variation (bottom). A: passive respiration, B: inspiratory effort.
IVC, inferior vena cava

Protocol

Three emergency physician (EP) sonographers, all with experience in IVC POCUS (>150 ultrasounds performed), performed the ultrasound examinations. Two of the EPs are Registered Diagnostic Medical Sonographer (RDMS)-certified, and the third EP was completing an emergency medicine fellowship in ultrasound. Measurements of the IVC were obtained with the patient in the supine position. Data collection consisted of gray scale (B-mode) and motion-mode (M-mode) IVC diameter. For M-mode, IVC diameters were measured both during quiet passive respiration and then followed by a rapid inspiratory effort or "sniff." Respiratory variability with percentage collapse of the IVC was calculated as the inferior vena cava collapsibility index (IVCCI): [(Maximum IVC diameter – Minimum IVC diameter) / Maximum IVC diameter] x 100.

Three anatomic approaches were used for data collection and comparison: 1) sub-xyphoid transabdominal long axis (LA) 2-3cm caudal to the right atrial (RA) junction (Figure 1); 2)

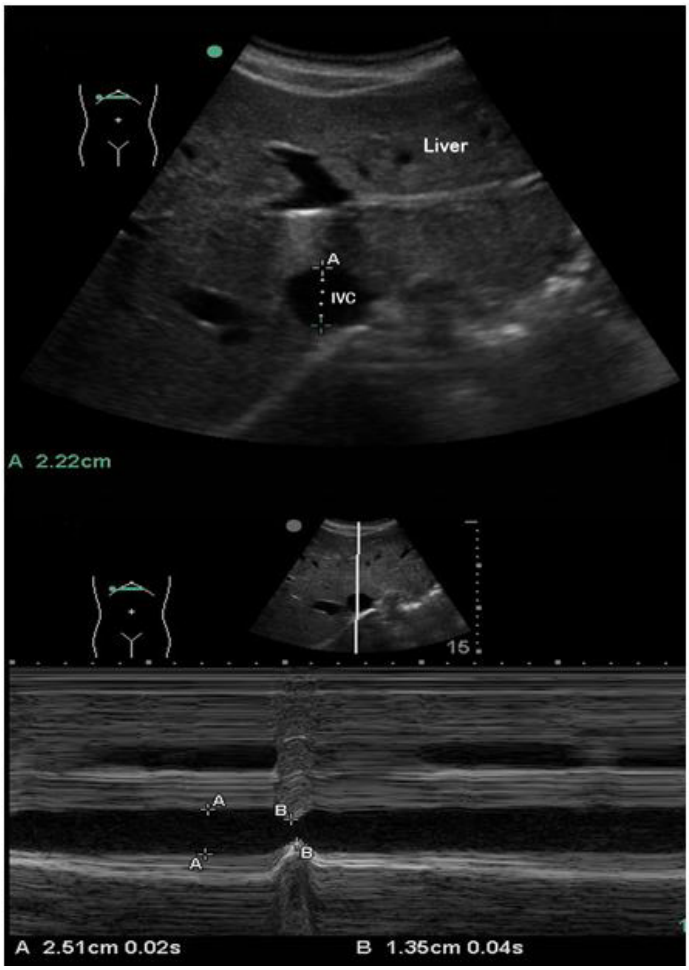

Figure 2. Transabdominal short axis (SA) in B-mode (top) and M-mode with respiratory variation (bottom). A: passive respiration, B: inspiratory effort.
IVC, inferior vena cava

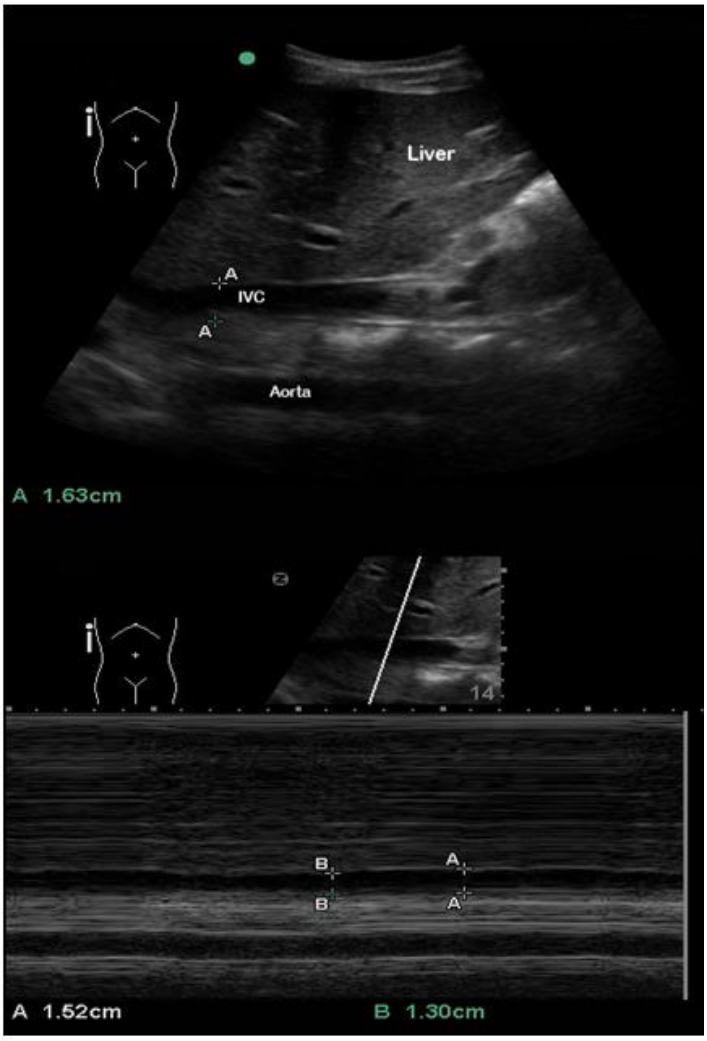

Figure 3. Right lateral transabdominal coronal long axis (CLA) (aka "rescue view") in B-mode (top) and M-mode with respiratory variation (bottom). A: passive respiration, B: inspiratory effort.
IVC, inferior vena cava

transabdominal short axis (SA) immediately inferior to the inflow of the hepatic veins (Figure 2); and 3) right lateral transabdominal coronal long axis (CLA) (aka "rescue view") 2-3cm caudal to the RA junction (Figure 3).

All measurements were obtained with a 3.5-Mhz curved array ultrasound (US) probe on a portable US device (M-Turbo-Fujifilm – Bothell, Washington). Data were recorded in both digital and analogue formats and reviewed for quality assurance. For discrepancies in recorded data, we discarded analogue measurements and included digital data for analysis.

Data Analysis

We calculated inter-rater reliability for each POCUS method using intra-class correlation coefficients (ICC) for continuous variables. In addition, the effects of sonographer and view acquisition on ICC values were analyzed via two-way univariate analyses of variance (ANOVA) with one repeated measure (EP by View) for both B- and M-mode to account for conditional changes imposed by the EP and method of acquisition. Significant main effects were followed up with post hoc analyses (Student Newman-Keuls (SNK)) and significant interactions were followed up with simple interactions. We performed statistical analysis using STATA v.12 (STATA Corp, College Station, TX). A sample size of 39 subjects was determined to have >80% power to detect a statistically significant difference in IVC measurement, with significance defined as alpha of 0.05.

RESULTS

Each of the three EPs evaluated 39 TSUPs who were included in final statistical analysis, representing 351 total ultrasound scans. None of the volunteers met exclusion criteria. Mean diameters were performed for B-Mode, expiratory M-mode (IVCe), and inspiratory M-mode (IVCi) (Table 1). The highest ICC was found to be B-mode LA, 0.86

Table 1. Mean inferior vena cava (IVC) diameter by ultrasound view and mode.

View	Mode	Mean (SD)
View	B-mode	1.86 (0.42)
	IVCe	1.97 (0.47)
	IVCi	1.25 (0.45)
SA (cm)	B-mode	1.89 (0.43)
	IVCe	1.98 (0.46)
	IVCi	1.33 (0.49)
CLA (cm)	B-mode	1.98 (0.44)
	IVCe	2.02 (0.47)
	IVCi	1.41 (0.46)

LA, sub-xyphoid transabdominal long axis; *SA*, transabdominal short axis; *CLA,* right lateral transabdominal coronal long axis; *IVCe,* inferior vena cava expiration; *IVCi*, inferior vena cava inspiration
N = 117 ultrasound scans per mode.

(95% confidence interval [CI] [0.76-0.92]) and poorest was M-mode IVCCI LA, 0.14 (95% CI [-0.27-0.47]) (Table 2).

We performed univariate ANOVA for each anatomic position and modality. Significant interaction effects between anatomical view and EP were observed for B-mode (p interaction < 0.01), IVCe (p interaction < 0.01), IVCi (p interaction < 0.01). Post hoc analyses revealed difficulty in consistent view acquisition between EPs.

DISCUSSION

There are limited data comparing acquisition techniques. Wallace et. al. demonstrated equivalence in two anatomical approaches, namely, at the level of the left renal vein and 2 cm caudal to the hepatic vein inlet, both of which differ from measurements taken at the junction of the right atrium (RA).[7] The most commonly cited approaches are 2-3cm caudal to the RA junction and inferior, caudal, or distal to the hepatic veins, suggesting the need to compare these approaches.[14,18-26]

In this study we found strong agreement between EP sonographers for B-mode IVC diameter measurements and moderate agreement for IVCe and IVCi, measurements. Agreement between IVCCI was poor. Fields et. al. also described a strong agreement in IVC measurements when comparing diameter dimensions, which is subsequently lost in IVCCI analysis. This was ascribed to multiplicative augmentation in diameter differences in the IVCCI calculation leading to a lowering of ICC when comparing IVCCI to its separate elements.[27]

Movement of the IVC occurs mediolaterally and craniocaudally during respirophasic POCUS, with collapse of the vessel occurring off axis from the true vertical.[28] This has led to suggestions in methodological approaches to IVC measurement favoring B-mode and discouraging M-mode[7,8], although recent literature indicates that this may not be of clinical significance.[8] Our results do support the use of B-mode over M-mode; however, ICC remains moderate in IVCe and IVCi.

Our data suggest that B-mode, subxyphoid LA 2-3cm caudal to the RA junction is the most reliable means of IVC acquisition. When compared to SA immediately inferior to the hepatic veins and CLA (aka "rescue view") 2-3cm caudal to the RA junction, LA has the highest ICC. IVC measurement is less reliable in M-mode when compared to B-mode. This discrepancy is augmented when calculating IVCCI. These findings are consistent with current literature on the topic.[8,14,27,29]

LIMITATIONS

The study population consisted of a cohort of young, healthy volunteers from a relatively small sample size. This represents the greatest limitation to the generalizability and clinical application of this study, given this is not the typical patient population on which critical care resuscitation and intravascular volume assessment is performed. In addition, the EP sonographers acquiring data for the purposes of this study had training and experience beyond the average provider. Respiratory variation was measured during a rapid, forceful "sniff" as opposed to quiet respiration. IVC measures were performed in sequence (i.e. SA followed by LA, followed by CLA). Effect of diameter measured due to order of acquisition is unlikely; however, randomization of acquisition could have eliminated the potential for interaction or bias. Finally, collapsibility indices may be less useful clinically and evaluation of percentage of IVC collapse may prove more reliable. These conditions together may limit the

Table 2. Interclass correlation coefficient by modality.

View	B-mode (95% CI)	IVCe (95% CI)	IVCi (95% CI)	IVCCI (95% CI)
LA	0.86 (0.76-0.92)	0.78 (0.60-0.88)	0.57 (0.19-0.78)	0.14 (-0.27-0.47)
SA	0.78 (0.63-0.88)	0.76 (0.53-0.88)	0.63 (0.28-0.81)	0.27 (-0.11-0.56)
CLA	0.74 (0.56-0.85)	0.68 (0.45-0.82)	0.66 (0.42-0.81)	0.32 (-0.08-0.60)

LA, sub-xyphoid transabdominal long axis; *SA*, transabdominal short axis; *CLA,* right lateral transabdominal coronal long axis; *IVCe,* inferior vena cava expiration; *IVCi*, inferior vena cava inspiration
N = 117 ultrasound scans per mode.

generalizability of our findings, and further investigation and validation is warranted.

CONCLUSION

POCUS of the IVC is a non-invasive means of volume assessment in the critically ill. Standardization and optimal techniques for IVC assessment have yet to be agreed upon. This study was designed to determine inter-rater reliability of ultrasound measurements between different views and modalities. These results suggest that B-mode LA holds the most promise to deliver reliable measures of IVC diameter. These data may help to establish a standardized approach to POCUS of the IVC for intravascular volume assessment. Future studies may focus on validation in a clinical setting as well as comparison to a reference standard.

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Ultrasound-Guided Radial Artery Compression to Assess Blood Pressure

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Introduction: We proposed using compression sonography to observe the coaptation and collapse of the radial artery as a surrogate for automated cuff blood pressures (BP). We hypothesize that the pressure required to achieve coaptation and complete collapse of the artery would correlate to the diastolic and systolic BP, respectively. This pilot study was to assess the feasibility of ultrasound-guided radial artery compression (URAC) for BP measurement and compare patient comfort levels during automated cuff with URAC measurements.

Methods: This was a prospective cohort pilot study with a convenience sampling of 25 adult patients at a single urban emergency department. URAC pressure was measured, followed by cuff manometry on the same arm. A 100mL normal saline bag was connected to the Stryker pressure monitor and placed on the volar wrist. Pressure was applied to the bag with a linear transducer and the radial artery was observed for coaptation of the anterior and posterior walls and complete collapse. Pressures required for coaptation and collapse were recorded from the Stryker display. Patient level of comfort was also documented during the URAC method, with patients reporting either "more," "same" or "less" comfort in comparison to automated cuffs. We analyzed data using intraclass correlation and paired t-tests. Interrater reliability was calculated using intraclass correlation.

Results: The mean cuff systolic BP was 138.6 ± 22.1 mmHg compared to 126.9 ± 19.8 mmHg for the URAC systolic BP (p=0.02). For diastolic BP, there was no significant difference between the cuff BP and the URAC BP (83.7 ± 13.0 cuff vs. 86.5 ± 19.8 URAC, p=0.46). The intraclass correlation (ICC) for systolic BP was 0.48 (p=0.04) and 0.57 (p=0.02) for diastolic BP. The agreement between the two observers was 0.88 for identifying coaptation on ultrasound (diastolic pressure) and was 0.92 for identifying collapse (systolic pressure). Eighty percent (20/25) of subjects found the URAC method more comfortable than the cuff measurement, and the remainder found it the same (5/20).

Conclusion: This pilot study showed statistically significant moderate correlation between automated cuff diastolic BP and URAC measurements for vessel coaptation. Additionally, most patients found the URAC method more comfortable than traditional cuff measurements. Compression ultrasonography shows promise as an alternative method of BP measurement, though future studies are needed. [West J Emerg Med. 2017;18(3)502-508.]

INTRODUCTION

Automated cuff devices are the standard method of measuring blood pressure (BP) in the emergency department (ED). When these devices fail to obtain accurate pressures,[1] clinicians may resort to invasive methods of determining BP, which have potential complications.[2,3] An alternative noninvasive method of measuring BP using materials readily available in the ED would be helpful.

We propose a new technique to assess intraluminal radial artery pressure using ultrasound-guided radial artery compression (URAC) sonography. It was previously shown that compression ultrasound of the arm can be used by non-vascular sonographers.

Thalhammer et. al. successfully measured peripheral venous pressure using compression ultrasound of the cephalic vein and a specialized pressure tranducer.[4] It has additionally been shown that clinicians can perform compression ultrasound after limited training[5] and consistently identify the radial artery under ultrasound.[6]

Our technique is novel in that it uses compression sonography to assess arterial pressures and only uses equipment commonly in place in the ED. We hypothesize that the pressure required to achieve coaptation and then collapse of the radial artery on ultrasound will correlate to the standard automated cuff measurements for diastolic and systolic BP, respectively.

Population Health Research Capsule

What do we already know about this issue?
Venous pressure can successfully be assessed using compression ultrasound of peripheral veins. However, no studies have used compression ultrasound to assess arterial blood pressure

What was the research question?
Is ultrasound-guided radial artery compression (URAC) a feasible method to assess blood pressure?

What was the major finding of the study?
There is a statistically significant correlation between automated cuff and URAC diastolic blood pressure measurements.

How does this improve population health?
If found to be an acceptable method of assessing blood pressure, URAC could be a backup method to measure blood pressure and potentially replace invasive methods of assessment in select patients.

METHODS

Inclusion criteria were any adult patients with a triage automated-cuff pressure reading. Exclusion criteria were toxic-appearing patients, patients with apparent life- or limb-threatening illness or injury, patients meeting triage criteria for emergent care, patients with significantly abnormal triage vital signs (BPs less than 90/50 or greater than 200/100, heart rate less than 50 or greater than 100, oxygen saturation less than 94% or respiratory rate greater than 16), patients unable to give verbal consent, and patients unable to have cuff blood pressures done in either upper extremity.

The ultrasound screen and pressure monitor were video recorded and over-read by another investigator who was blinded to the initial URAC measurements.

Description of Setup

Patient was seated in a standard triage chair with an armrest. The radial artery was identified using a Zonare ZS-3 Ultrasound System (Mountain View, CA) and an L10-5 linear ultrasound transducer set to the vascular exam settings. A 100mL bag of normal saline was connected to a Stryker intra-compartmental pressure monitor using standard intravascular tubing and flushed with saline to remove any air (Figure 2). The 100mL bag was placed on the patient's volar wrist overlying the radial artery (Figure 3). Ultrasound gel was applied between each layer. Pressure was slowly applied to the bag with the linear transducer, and the radial artery was observed for coaptation of the anterior and posterior walls and then complete collapse (Figure 4). We defined *coaptation* as the point at which the anterior and posterior walls of the pulsatile radial artery first touched and *complete collapse* as the point at which the radial artery no longer visibly opened or displayed pulsatility. The pressure reading on the Stryker monitor was recorded at the points of coaptation and complete collapse. The ultrasound screen and Stryker monitor were recorded with a Sony Handycam camcorder, which was reviewed by the principal investigator to independently identify the point of coaptation and complete collapse to assess agreement. The patient's BP was then measured using a standard automated cuff. Patient level of comfort with the URAC method was also assessed, with patients reporting either "more," "same" or "less" comfort compared to automated cuffs.

Statistical Analysis

We performed data analysis using SPSS Statistics version 24.0 (IBM Corp. Released March 15 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY). A paired samples t-test was performed for both systolic pressure (URAC vs cuff pressure) and diastolic pressure (URAC vs cuff pressure) to determine any statistically significant differences. We also compared the URAC and cuff pressures using the intraclass correlation coefficient. Interrater reliability between the two observers was calculated using the intraclass correlation coefficient.

RESULTS

This study found a statistically significant difference between automated systolic pressure and URAC pressure for artery collapse ($p = 0.02$), but no statistically significant difference between automated diastolic pressure and URAC coaptation pressure ($p = 0.46$) (Table 1). Intraclass correlation was 0.48

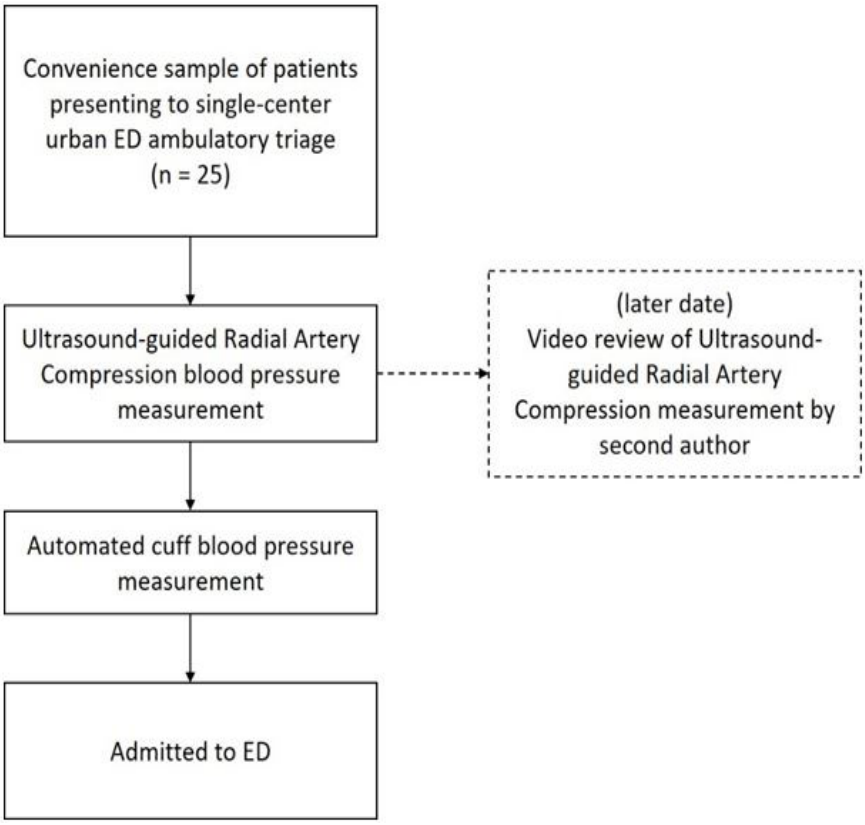

Figure 1. Patient flow diagram.
ED, emergency department

Figure 2. Noninvasive pressure measurement setup, showing 100mL bag of normal saline connected to Stryker pressure meter via standard intravenous (IV) tubing.

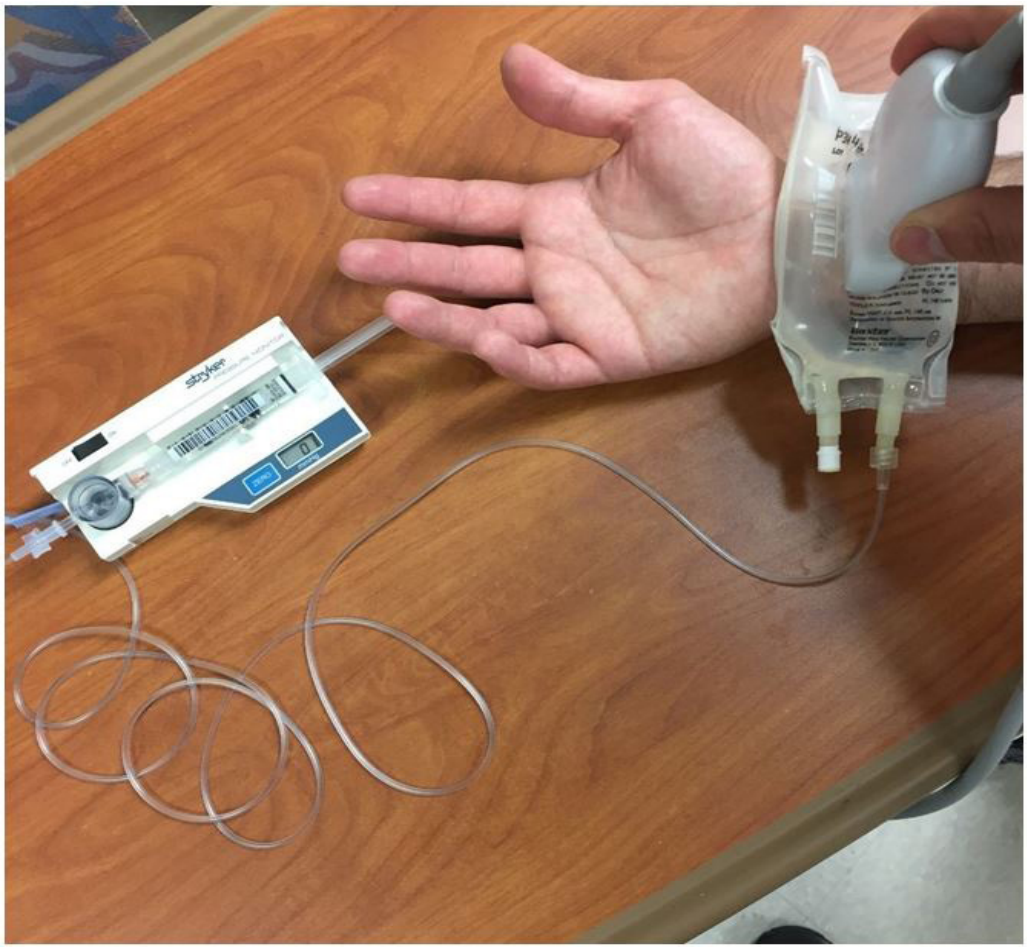

Figure 3. Radial artery is visualized through 100mL bag of normal saline with ultrasound probe and compression is applied to achieve coaptation and complete collapse of the artery wall

(p=0.04) for systolic BP and 0.57 (p=0.02) for diastolic BP (Table 2). Of 25 patients sampled, 20 (80%) found the URAC method more comfortable than the cuff measurement (Table 3). The agreement between the two observers using intraclass correlation was 0.88 for identifying coaptation on ultrasound and 0.92 for identifying collapse (Table 4).

DISCUSSION

We often guide the management of patients in the ED by their BPs. When unable to obtain accurate readings using automated methods, we spend precious time attempting different locations, using standard cuff manometry and occasionally resorting to invasive methods with its inherent risks. For these reasons a simple, non-invasive and reliable method of measuring BP is desirable for when the automated cuff fails.

As described by Thalhammer et al., compression sonography using special equipment is capable of accurately measuring venous pressure with peripheral veins.[4] In addition, multiple studies have shown that the radial artery can be easily identified via ultrasound.[6,8,9] We attempted to show that noninvasive peripheral arterial BP could be similarly assessed using common items found in most EDs.

This pilot study found a statistically significant moderate correlation between automated diastolic pressure and URAC

Table 1. Comparison of mean automated cuff pressure versus mean ultrasound-guided radial compression (URAC) pressure and corresponding p-values.

	Cuff pressure	URAC	p-value
Systolic	138.6 ± 22.1	126.9 ± 19.8	0.02
Diastolic	83.7 ± 13.0	86.5 ± 19.8	0.46

Table 2. Intraclass correlation between automated cuff and ultrasound-guided radial compression (URAC) systolic and diastolic blood pressure.

	Intraclass correlation	p-value
Systolic	0.48	0.04
Diastolic	0.57	0.02

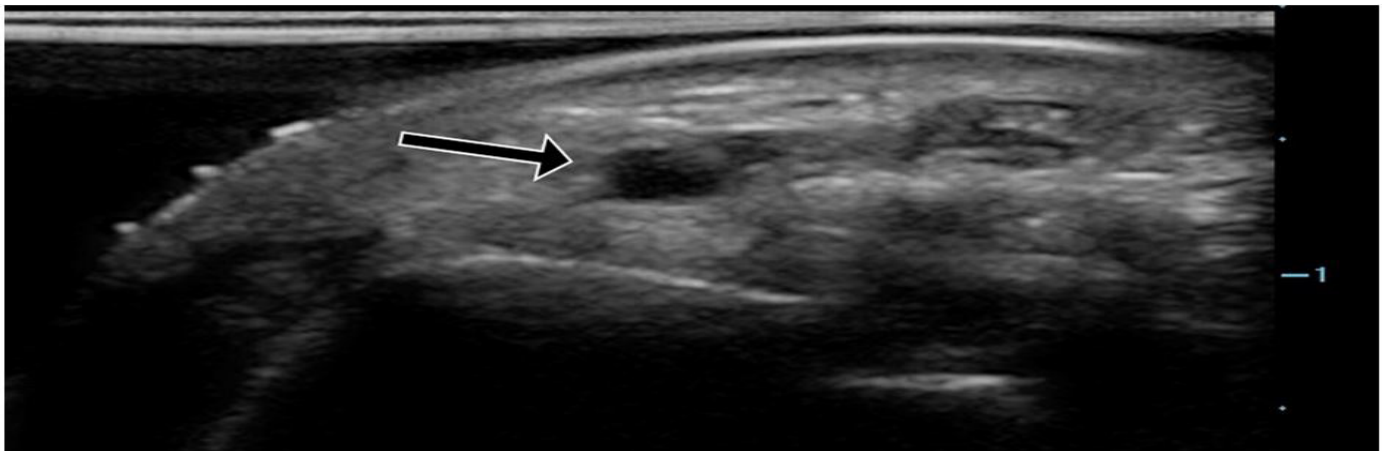

Figure 4a. Ultrasound of the radial artery showing normal anatomy (arrow).

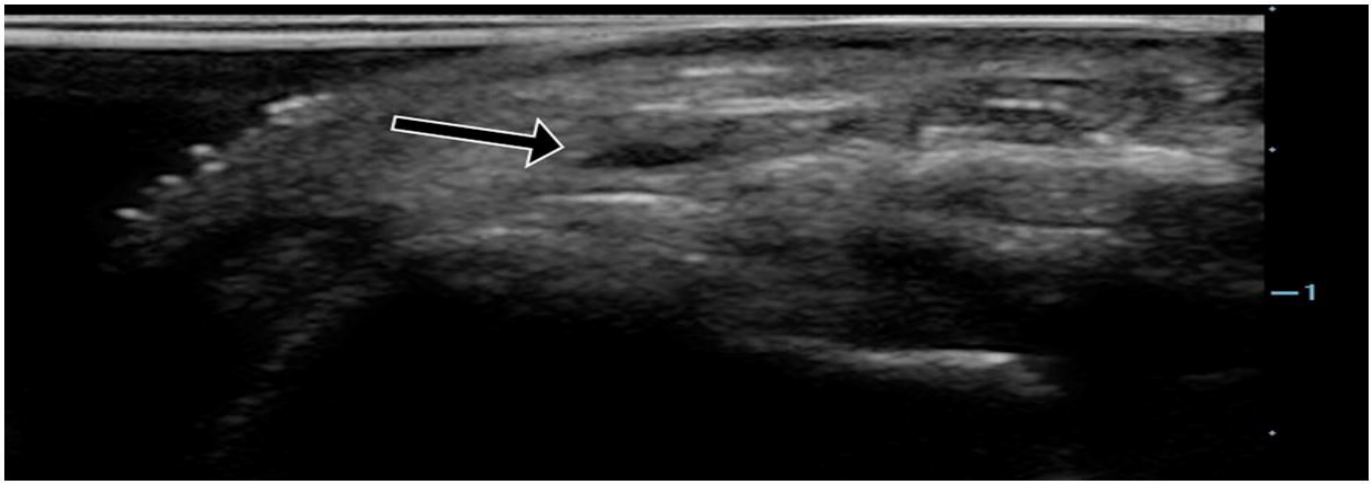

Figure 4b. Ultrasound of the radial artery with pressure applied, beginning to show coaptation of the anterior and posterior walls representing diastolic pressure (arrow).

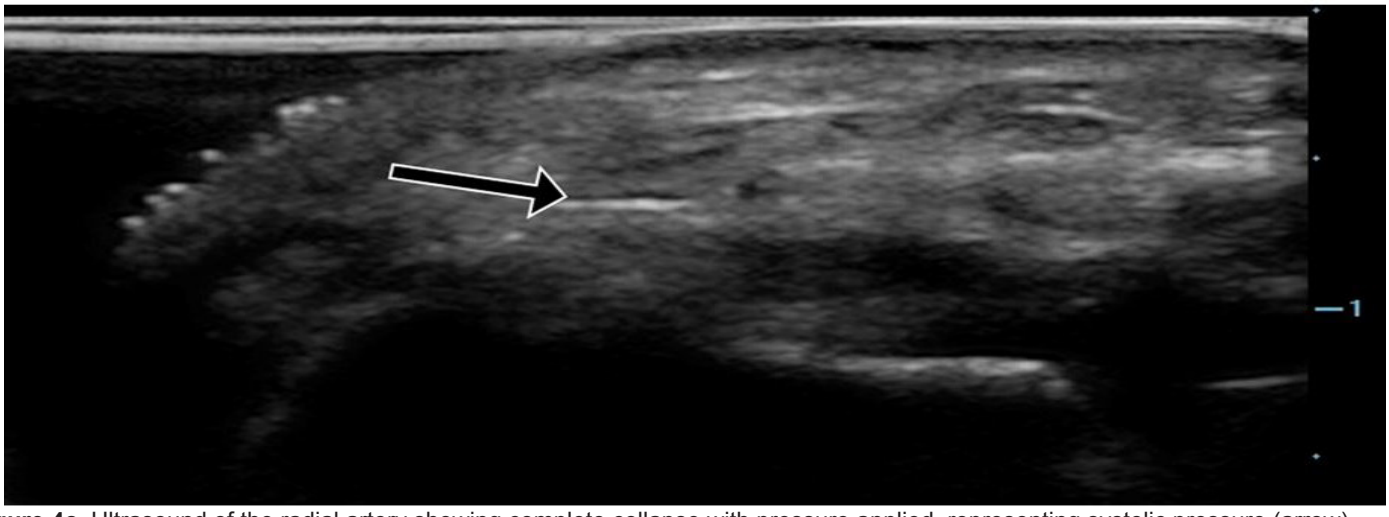

Figure 4c. Ultrasound of the radial artery showing complete collapse with pressure applied, representing systolic pressure (arrow).

Table 3. Automated cuff BP compared to ultrasound-guided radial compression (URAC) BP and comfort level.

	Cuff BP		URAC BP		Comfort
Patient	Systolic	Diastolic	Collapse	Coaptation	
1	162	106	160	122	More
2	145	80	165	125	More
3	139	79	114	79	Same
4	171	121	157	124	More
5	143	88	110	65	Same
6	130	90	111	72	More
7	145	91	132	100	More
8	130	82	153	116	Same
9	188	95	129	64	More
10	111	75	106	73	More
11	158	82	89	58	More
12	125	87	117	72	More
13	120	75	123	79	More
14	191	106	134	94	More
15	115	78	140	108	More
16	117	66	118	78	More
17	114	83	124	96	More
18	146	77	139	67	More
19	127	81	130	81	More
20	117	71	93	77	More
21	137	74	120	92	Same
22	152	88	152	91	Same
23	139	72	118	66	More
24	120	64	115	82	More
25	124	82	124	82	More

BP, blood pressure.

measurement for coaptation pressure ($p = 0.46$). Furthermore, there was a high level agreement between two observers independently identifying the points of coaptation and collapse of the radial artery walls. The results show the URAC method has some promise as a reliable alternative method of BP assessment.

Given the focal pressure being applied to the arm with the URAC method, the secondary aim of this study was to compare patient's comfort level during automated cuff and URAC measurements. Automated BP cuff measurements are commonly uncomfortable for the patient.[7] The overwhelming majority of patients (80%) found the URAC method to be more comfortable than the automated cuff measurement, and none found it to be less comfortable.

The authors of this study did not undergo any special training for this procedure but are trained in emergency sonography with fellowship or equivalent training. However, previous studies have shown that vascular compression of the forearm can be successfully performed after brief training,[5] and the authors feel the URAC technique could be easily mastered by novice sonographers.

Table 4. Correlation between the two observers to identify on ultrasound the point of initial coaptation of radial arterial walls (diastole) and complete collapse (systole).

	Intraclass correlation
Coaptation (diastolic pressure)	0.88
Collapse (systolic pressure)	0.92

LIMITATIONS

This pilot study has several limitations. It consisted of a small convenience sampling of patients at a single urban ED, which limits its generalizability. As a standard, our study used automated cuff pressures instead of a more accurate invasive BP measurement. Patients with significantly abnormal BPs were excluded. The technique requires the observer to be comfortable with identification of the radial artery on ultrasound, image optimization, and maintaining an adequate image of the vein while applying pressure on the saline bag. For this pilot study we used tools commonly found in most EDs, but not all EDs may have a Stryker or other intra-compartmental pressure monitor available. The system would have to remain partially constructed to be efficient. However, if compression-ultrasound BP assessment is further validated, a simple and integrated device could be developed.

CONCLUSION

Compression ultrasonography shows promise as a method for BP measurement. Further studies are needed and should target comparison of compression sonography measurements to more accurate standards. If proven reliable, compression ultrasonography could serve as a backup method for BP measurement, reduce the need for arterial line placement, and be integrated into workflows for efficient use.

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Differentiating Urgent and Emergent Causes of Acute Red Eye for the Emergency Physician

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Patients commonly present with an acute red eye to the emergency department (ED). It is important to distinguish between benign and sight-threatening diagnoses. Here we provide a comprehensive overview on the acute red eye in the ED. [West J Emerg Med. 2017;18(3)509-517.]

INTRODUCTION

Emergency physicians (EP) must be knowledgeable in the evaluation of the acute red eye. For the purposes of this review, the acute red eye refers to a patient with conjunctival and/or scleral redness. The differential diagnosis ranges from routine (subconjunctival hemorrhage) to immediately sight-threatening diagnoses (acute angle closure glaucoma [AACG] or endophthalmitis). Asking key historical questions and performing a complete ocular examination will help to distinguish whether emergent, urgent, or as-needed ophthalmologic follow up is necessary. Here we discuss key historical and physical examination features in the workup of the acute red eye. We provide a comprehensive overview of the differential diagnosis for the patient who presents to the emergency department (ED) with an acute red eye.

HISTORICAL FEATURES

Pain or Photophobia

Pain and/or photophobia are important features in distinguishing between minor and serious ophthalmologic diagnoses. Mild irritation or foreign body sensation may be present in minor diagnoses (conjunctivitis, episcleritis).[1,2] Early viral keratitis, however, may present with irritation only. It is important to perform a thorough skin and fluorescein examination in these patients. Physicians should take caution in any patient who has pain or photophobia, as these can be signs of more serious diagnoses (AACG, bacterial keratitis, scleritis, anterior uveitis). Photophobia can either be direct, consensual, or both. Direct photophobia refers to pain with light shone in the affected eye; whereas, consensual photophobia refers to pain with light shone in the unaffected eye. Consensual photophobia, though a subjective finding, is suggestive of iritis (anterior uveitis) over superficial corneal processes.[3] Corneal abrasions may present with severe pain, but the pain typically subsides in 24-48 hours and patients will have a characteristic lesion on fluorescein examination.[4] Patients with corneal abrasions from contact lenses should routinely see an ophthalmologist within 24-48 hours, especially if symptoms have not improved.[4]

Associated Symptoms

The EP should determine if the patient has any associated symptoms, such as headache or vomiting, concerning for AACG.[5] Symptoms of an upper respiratory tract infection are often associated with viral conjunctivitis.[1]

History of Trauma, Exposure, or Surgery

A history of minor trauma should raise suspicion for a corneal abrasion or subsequent infectious keratitis.[4,6] Physicians should be concerned for an ocular foreign body in metal workers or ultraviolet (UV) keratitis in patients with exposure to the sun or occupational UV light.[7] A history of moderate or major trauma should raise suspicion for globe rupture or traumatic iritis.[8,9] The EP should strongly consider

endophthalmitis in a patient with recent ophthalmologic surgery.[10] Chemical burns or chemical conjunctivitis are the result of ocular chemical exposure; identification of the chemical content of the exposure and possible acidity or basicity may aid therapy.

Risk Factors

Episcleritis, scleritis, and anterior uveitis are associated with autoimmune and rheumatologic conditions.[2] Patients with a history of contact lens use are at an increased risk for infectious keratitis.[11] Medication history may also guide diagnosis; for example, anticoagulants are associated with subconjunctival hemorrhage, while topiramate is associated with angle closure.

PHYSICAL EXAMINATION FEATURES

Skin and Lid Examination

In a patient with an acute red eye, herpetic lesions on the skin warrant further investigation for herpes or varicella keratitis by fluorescein and slit lamp examination.[8] If there is confirmed or high suspicion for herpes or varicella keratitis patients should be started on oral or topical antivirals in the ED. The patient should have urgent (24-48 hours) follow up with ophthalmology to determine the extent of ocular involvement. If antiviral treatment is not initiated, ophthalmologic follow up or consultation should be within 12 hours. Erythema or edema of the skin should raise suspicion for periorbital cellulitis, dacrocystitis, stye, or blepharitis, which may have associated conjunctivitis. More serious causes of an acute, red painful eye with periorbital edema and erythema are orbital cellulitis and cavernous sinus thrombosis, which may present with pain on eye movement or ophthalmoplegia. It is also important to examine underneath the lid ("flipping the lid") in patients with a corneal epithelial defect (positive fluorescein staining often vertically oriented) to ensure that there is no retained foreign body, causing repetitive trauma to the eye.

Visual Acuity

An assessment of visual acuity (VA) should be performed in all patients presenting with ocular complaints. The patient should wear his/her own corrective lenses for the exam with distance or near correction as necessary.[9] If the patient does not have corrective lenses, a practitioner can perform a VA with pin holes to compensate for refractive error. When administering a visual acuity exam, patients should be encouraged to give their best "guess" for each line. For patients with significant discomfort due to a corneal abrasion, the VA should be checked after application of topical anesthetics. An acutely decreased visual acuity should raise a high suspicion for a vision-threatening process, such as AACG or endophthalmitis.

Response to Topical Anesthetic

Instillation of proparacaine or other anesthetic eye drops should significantly improve symptoms if the pain is secondary to a lesion at the corneal or conjunctival surface, such as a corneal abrasion. Improvement of pain following topical anesthetic administration is reassuring; however, corneal ulcers/bacterial keratitis, foreign bodies, and viral keratitis must still be considered. While some studies have supported the practice of discharging patients home with a short course of topical anesthetics,[12-14] we do not recommend this as routine practice, as their use is toxic to the corneal epithelium and can potentially result in severe complications.[15,16]

Response to Phenylephrine

Although we do not routinely instill phenylephrine drops to all patients with an acute red eye, the response to phenylephrine is useful in distinguishing between episcleritis and scleritis.[2] The redness of episcleritis should improve with instillation of phenylephrine, as the episcleral vessels constrict, but the redness of scleritis should not improve.[2] Phenylephrine should be instilled only after accurate normal intraocular pressure (IOP) has been determined, so as to not exacerbate AACG.[17]

Slit Lamp Examination

A slit lamp examination is necessary to identify cells and flare in the anterior chamber, as this is a sign of an acute inflammatory process, such as anterior uveitis or bacterial keratitis.[11] While up to 75% of patients with bacterial keratitis will not have anterior chamber inflammation,[18] cell and flare in the anterior chamber warrant urgent ophthalmologic consultation.[11] The EP can assess for anterior chamber inflammation at the slit lamp by setting the slit beam at a small 1x1 mm beam and projecting it at an oblique angle through the anterior chamber. Inflammation is characterized by the presence and density of circulating immune cells (cell) and a foggy appearance to the slit beam (flare) caused by protein leaking into the anterior chamber through inflamed vessels. The slit lamp will also identify a corneal infiltrate associated with bacterial or fungal keratitis.

Fluorescein Examination

In conjunction with the slit lamp examination, fluorescein will identify a corneal epithelial defect, such as a corneal abrasion or a corneal defect associated with a microbial keratitis infiltrate. UV keratitis can present with diffuse punctate staining. Branching lesions with end bulbs that brightly stain with fluorescein are typical of herpes simplex virus (HSV).[19] Small, non-staining vesicles may be the only finding during the first 24 hours of HSV infection, or in patients who are immunocompromised.[19] Highly branched

lesions without end bulbs are typical of varicella zoster virus (VZV), and these stain less brightly with fluorescein.[19] In addition to VZV, these "pseudodendrites" can be caused by neurotrophic epitheliopathy and Acanthamoeba, but these diagnoses are beyond the scope of the EP.[19]

In a patient with a normal lid examination (or for patients with vesicles on their lid examination), the presence or absence of pain and/or photophobia, response to phenylephrine and topical anesthetics, intraocular pressure, slit lamp examination (including fluorescein), and visual acuity are the most helpful historical and physical findings in distinguishing between mild and serious processes.

DIFFERENTIAL DIAGNOSIS FOR THE ACUTE RED EYE WITH NORMAL LIDS

Subconjunctival Hemorrhage

Subconjunctival hemorrhage (SH) is defined as the presence of heme under the conjunctiva, secondary to a ruptured conjunctival blood vessel.[8] Risk factors for SH include trauma, straining (coughing, sneezing, vomiting, Valsalva), conjunctivitis, chronic health conditions (diabetes, hypertension), and coagulopathy.

- Pain: None
- Photophobia: None
- Response to topical anesthetic: Not applicable
- Response to phenylephrine: None
- Visual Acuity: Normal
- Pupils: Normal
- Anterior chamber: Clear
- Fluorescein: No uptake

It is important to consider globe rupture in patients with a history of blunt or penetrating trauma or 360-degree bullous hemorrhage. The EP may consider checking an INR in patients on warfarin. One should also consider non-accidental trauma in a child with SH and no history of vomiting or straining.[20,21] Patients with subconjunctival hemorrhage may be reassured and advised to use topical lubrication as needed. Patients may be referred to a primary care doctor for routine follow up of any chronic health conditions.

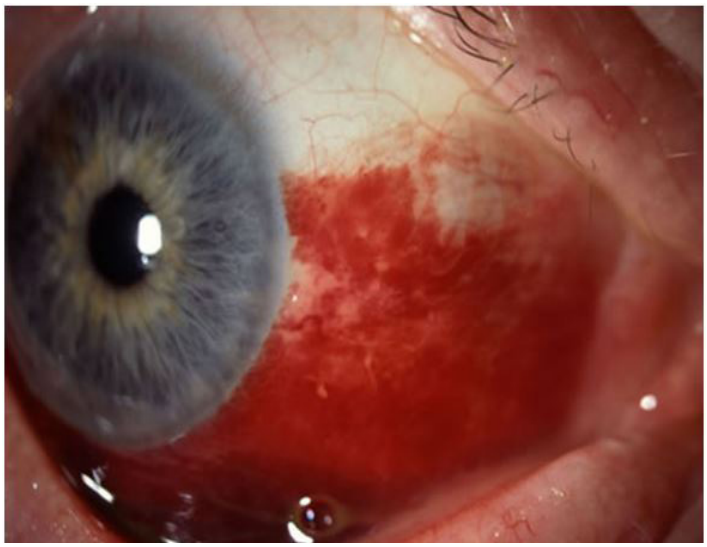

Figure 1. Subconjunctival hemorrhage. Image courtesy of Andrew Pearson, MA, MRCP.

Conjunctivitis

Conjunctivitis is defined as infectious or non-infectious inflammation of the bulbar and palpebral conjunctiva.[1] Patients typically have a mild burning sensation, tearing, discharge, and associated viral symptoms. Conjunctivitis can be viral, bacterial, or allergic. While purulent/mucopurulent discharge is more typical of bacterial conjunctivitis and watery discharge is typical for viral conjunctivitis, this distinction is not entirely reliable.[22] One study found that the combination of bilateral eye mattering (crusting), lack of itching, and lack of prior history of conjunctivitis was most predictive of bacterial conjunctivitis.[22] Viruses cause the majority of cases of conjunctivitis, most commonly adenovirus.[22] Acute bacterial conjunctivitis may be caused by *Staphylococcus aureus, Streptococcus pneumoniae, Haemophilus influenza, Neisseria gonorrhea, Chlamydia trachomatis,* or diphtheria. *Neisseria gonorrhea* causes a hyperacute bacterial conjunctivitis with copious purulent discharge.[22]

- Pain: Minimal to none
- Photophobia: None
- Response to topical anesthetic: Reduction in irritation
- Response to phenylephrine: Mild improvement in redness
- Anterior Chamber: Clear
- Pupils: Normal
- Visual Acuity: Normal
- Fluorescein: No uptake

Patients with allergic conjunctivitis can be treated with topical antihistamines. Viral conjunctivitis can be treated with supportive care and preservative-free artificial tears up to eight times per day. Viral conjunctivitis is highly contagious one to two weeks from onset. Contact precautions are recommended; sterilization of the patient encounter room should be performed after the visit.

Topical antibiotics for bacterial conjunctivitis shorten the duration of disease, but the disease itself is usually self-limited.[22] Furthermore, topical antibiotics may cause side effects such as worsening eye irritation and community anti-microbial resistance.[22] Patients with hyperacute bacterial conjunctivitis secondary to *N. gonorrhea* should be treated for both *N. gonorrhea* and *C. trachomatis* with ceftriaxone and

azithromycin or doxycycline. Appropriate treatment is necessary to avoid corneal involvement and perforation.[22]

Patients with viral or bacterial conjunctivitis can follow up with primary care, but contact lens users should have close follow up to ensure that their "conjunctivitis" is not an early bacterial keratitis. One should question the diagnosis of conjunctivitis if the palpebral conjunctiva is not involved. One should similarly question the diagnosis if the patient is having pain or photophobia, as these symptoms should raise suspicion for bacterial keratitis or uveitis.

Episcleritis

Episcleritis is defined as idiopathic inflammation of the episclera, which is the vascularized tissue between conjunctiva and sclera.[2] Episcleritis risk factors include female gender (70%), age (fifth decade of life), and systemic autoimmune conditions.[2] Redness is usually focal in the interpalpebral zone (the area visible when the eye is open).

- Pain: Mild irritation is possible; chronic or nodular episcleritis may have pain[2]
- Photophobia: None
- Response to topical anesthetic: May improve irritation
- Response to phenylephrine: Resolution of episcleral redness after 10-15 minutes (key feature)
- Visual Acuity: Normal
- Pupils: Normal
- Anterior Chamber: Clear
- Fluorescein: No uptake

The key feature in distinguishing between episcleritis and scleritis is the patient's response to phenylephrine. The vessels in episcleritis will constrict and the eye redness will improve; this is not true of scleritis. Additionally, the inflamed vessels of episcleritis will move with gentle pressure from a cotton-tipped applicator. Patients with episcleritis are treated with topical lubricants and oral non-steroidal anti-inflammatory drugs.[23] Patients can follow up with primary care for continued management and for workup of any underlying cause. Patients should be given return precautions for symptoms of scleritis (worsening pain).

Anterior Scleritis

Anterior scleritis is defined as scleral inflammation that is frequently associated with autoimmune systemic disease.[2] Fifty percent of patients with anterior scleritis have associated autoimmune, systemic disease (rheumatoid arthritis, granulomatosis with polyangiitis, formerly known as Wegener's granulomatosis), while 4-10% have associated infectious processes.[2] There are three forms of anterior scleritis: diffuse, nodular, and necrotizing, the latter of which usually causes the most severe pain and has the worst outcome. The sclera may have a typical blush in natural light as uveal tissue may be apparent through a thin and inflamed sclera.[24]

- Pain: Gradual onset, severe, boring, and piercing eye pain. Pain is worse at night, with extraocular movements, and may radiate to the face[2,24]
- Photophobia: May be present
- Response to topical anesthetic: Should not improve pain
- Response to phenylephrine: Redness does not improve
- Visual Acuity: Normal or decreased, depending on extent of the disease
- Pupils: Normal
- Anterior Chamber: Clear
- Fluorescein: May show peripheral keratitis, which is more common in the necrotizing form.[2]

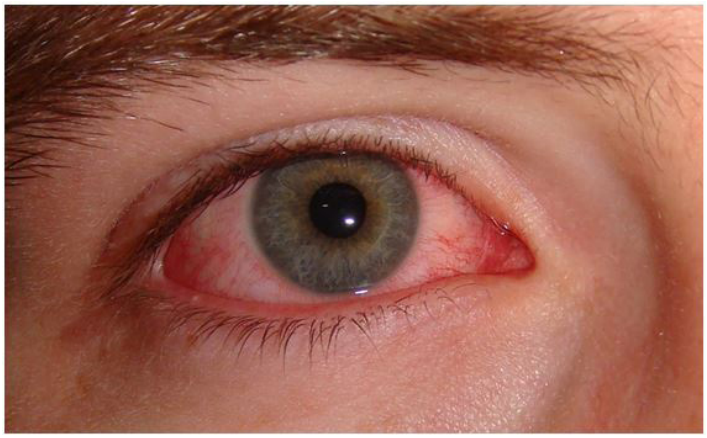

Figure 2. Acute viral conjunctivitis. Image courtesy of Wikimedia Creative Commons.

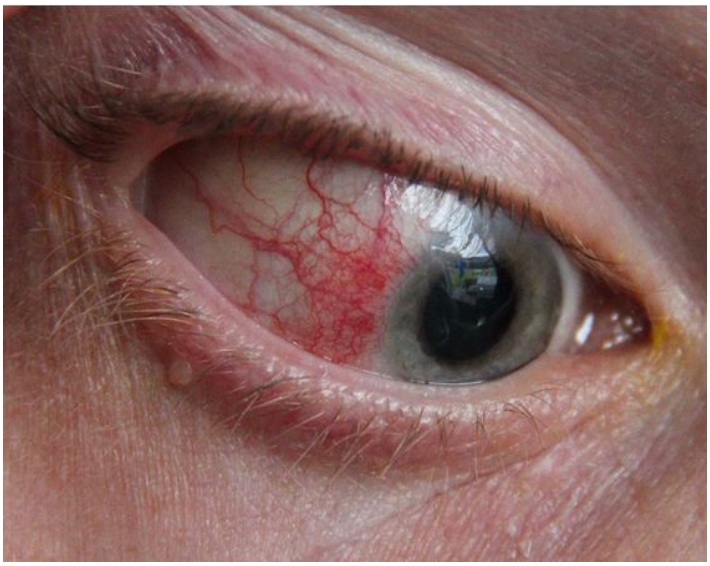

Figure 3. Episcleritis. Image courtesy of Asagan, Wikimedia Creative Commons.

Patients with anterior scleritis should be referred emergently to ophthalmology to initiate treatment and to prevent scleral melting.[9,25] If there is excessive scleral thinning, patients are at risk for perforation and an eye shield should be placed.

Anterior Uveitis/Iritis

Anterior uveitis is defined as idiopathic inflammation of the uvea (iris, choroid, and/or ciliary body), causing redness and pain. Risk factors include systemic diseases (spondyloarthropathies), infectious processes (syphilis, tuberculosis, Lyme disease, toxoplasmosis, herpesviruses, cytomegalovirus), and certain drugs (rifabutin, cidofovir, sulfas, moxifloxacin).[26] Patients present with pain, diffuse redness pronounced at the limbus (ciliary flush), consensual photophobia, tearing, and possibly decreased vision.

- Pain: Moderate to severe
- Photophobia: Consensual photophobia (key feature)
- Response to topical anesthetic: Should not improve pain
- Response to phenylephrine: Redness does not improve
- Visual Acuity: Normal or decreased
- Pupils: Constricted or irregular
- Anterior Chamber: Cells and flare present
- Fluorescein: May reveal dendrites if the underlying cause is HSV.

The treatment for anterior uveitis is topical steroids, although this should only be done in conjunction with ophthalmologic consultation, since topical steroids may worsen the prognosis for patients with HSV keratitis. Patients may also be treated with dilating drops to help to prevent scarring of the iris to the lens (synechiae). Patients must follow up with ophthalmology within 24 hours to control symptoms, limit inflammatory consequences, and to consider lab work for an underlying cause.

Acute Angle Closure Glaucoma

AACG is defined as closure (or narrowing) of the anterior chamber angle, causing elevated intraocular pressure and eventual optic nerve damage.[5,27] Risk factors include increased age, female gender (three times more common), Asian ethnicity, shallow anterior chamber, hyperopia, and certain medications (topiramate or sulfa).[27] Patients typically present with headache, nausea, vomiting, halos around lights, photophobia, blurred vision, and pain. Eye redness is diffuse, with characteristic ciliary flush.

- Pain: Moderate to severe
- Photophobia: Present
- Response to topical anesthetic: Should not improve pain
- Response to phenylephrine: Instillation of phenylephrine may exacerbate condition and should not be given[17]
- Visual Acuity: Decreased
- Pupils: Mid-sized or dilated, non-reactive pupil[17]
- Anterior Chamber: Shallow
- Fluorescein: No uptake

The diagnosis of AACG is confirmed with elevated intraocular pressure, which may be elevated as high as 60 mmHg. AACG must be treated early to avoid optic nerve ischemia. Treatment includes topical parasympathomimetics (pilocarpine 2%; avoid anything higher than 2%), topical beta-blocker (0.5% timolol; caution in asthmatics, COPD patients, and patients with heart block), carbonic anhydrase inhibitors (acetazolamide, 500 mg IV; avoid in sickle cell patients and possibly in sulfa allergy patients), and alpha agnoists

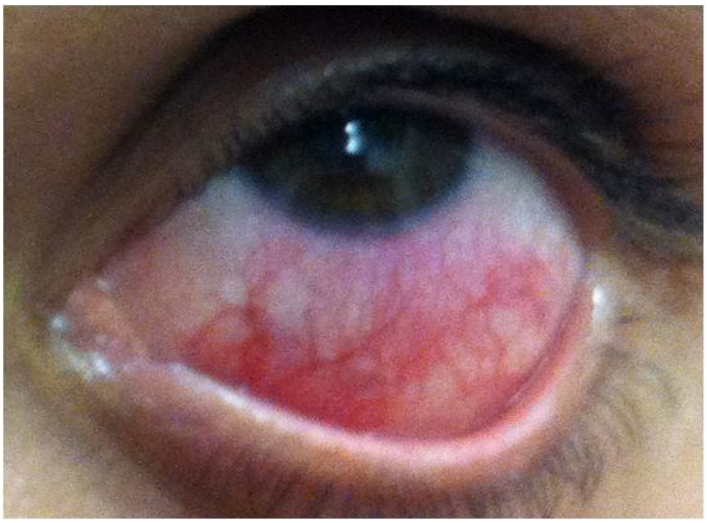

Figure 4. Anterior scleritis. Image courtesy of Marc Yonkers, MD, PhD.

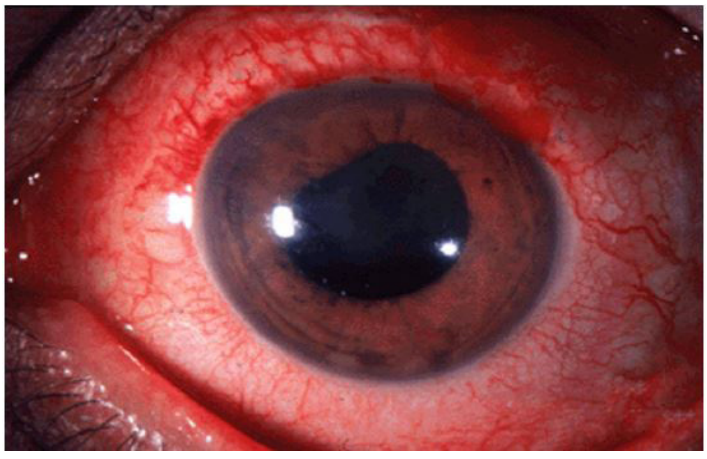

Figure 5. Anterior uveitis. Image courtesy of Jonathan Trove, MD, Wikimedia Creative Commons.

(brimonidine 0.1%; avoid in patients on monoamine oxidase inhibitors). Practitioners should avoid apraclonidine, as it can lead to dilation. Ophthalmologic consultation should be sought emergently for continued management recommendations and definitive treatment, usually with laser iridotomy.

Corneal Abrasion/Corneal Foreign Bodies

Defects to the corneal epithelium from abrasions or foreign bodies can cause irritation, pain, tearing, and photophobia.[4] Risk factors include trauma, contact lens use, male gender, young age, and construction or manufacturing job without the use of eye protection. For corneal abrasions, moderate or severe pain is common, but it usually lasts less than 24-48 hours.[4]

- Pain: Moderate to severe, lasts less than 48 hours
- Photophobia: Present
- Response to topical anesthetic: Should significantly improve pain
- Response to phenylephrine: Redness improves
- Visual Acuity: May be decreased if the defect is in the visual axis
- Pupils: Normal
- Anterior Chamber: Normal
- Fluorescein: Uptake at the site of the corneal abrasion (corneal epithelial defect).

Corneal abrasions are treated with lid eversion to exclude foreign body, lubricating ointment or drops, and topical antibiotics (polymixin B, trimethoprim or polysporin; quinolones for contact lens wearers). Contact lens wearers should follow up with ophthalmology within 48 hours. If there is concern for a corneal ulcer or if the pain is not improving within 24 hours, patients should be referred to ophthalmology emergently. A corneal foreign body requires removal of foreign body by an ophthalmologist or EP as soon as possible. A Seidel's test should be performed if there is concern for corneal laceration or globe rupture. A Seidel's test is performed by placing fluorescein dye gently against the bulbar conjunctiva; any disruption of epithelial cells will show positive staining.[28]

Bacterial or Fungal Keratitis/Corneal Ulcer

Bacterial or fungal keratitis is a corneal epithelial defect with stromal haze due to microorganisms.[6] Risk factors include the following: contact lens use,[18,29] agricultural work,[11] eye trauma (including corneal abrasion), use of corticosteroids, systemic diseases (diabetes), prior ocular surgery, and chronic ocular surface disease.[11] It is rare to develop bacterial or fungal keratitis without risk factors.[18] *Staphylococcus aureus,* coagulase negative staphylococci, and *Pseudomonas aeruginosa* are commonly isolated organisms in bacterial keratitis.[18,30] Patients present with diffuse redness of the eye accompanied by significant pain, tearing, discharge, and photophobia. The exam may mimic that of conjunctivitis, so it is important to have a high index of suspicion for microbial keratitis in patients with pain and/or risk factors. While Figure 8 shows a very large corneal ulcer, the presentation may be much more subtle, with about 40% of patients presenting with lesions smaller than 5 mm^2.[18]

- Pain: Moderate to severe
- Photophobia: Present
- Response to topical anesthetic: May improve pain

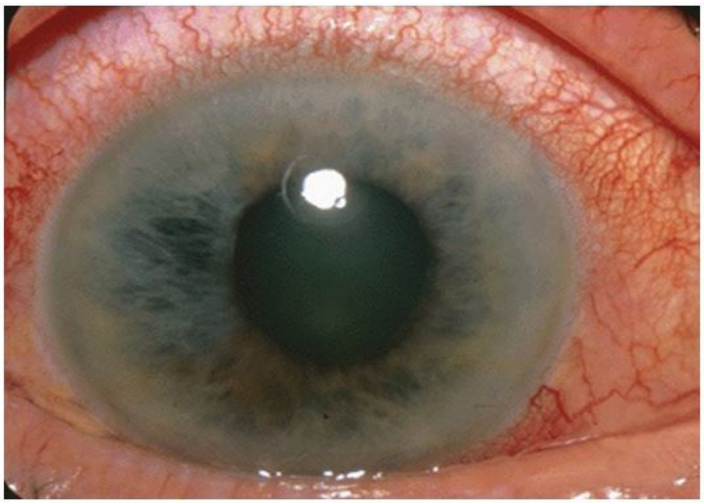

Figure 6. Acute angle closure glaucoma: note cloudy/ "steamy" cornea and mid-position, fixed pupil. Image courtesy of Jonathan Trove, MD, Wikimedia Creative Common.

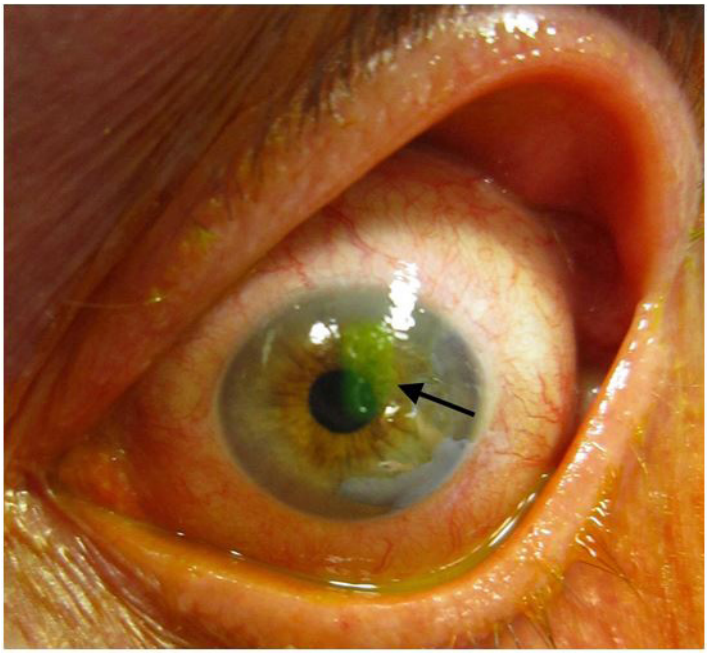

Figure 7. Corneal abrasion on fluorescein staining. Image courtesy of James Heilman, MD, Wikimedia Creative Commons.

- Response to phenylephrine: May improve redness
- Visual Acuity: May be decreased if the defect is in the visual axis
- Pupils: Normal
- Anterior Chamber: Cell and flare in 25% of patients; patients may have a frank hypopyon[18]
- Fluorescein: Uptake at the associated corneal epithelial defect

Treatment includes fortified topical antibiotics. Patients should follow up with ophthalmology within 24 hours (or sooner, depending on the severity). The complications of microbial keratitis include corneal perforation and extension into the visual axis.

Endopthalmitis

Endopthalmitis is defined as a bacterial or fungal infection involving the vitreous and/or aqueous humor.[10] Risk factors include eye surgery (cataract surgery has 0.1% risk), penetrating ocular trauma, corneal infection, intravitreal injections, and hospitalization with central venous access, total parenteral nutrition, or broad spectrum antibiotics.[10] Endophthalmitis usually occurs 2-7 days post-operatively or 12-24 hours after trauma.

- Pain: Moderate to severe
- Photophobia: Present
- Response to topical anesthetic: No improvement
- Response to phenylephrine: Minimal improvement
- Visual Acuity: Decreased
- Pupils: May have afferent pupillary defect[31]
- Anterior Chamber: Commonly associated with hypopyon[10]
- Fluorescein: May diagnose the inciting traumatic lesion

Ophthalmology should be consulted immediately. If the patient's vision is "hand motion" or better, then the patient is treated with intravitreal injection of antibiotics by ophthalmology. If the patient's vision is "light perception" or worse, then the patient will need an emergent vitrectomy with ophthalmology if there is potential for vision loss.

Viral Keratitis

Viral keratitis is defined as corneal inflammation caused by herpes simplex (HSV-1 most commonly), varicella zoster, or adenovirus (adenovirus 8, 19, 37 causing epidemic keratoconjunctivitis, EKC) characterized by pain, tearing, photophobia, and corneal epithelial defects.[32] Patients at risk for VZV keratitis typically have a the characteristic vesicular rash in the V1 (ophthalmic) branch of the trigeminal nerve. It is classically taught that a lesion on the nose, indicating involvement of the nasociliary branch of the ophthalmic nerve precedes ocular involvement of VZV, although this is not sensitive or specific.[33]

- Pain: Present
- Photophobia: Present
- Response to topical anesthetic: May improve pain
- Response to phenylephrine: Minimal improvement
- Visual Acuity: Normal or decreased
- Pupils: Normal
- Anterior Chamber: May have cell and flare
- Fluorescein: Fluorescein depicts branching pattern with terminal bulbs (HSV), branching with tapered ends (VSV), or diffuse fine keratitis (EKC).

Patients with HSV and VZV keratitis are treated with topical (trifluridine 1% q2h) and/or oral anti-virals (acyclovir, valacyclovir). Topical steroids may be added to reduce associated inflammation in treatment of VZV ophthalmicus, but this should only be done in consultation with ophthalmology and not without anti-virals. If treatment

Figure 8. Corneal ulcer. Image courtesy of Andrew Pearson, MA, MRCP.

Figure 9. Endophthalmitis. Image courtesy of Marc Yonkers, MD, PhD.

is initiated by the EP, a patient should follow up with ophthalmology within 24 hours. Otherwise, the patient should follow up with ophthalmology emergently (within 12 hours). The ophthalmologist must assess the depth of corneal involvement and associated sequelae of HSV (such as elevated IOP) to determine course of treatment.

SUMMARY

It is important for the EP to perform a detailed history and physical examination in the patient who presents with an acute red eye. An assessment of the patient's subjective symptoms along with a slit lamp examination focusing on a pattern of corneal fluorescein uptake or anterior chamber inflammation will significantly help narrow the diagnosis. While we did not specifically address patients with an abnormal lid examination, an EP should consider periorbital or orbital cellulitis, dacrocystitis, or blepharitis with associated eyelid erythema. Pain is an important distinguishing feature for the acute red eye; bacterial or viral keratitis, uveitis, AACG, corneal abrasion, or scleritis should be considered in patients with more than minimal pain or irritation. A patient's pain will generally improve after instillation of topical anesthetics in processes isolated to the cornea, such as corneal abrasion and early viral or bacterial keratitis. Instillation of phenylephrine may help to distinguish between episcleritis and scleritis, since the redness of episcleritis typically improves after phenylephrine. The presence of cells and flare in the anterior chamber should raise suspicion for anterior uveitis or bacterial keratitis. Bacterial and viral keratitis and corneal abrasion/foreign body will have uptake on fluorescein examination. To summarize, patients with moderate or severe pain, photophobia, elevated intraocular pressure, anterior chamber inflammation, corneal epithelial defects with associated infiltrate, or decreased visual acuity should be referred urgently or emergently to ophthalmology.

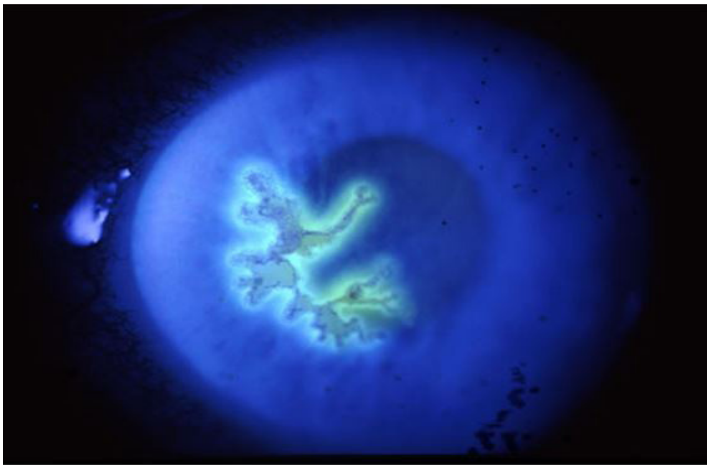

Figure 10. Viral keratitis (HSV keratitis). Image courtesy of Andrew Pearson, MA, MRCP.

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Inter-rater Agreement of End-of-shift Evaluations Based on a Single Encounter

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Introduction: End-of-shift evaluation (ESE) forms, also known as daily encounter cards, represent a subset of encounter-based assessment forms. Encounter cards have become prevalent for formative evaluation, with some suggesting a potential for summative evaluation. Our objective was to evaluate the inter-rater agreement of ESE forms using a single scripted encounter at a conference of emergency medicine (EM) educators.

Methods: Following institutional review board exemption, we created a scripted video simulating an encounter between an intern and a patient with an ankle injury. That video was shown during a lecture at the Council of EM Residency Director's Academic Assembly with attendees asked to evaluate the "resident" using one of eight possible ESE forms randomly distributed. Descriptive statistics were used to analyze the results with Fleiss' kappa to evaluate inter-rater agreement.

Results: Most of the 324 respondents were leadership in residency programs (66%), with a range of 29-47 responses per evaluation form. Few individuals (5%) felt they were experts in assessing residents based on EM milestones. Fleiss' kappa ranged from 0.157 - 0.308 and did not perform much better in two post-hoc subgroup analyses.

Conclusion: The kappa ranges found show only slight to fair inter-rater agreement and raise concerns about the use of ESE forms in assessment of EM residents. Despite limitations present in this study, these results and a lack of other studies on inter-rater agreement of encounter cards should prompt further studies of such methods of assessment. Additionally, EM educators should focus research on methods to improve inter-rater agreement of ESE forms or other evaluating other methods of assessment of EM residents. [West J Emerg Med. 2017;18(3)518-524.]

INTRODUCTION

End-of-shift evaluation (ESE) forms, also known as daily encounter cards, are useful for assessing performance in a non-simulated clinical environment. While many other methods exist, such as the mini-clinical evaluation exercise and the Standardized Direct Observation Assessment Tool, the use of ESE forms has become more common.[1-4] ESE forms are used in emergency medicine (EM), internal medicine, surgery, obstetrics and gynecology, and pediatrics.[5-8] In addition to assessing medical students and residents, they have also been used for evaluation of faculty.[9]

Generation of feedback, feasibility to implement, minimal recall, and acceptance as a method of evaluation are reasons that ESE forms have become so popular. Some authors found increased feedback after the implementation of encounter cards with students that is inclusive of multiple domains.[2,5,7,8] Others have found encounter cards practical to implement for individual encounters and daily encounters.[10] Individuals

do not feel the time required is burdensome, with multiple authors noting a high completion rate. Both students and faculty are comfortable using ESE forms.[6,9]

Some issues have been raised on using encounter cards for evaluation. One of them is conflicting evidence on learner satisfaction with the feedback generated.[10] Another is that assessments using ESE cards suffer from leniency bias, which may lead to inaccurate evaluation.[2] Finally, data entry after completing an evaluation card may add administrative time not initially planned.[7]

As the ESE form represents an evaluation and may have a role in summative assessment, the measurement characteristics such as inter-rater reliability and internal consistency should be considered.[11] Aspects of an evaluation form's internal structure include inter-rater reliability and inter-rater agreement.[12] ESE forms have been shown to have acceptable inter-rater reliability assessing students.[13] While inter-rater reliability and inter-rater agreement may coexist, an acceptable inter-rater reliability doesn't guarantee acceptable inter-rater agreement, making it necessary to evaluate the inter-rater agreement as well.[14]

The primary objective of this study was to evaluate the inter-rater agreement of ESE forms using a single encounter. We hypothesized that there would be a high rate of inter-rater agreement.

Population Health Research Capsule

What do we already know about this issue?
End-of-shift evaluation forms are a common method of evaluating learners and faculty. Some evidence of validity has been demonstrated with prior research.

What was the research question?
What is the inter-rater agreement of one set of end-of-shift evaluation forms using a single encounter?

What was the major finding of the study?
Inter-rater agreement was only slight to fair when using one set of end-of-shift evaluation forms.

How does this improve population health?
This study identifies lack of one aspect of validity evidence for a common assessment tool used to evaluate EM residents' competency.

METHODS

Development of ESE forms

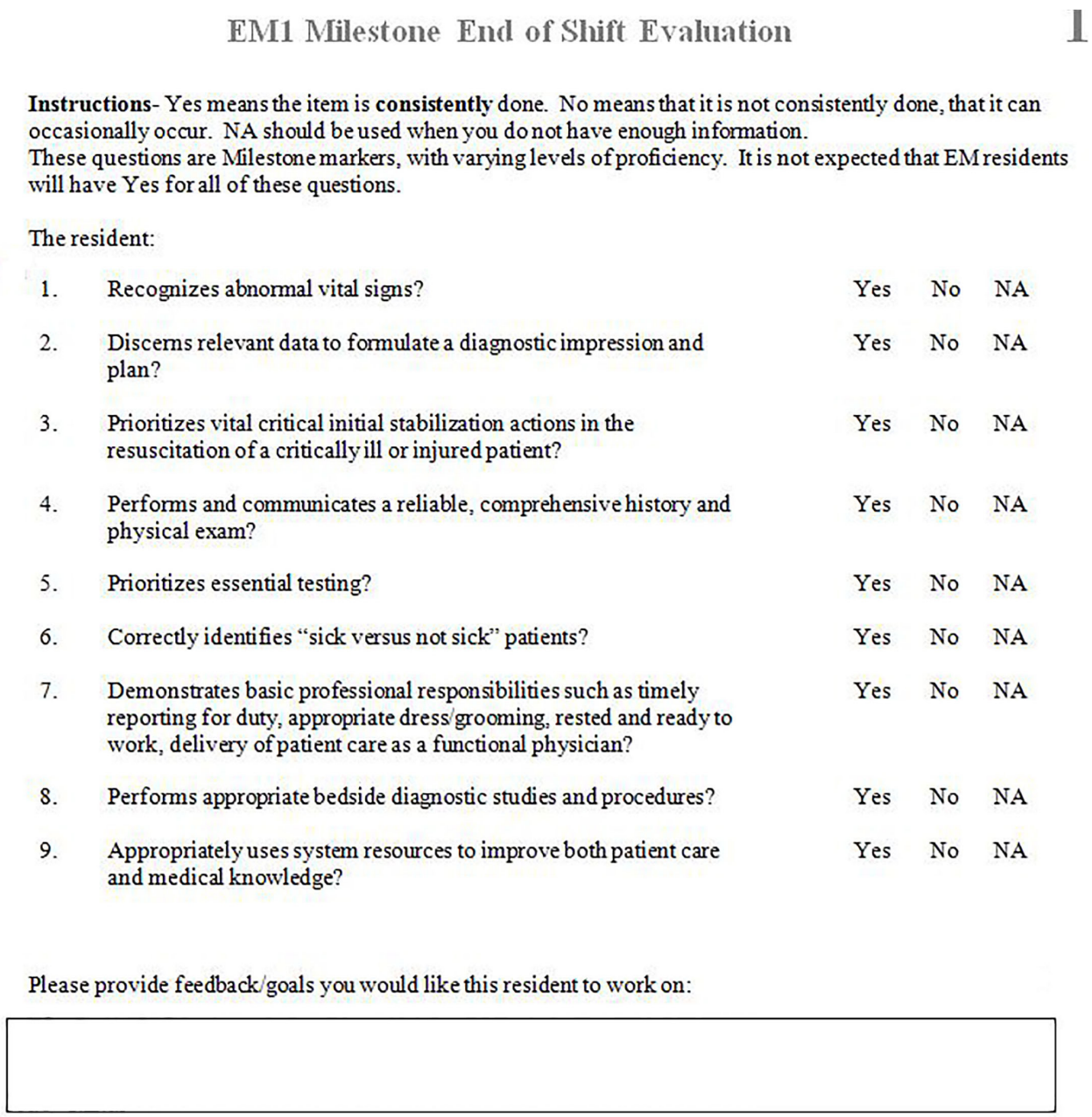
We developed a set of eight ESE forms for interns and eight for more senior residents to address the new assessment needs of the EM milestones.[15,16] Multiple forms were used instead of one due to the number of questions necessary to assess each milestone and subcompetency. Each question used language directly from individual milestones since the EM Milestones Project involved multiple forms of validity evidence.[17,18] We developed a separate set of forms for interns and senior residents due to the different milestone levels. A section to provide open-ended feedback was also included. Answer choices for each question on the form were "yes," "no," or "not applicable," and were further explained with scoring anchors. Examples of a form and scoring anchor are in Figures 1 and 2 respectively. These forms were then shared and implemented at multiple residency programs across the country. Anecdotal evidence from the implementation showed them to be both feasible to implement and easy to use.
The forms used in this study to assess interns, collectively capture 76 data points from 16 of the 23 subcompetencies. The six procedural subcompetencies were purposefully left out due to the ability to assess those subcompetencies through existing formats. The medical knowledge subcompetency was also left out as its milestones could not be evaluated from ESE forms (e.g., "Passes national licensing examinations").[16]

Standardized video

We developed a video using a scripted encounter simulating an EM intern evaluating a patient with an ankle injury. The script for the encounter was based on the ESE forms for assessing interns to ensure approximately equal representation of answers for "yes," "no," and "not applicable."

Data collection

Following institutional review board approval at the authors' institution, the standardized video was played during a lecture on EM milestone assessment at the 2013 Council of Emergency Medicine Residency Directors Academic Assembly. Individuals in the lecture were randomly given one of the eight forms available for assessing an intern based on where they sat at the beginning of the lecture. The attendees were asked to complete their ESE form based on the encounter in the video. Forms given included scoring anchors attached and were identical to the forms developed, with the exception of added demographic data on the respondent's role in their residency program and their perception of their own knowledge level on the EM milestones. Completion was voluntary and anonymous as there was no personal or program identifying information.



EM1 Milestone End of Shift Evaluation 1

Instructions- Yes means the item is **consistently** done. No means that it is not consistently done, that it can occasionally occur. NA should be used when you do not have enough information.
These questions are Milestone markers, with varying levels of proficiency. It is not expected that EM residents will have Yes for all of these questions.

The resident:

1.	Recognizes abnormal vital signs?	Yes	No	NA
2.	Discerns relevant data to formulate a diagnostic impression and plan?	Yes	No	NA
3.	Prioritizes vital critical initial stabilization actions in the resuscitation of a critically ill or injured patient?	Yes	No	NA
4.	Performs and communicates a reliable, comprehensive history and physical exam?	Yes	No	NA
5.	Prioritizes essential testing?	Yes	No	NA
6.	Correctly identifies "sick versus not sick" patients?	Yes	No	NA
7.	Demonstrates basic professional responsibilities such as timely reporting for duty, appropriate dress/grooming, rested and ready to work, delivery of patient care as a functional physician?	Yes	No	NA
8.	Performs appropriate bedside diagnostic studies and procedures?	Yes	No	NA
9.	Appropriately uses system resources to improve both patient care and medical knowledge?	Yes	No	NA

Please provide feedback/goals you would like this resident to work on:

Figure 1. One end-of-shift evaluation form for emergency medicine interns.

Analysis of data

We evaluated the data obtained by descriptive statistics with inter-rater agreement tested on each form using Fleiss' kappa using listwise deletion for incomplete datasets. Two post-hoc subgroups were analyzed for inter-rater agreement as follows:

After an initially low kappa, we excluded from analysis data from program coordinators and those with self-identified minimal knowledge. Inter-rater agreement was re-calculated using Fleiss' kappa as post-hoc analysis 1. This was done after finding only fair inter-rater agreement to determine if those not familiar with the milestones or assessing residents affected the data.

We used post-hoc analysis 2 to determine the inter-rater agreement of each competency's milestones from all forms combined; this was done to determine if inter-rater agreement using an ESE form was partially dependent on domain evaluated. In calculating kappa for each domain the data required adjustment due to each set of forms having a different number of respondents (range 29-47). As Fleiss' kappa does not require each rater to rate each item, we grouped all items related to a competency from each of the eight forms. Then items with less

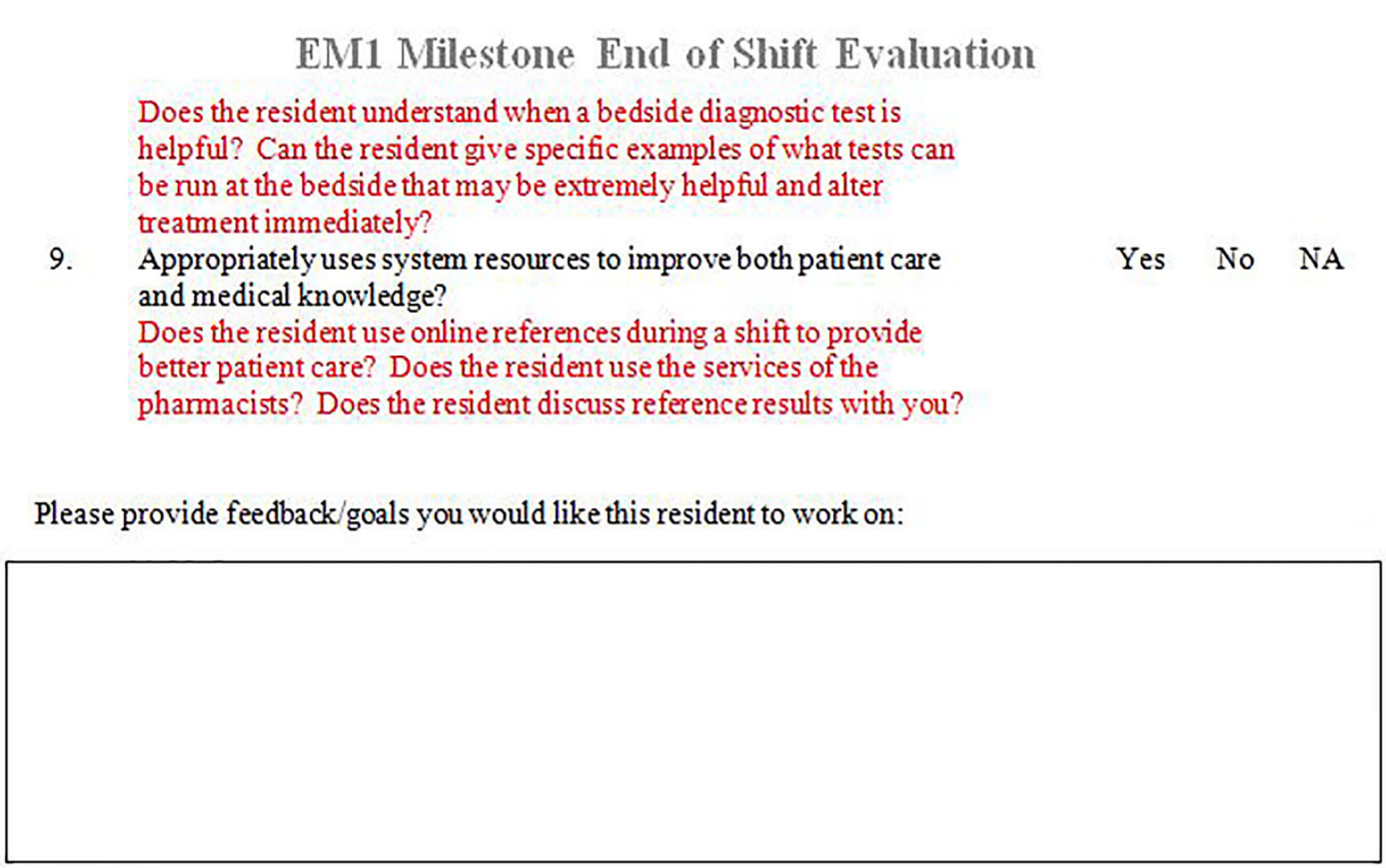
EM1 Milestone End of Shift Evaluation 1

Instructions- Yes means the item is **consistently** done. No means that it is not consistently done, that it can occasionally occur. NA should be used when you do not have enough information.
These questions are Milestone markers, with varying levels of proficiency. It is not expected that EM residents will have Yes for all of these questions.

The resident:

1.	Recognizes abnormal vital signs? This can be ascertained by asking the resident of the significance of the patient vital signs, and determining whether the resident is aware of any abnormalities and what their significance may be. Specific questions can be asked of the resident such as the significance if any tachypnea with chest pain.	Yes	No	NA
2.	Discerns relevant data to formulate a diagnostic impression and plan? The resident needs to be asked what specific information lead them to their diagnostic impression and evaluative/treatment plan. What other information did they consider but did not rely on?	Yes	No	NA
3.	Prioritizes vital critical initial stabilization actions in the resuscitation of a critically ill or injured patient? This question relates to whether the resident can develop a set of priorities in initial stabilization actions for a patient significantly ill or injured. This does not necessarily mean a patient in cardiac arrest. It could mean a patient requiring stabilization measures prior to admission to a critical care unit, surgical or medical.	Yes	No	NA
4.	Performs and communicates a reliable, comprehensive history and physical exam? Do you trust this resident with their history and physical examination? Do you have different findings than the resident? Is the resident able to present the history and physical examination to you in a comprehensive manner, highlighting the findings key to their presentation? As an example, in a patient complaining of a cough and fever, is the resident able to present the history and physical examination that highlights the respiratory examination?	Yes	No	NA
5.	Prioritizes essential testing? Is the resident able to discuss how the test results may alter treatment? As an example, in a patient complaining of a cough but who is well otherwise, can the resident answer why a chest is necessary and how it will affect their treatment of the patient?	Yes	No	NA
6.	Correctly identifies "sick versus not sick" patients? A key part of our practice! Is the resident able to recognize when a patient needs priority care, such as immediate fluids, intubation etc.? Is the resident able to determine which patient is sick enough that will need to be admitted regardless of testing results?	Yes	No	NA
7.	Demonstrates basic professional responsibilities such as timely reporting for duty, appropriate dress/grooming, rested and ready to work, delivery of patient care as a functional physician? Was the resident on time for his/her shift? Was the resident ready to go? Was the resident in appropriate attire for the ED?	Yes	No	NA
8.	Performs appropriate bedside diagnostic studies and procedures?	Yes	No	NA

Figure 2. One scoring anchor for an end-of-shift evaluation form.



EM1 Milestone End of Shift Evaluation 1

Does the resident understand when a bedside diagnostic test is helpful? Can the resident give specific examples of what tests can be run at the bedside that may be extremely helpful and alter treatment immediately?

9. Appropriately uses system resources to improve both patient care and medical knowledge? Yes No NA

Does the resident use online references during a shift to provide better patient care? Does the resident use the services of the pharmacists? Does the resident discuss reference results with you?

Please provide feedback/goals you would like this resident to work on:

Figure 2. Continued.

than 47 raters were assigned a null value to allow for Fleiss' kappa to be completed, as it requires the same total number of raters. To address the potential bias created by including the average of the null category, which was inevitably low, we then recalculated the average kappa without the null kappa. Of note, the competency "Practice-Based Learning and Improvement" did not have a kappa calculated, as there was only one milestone for evaluation associated with it on the eight forms.

We performed data analysis using the Real Statistics Resource Pack software ([Release 4.3] Copyright 2013 – 2015, Charles Zaiontz [www.real-statistics.com]).[19]

RESULTS

Descriptive results

A total of 324 forms were turned in with 318 (98.1%) providing information on roles within the program, 313 (96.6%) providing self-ranking of knowledge on the EM milestones, and 309 (95.4%) having all ESE questions answered. Most respondents self-identified as assistant/associate program director (38%), followed by program directors (28%), and other non-program coordinator individuals (24%), and finally program coordinators (11%). Over half of the respondents (58%) identified themselves as "knowledgeable but not expert," with approximately one third (37%) characterizing their knowledge as "minimal," while few (5%) labeled themselves as "expert."

Inter-rater agreement

Each of the eight forms' kappa was determined based on data collected after listwise deletion to address incomplete forms and ranged from 0.157 - 0.308, with number of respondents per form listed in Table. Removal of data from program coordinators and those who self-identified as having minimal knowledge on the EM milestones did not significantly change the results with a kappa range = 0.158 - 0.358 (see Table). Finally, average kappa by domain (Patient Care, Interpersonal and Communication Skills, Professionalism, and Systems-Based Practice) instead of form were calculated and ranged from 0.155 – 0.222 (Table).

DISCUSSION

Using generally accepted interpretations of kappa the results show there was slight to fair agreement among observers of a single scripted resident-patient interaction.[20] Taking out individuals twho self-identified to not have much knowledge on the EM milestones and program coordinators who were not expected to have much knowledge with assessment of residents did not result in a significant increase in inter-rater agreement.

Further analysis of the data showed similarly disappointing inter-rater agreement using an ESE form for individual domains.

The most concerning ramification of this study is the need consider the low inter-rater agreement as one threat to validity evidence of ESE forms and encounter cards. While inter-rater agreement may not be important if the form is being used to collect feedback, it is important to consider if the form is being used as a formal evaluation of learners. Consideration of this threat, as with all other validity evidence, should be used when educators are selecting assessment tools useful for the situation and setting. One example is when multiple individuals will be assessed infrequently by a large number of raters. In that instance the evidence for acceptable inter-rater reliability using encounter cards may be overcome by the threat of poor inter-rater agreement.[13] Additionally, programs using ESE forms as part of a summative assessment, as suggested by others, should consider further evaluation of their own ESE form's validity evidence.[11]

A second ramification of this study is the need for further research on methods to improve inter-rater agreement of ESE forms. As these forms have become popular the ability to improve testing characteristics using them would make them more useful. Methods to be studied could include pre-training faculty on forms, focused faculty development on assessment, and evaluation of scoring-anchor characteristics.

Table. Kappa for each analysis of end-of-shift evaluation forms.

Analysis	Number of forms	Kappa
Original data	324	0.223
ESE form 1	44	0.202
ESE form 2	29	0.308
ESE form 3	43	0.248
ESE form 4	39	0.199
ESE form 5	47	0.157
ESE form 6	38	0.301
ESE form 7	44	0.213
ESE form 8	40	0.159
Post-hoc subset 1	186	0.232
ESE form 1	22	0.175
ESE form 2	16	0.304
ESE form 3	26	0.277
ESE form 4	25	0.228
ESE form 5	26	0.158
ESE form 6	24	0.358
ESE form 7	26	0.177
ESE form 8	21	0.18
Post-hoc subset 2	N/A	0.184
Patient care	N/A	0.202
Interpersonal and communication skills	N/A	0.222
Professionalism	N/A	0.155
Systems-based practice	N/A	0.156

Original Data: Fleiss' kappa for each form without any exclusions
Post-hoc Subset 1: Program coordinators and those self-identified with minimal knowledge excluded from analysis.
Post-hoc Subset 2: Fleiss' kappa calculated by domain and not by form.

LIMITATIONS

We noted multiple limitations regarding our study. First, while it was conducted with individuals who were expected to have experience in assessment of residents, the lack of training on the specific ESE forms used was a limitation and may have biased the results obtained. Importantly, this was recognized by the authors, but as some institutions implement such evaluation methods without pre-training faculty the study was felt to be representative of the authors' institutions (i.e., without pre-training faculty). While some residency programs provide significant training to all faculty prior to implementation, not all residency programs have that capability, and so this study represents the potential inter-rater agreement at such institutions. Evaluation of inter-rater agreement of ESE forms completed by individuals who have undergone training prior to their use may yield different results and represents potential secondary research.

Another limitation of the study was the use of a single recorded encounter despite the ESE forms being intended for assessment following the completion of a shift in the emergency department. Due to the setting being a session at a national conference, and the inherent time limitations associated with that, the authors did not feel more than one recorded encounter would be able to be shown and evaluated. While it can be hypothesized that our ESE form could translate to use for one encounter, it is still a limitation. Studying the ESE form's inter-rater agreement based on a full shift, or multiple patient encounters, was not feasible in the setting chosen.

A third limitation of the study and using these forms for evaluation purposes is the fact that eight separate questionnaires for seniors, and another eight separate questionnaires for interns, were used due to the number of questions that would be required if only one form were used. Each individual form only targets certain domains and sub-competencies and in doing so limits when data points are collected on learners and makes the evaluation of such forms more difficult. Regardless, it was felt necessary due to the potential for fatigue bias and potential that faculty may be more likely to complete evaluations in this format compared to a single form with over 50 questions per evaluation.

A final limitation of this study was the possibility that the domains planned for assessment in the EM milestones may not have translated into the questions on the ESE forms developed. While language was used directly from the EM milestones, validity evidence from their development doesn't necessarily translate to validity evidence of the forms. No strict guidelines

were used, aside from following the EM milestones, in the development of the ESE forms.

CONCLUSION

This study adds to the current literature on assessment in emergency medicine using ESE forms by documenting evidence of their slight to fair inter-rater agreement. Its importance stems from educators' needs to identify assessment instruments that will perform at an acceptable level in their setting for a chosen purpose. Educators must consider the low inter-rater agreement of ESE forms when choosing them as an assessment tool.

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Audience Response System Facilitates Prediction of Scores on In-Training Examination

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Introduction: Audience response systems (ARS) are increasingly popular; however, their contribution to education is not completely clear. Our study found that scores from review quizzes delivered by an ARS correlate with in-training exam (ITE) scores and are viewed positively by residents. This information may be useful in identifying poor performers early so that targeted educational interventions can be made. The objective was to determine if scores on review quizzes delivered by an ARS correlate with ITE scores and to obtain participant feedback on use of the ARS for ITE preparation.

Methods: This was a prospective observational study of emergency medicine (EM) residents at six accredited EM residency programs. Subjects included residents who had taken previous ITEs. Subjects participated in bimonthly review sessions using an ARS. Twelve review quizzes were administered, each consisting of 10 multiple-choice questions. After the ITE, subjects completed an attitudinal survey consisting of six Likert-scale items and one "yes/no" item. We used a mixed linear model to analyze the data, accounting for prior 2012 ITE scores and nesting due to institution.

Results: Among 192 participants, 135 (70.3%) completed the ITE in both 2012 and 2013; we analyzed their data for the first objective. Results from the mixed linear model indicate that the total mean score on the review quizzes was a significant [$t(127) = 6.68$; $p < 0.001$] predictor of the 2013 ITE after controlling for the 2012 ITE score. One hundred forty-six (76.0%) participants completed the attitudinal survey; 96% of respondents stated that they would like ARS to be used more often in resident education. Respondents felt the sessions aided in learning (mean 7.7/10), assisted in preparation for the ITE (mean 6.7/10), and helped identify content areas of weakness (mean 7.6/10).

Conclusion: Our results suggest that scores from review quizzes delivered by an audience response system correlate with in-training exam scores and is viewed positively by residents. [West J Emerg Med. 2017;18(3)525-530.]

INTRODUCTION

To become board certified, emergency physicians must pass the American Board of Emergency Medicine (ABEM) written and oral certification examinations. In preparation, residents take an annual in-training exam (ITE). EM residencies aim for all residents to pass the written examination. As a result, it is common practice for residencies to dedicate specific didactic time as review sessions to improve ITE scores. The amount and method of this preparation is variable. We sought to develop a curriculum using an audience response system (ARS) that could potentially predict how residents would perform on the ITE.

There are a number of ARSs available and they are increasingly used for didactic teaching. They involve wireless technology where participants send a response via keypads, clickers or cell phones to a computer that then tallies and projects those responses to the audience. The audience responses to questions or stimuli can be embedded graphically in a PowerPoint lecture providing immediate feedback to the audience about their input. ARS have been shown to improve the effectiveness of didactic lectures by increasing attendance, attention levels, motivation, participation and engagement.[1-8]

The literature on ARS is clear that students embrace this technology as a learning tool; however, it remains unclear whether participation and tracking of results through an ARS can assist educators in predicting which students will do poorly on an annual comprehensive exam. If such a system could predict those at risk for poor outcomes, early targeted educational interventions could take place. The primary objective of this study was to determine if the results of bi-monthly, written, board-style questions using the ARS were correlated with the annual ITE scores among EM residents from six different programs. In addition, we wanted to determine resident reactions to the use of an ARS for ITE review.

Population Health Research Capsule

What do we already know about this issue?
Learners enjoy the use of an audience response system for didactic education. Whether it is valuable in predicting or improving learning is not entirely clear.

What was the research question?
Do scores on review quizzes delivered in resident conference using an audience response system correlate with scores on the in-training exam?

What was the major finding of the study?
Review quizzes delivered by an audience response system are viewed positively by residents, and results correlate with in-training exam scores.

How does this improve population health?
Improvements in the education of core content to residents will likely improve the quality of care delivered by them in the long run.

METHODS

Study Setting and Population

Residents from six EM residency programs accredited by the Accreditation Council for Graduate Medical Education participated in this study. Collaboration was facilitated through the MERC (Medical Education Research Certificate) at

Table. Characteristics of participating institutions at time of a study of the effect of an audience response system on emergency medicine residents' in-service exam scores.

Residency program	Years of Post-graduate training	Number of residents in program	Resident male/ female ratio	Average age (SD)	Number of sessions completed
Mt. Sinai	4	60	35:25	29.0 (2.1)	12
Baystate	3	38	24:14	NA	7
Rutgers Robert Wood Johnson	3	16	11:5	29.1 (2.7)	9
NY Methodist	3	30	16:14	29.9 (2.6)	12
Harbor-UCLA	3	45*	16:14	29.3 (2.7)	12
University of Kansas	3	18	12:6	30.0 (4.0)	8

NA, not available.
*Only 30 residents were eligible to participate because interns do not typically attend conference at this training program.

CORD (Council of Residency Directors) Program. The table describes the residency programs involved. Written informed consent was obtained from each subject prior to initiation of the study. The institutional review board of each institution approved the study protocol.

Study Design

This prospective, multicenter cohort study was conducted from August 2012 to January 2013. Study participants were all the EM residents at each training site that routinely attend conference. They were all consented for participation. No residents were excluded; however, because first-year residents at Harbor-UCLA Medical Center do not attend didactic conference they were not consented and they did not participate. Although the interns at the other sites did not have prior ITE scores for comparison, they were included in the study because they would be participating in the ARS and completing the post-survey. All participants present for the session answered EM board-style questions during didactic conference twice per month for the six months (total 12 sessions) preceding the ITE in February 2013. Each program has regular didactics that occur on a weekly basis. Residents who were present for the board review (which could vary from week to week due to clinical responsibilities that prevent attendance, e.g., working in the intensive care unit or scheduled to work the night before conference) would voluntarily answer the questions via the audience response clickers. Administration of questions was done by a single person at each institution, using the Turning Point Technology™ ARS.

Topics were chosen a priori based on the list of most commonly asked question topics published by ABEM on their website.[9] However, the residents were not aware of topics prior to the session. The 12 topics are listed in Appendix 1. Each review session consisted of 10 questions on a particular topic that were randomly obtained from a question bank created by emergency physicians developing what is now RoshReview, LLC. The questions were developed primarily for a novel, web-based question bank for resident preparation for the national ABEM-certifying exam. When this study was designed and initiated, these questions were not released to the public. Since the questions were not available to the study participants, they were ideal because residents could not have prior knowledge of the correct answers.

Turning Point Technologies™ (Youngstown, Ohio) is a specific audience response product using audience clickers, which send feedback to a receiver with a USB hub that attaches to the computer. It is completely integrated with PowerPoint such that the slideshow appears identical to what residents are accustomed to seeing. Subjects were given a question and multiple-answer choices on the slide. After everyone clicked their answer selection, a graphic display of the percentage or number of subjects who selected each choice was displayed for everyone to see. Participants were not individually identified. Thereafter, a checkmark appeared informing the audience of the correct answer. There wasn't a scripted discussion of the correct answers, but the administrator of the questions was allowed to explain why the answer was correct and why the other options were incorrect.

Study Protocol

One investigator (KS) randomly selected the 10 questions for each topic from the topic-specific pool of questions on the RoshReview website. Questions were then placed in a PowerPoint presentation that allowed for use with Turning Point Technologies™. PowerPoint sessions were then sent to the lead investigator at each site. Sessions were consistently administered by the lead investigators (DL, GW, JJ, KJ, KS, LLC) twice a month for six months to cover the 12 most commonly tested topics. If a session could not be administered in the assigned month, the topic was skipped to ensure all participants completed the questions at the same time in their residency training.

Residents were assigned particular clickers that they used for each session, thereby maintaining a unique identifier that remained de-identified to the study investigators. The answer choice selected by each participant (and correct or incorrect designation) was automatically recorded with the unique identifier of each participant. At the completion of each session, data automatically generated by the ARS was sent to one investigator (KS) for collection.

After the ITE, subjects completed a questionnaire to determine their attitudes toward the review sessions delivered by an ARS. The questionnaire consisted of six 10-point Likert-type items and one "yes/no" item. The questions were developed by the research group with attention to content validity through iterative drafts of the survey. Internal structure and response process validity was supported by adherence to survey design principles, review by an educational research expert, and piloting and revision of survey; consistency was determined by Crohnbach's alpha of 0.81. See list of questions in Appendix 2.

Data Analysis

To control for prior performance on the ITE, we completed this analysis using only residents who had a 2012 ITE score in addition to a 2013 ITE score. Analysis was performed using a nested mixed linear regression model using SAS version 9.3. We calculated the score on each quiz in terms of the percentage correct, and adjusted the total percentage correct on all tests by the total number of tests taken. Scores from incomplete quizzes, defined as less than 7 out of 10 questions answered, were excluded from analysis. The total ITE score in 2013 was the outcome and it was adjusted for each participant's 2012 ITE score and the participant's institution. We included all available demographic variables and the institution in the model. For the

attitudinal responses, mean ratings with standard deviations for Likert scale items were calculated using Excel. Response rate for the single "yes/no" question was also recorded.

RESULTS

A total of 192 residents participated in the study. We included only 135 participants in the primary analysis because 57 participants did not have both a 2012 and 2013 ITE score. Results from the mixed linear model indicate that the total mean score on the review quizzes was a significant [$t(127) = 6.68$; $p < 0.0001$] predictor of the 2013 ITE score after controlling for the 2012 ITE score.

One hundred forty-six participants (76.0%) completed the survey evaluation of the ARS. Of the 146 residents who completed the attitudinal survey, 95.8% (140) stated "yes" they would like ARS to be used more often in resident education. Participants overall enjoyed the ARS review sessions with a mean score of 8.7 ± 1.8 on a 10-point scale. They also felt that these sessions aided in learning (mean 7.7 ± 1.8), assisted in preparation for the ITE (mean 6.7 ± 2.1), and helped identify content areas of weakness (mean 7.6 ± 2.0). Participants were equivalent on whether the ARS review sessions prompted them to study more (mean 5.8 ± 2.7).

DISCUSSION

This study found a positive correlation between total mean scores on review quizzes delivered by an ARS and ITE scores, after controlling for prior ITE score. These results suggest that review quiz scores may be predictive of ITE scores. Many programs use various forms of "practice tests" or "quizzes" as preparation, but there is little published data in EM to suggest that performance on these tests or quizzes can predict ITE scores.

Residents who have done poorly on the ITE are often encouraged or required to complete some form of remediation or targeted educational intervention; this can improve future outcomes.[10] However, it is late in their first year of training that residents have completed the ITE and receive their score. Our study suggests that review quizzes delivered by an ARS can be used to help identify residents at risk of poor test outcomes earlier in their course. This is valuable information for residents, program directors and physician educators.

Consistent with prior research on ARS, participants in our study provided positive feedback about this type of educational intervention. This is also not surprising as an ARS allows for increased interactivity and active learning, which are both enjoyable to learners and can positively impact outcomes.[11,12] This may also be a reflection of learner preferences, as active methods have been recommended for "millennial learners."[13]

In addition to being engaging and stimulating, the ARS when used for ITE preparation or core content knowledge acquisition for residents has two additional features that are important specifically for group testing, including anonymity and self-assessment. It is clear based on many reports that students value anonymity;[14-21] the likely reason is that it eliminates the fear of being judged by peers and instructors. By eliminating this fear, more students will likely attempt to recall and grapple with the content of the material, which can lead to greater participation and greater understanding. In fact, anonymity of clicker responses likely increases responses from students who do not normally respond when general participation is requested.[22] Using an ARS helps improve the feedback process by allowing anonymity, immediately collecting and summarizing student responses, and preventing participants from copying the answers from their peers.

Displaying all responses also allows learners to gauge their performance against the group, a critical feature for ITE preparation. There is some evidence to suggest that students like to know how well they are performing relative to their peers.[14,15,19,23,24] Students may want to monitor their progress or seek assurance that they are not alone in their misunderstanding of key concepts. If you're among a small group to choose the wrong answer (weaker knowledge base), the self-assessment is very different than when multiple wrong choices were selected by the group (difficult question). In fact, resident participants noted that the ARS review sessions helped them identify areas of weakness.

This information will significantly contribute to the current body of knowledge in that we have found a potential predictor of ITE scores in a method that trainees view positively[3,25] and may increase their learning.[5,6,26,27] This method can also assist residents and their residency educators in preparation for the ITE by identifying areas of weakness.

LIMITATIONS

This study has several limitations. Although there are a large number of participants in our study, the number of questions in each session (10) was small. A greater number of questions/topics would likely more accurately stratify resident knowledge base. RoshReview questions that we used do not have validity evidence. It is unclear if these questions correspond accurately to the ITE material. However, the authors, who are all leaders in EM education, provided content validity in the questions used in the review sessions, although item analysis on the questions was not performed.

Three of the study sites did not complete all the scheduled quizzes. There were logistical issues with conference scheduling and technical difficulties that prevented site investigators from completing the ARS quizzes within the designated month. Although this is a real limitation of the study, given that there were six sites, multiple sessions and multiple questions, we don't believe the analysis or study outcome was compromised.

We chose to study the ARS as a potential predictor of ITE scores, but certainly paper quizzes or independent computer

quizzes with immediate feedback could similarly correlate with performance. Comparing the various evaluation modalities is certainly an area of future research.

Finally, as this study only looked at mean total scores across multiple months and quizzes (12 quizzes over six months), we do not know the minimum number of ARS quiz scores necessary (e.g., are three quizzes enough?) that are correlated with higher ITE scores. This is an area that requires future research.

CONCLUSION

Performance on review quizzes delivered by an audience response system is correlated with resident in-training exam scores. This type of review is viewed positively by residents and can assist residents in identifying areas of weakness and preparing for the in-training exam.

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Blog and Podcast Watch: Orthopedic Emergencies

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Introduction: The *WestJEM* Blog and Podcast Watch presents high quality open-access educational blogs and podcasts in emergency medicine (EM) based on the ongoing ALiEM Approved Instructional Resources (AIR) and AIR-Professional series. Both series critically appraise resources using an objective scoring rubric. This installment of the Blog and Podcast Watch highlights the topic of orthopedic emergencies from the AIR series.

Methods: The AIR series is a continuously building curriculum that follows the Council of Emergency Medicine Residency Directors (CORD) annual testing schedule. For each module, relevant content is collected from the top 50 Social Media Index sites published within the previous 12 months, and scored by eight AIR board members using five equally weighted measurement outcomes: Best Evidence in Emergency Medicine (BEEM) score, accuracy, educational utility, evidence based, and references. Resources scoring ≥30 out of 35 available points receive an AIR label. Resources scoring 27-29 receive an honorable mention label, if the executive board agrees that the post is accurate and educationally valuable.

Results: A total of 87 blog posts and podcasts were evaluated. Key educational pearls from the three AIR posts and the 14 honorable mentions are summarized.

Conclusion: The *WestJEM* Blog and Podcast Watch series is based on the AIR and AIR-Pro series, which attempts to identify high quality educational content on open-access blogs and podcasts. This series provides an expert-based, post-publication curation of educational social media content for EM clinicians with this installment focusing on orthopedic emergencies. [West J Emerg Med. 2017;18(3)531-538.]

BACKGROUND

Despite the rapid rise of social media educational content available through blogs and podcasts in emergency medicine (EM),[1] identification of quality resources for educators and learners has only received preliminary progress.[2-4] In 2008 the Accreditation Council for Graduate Medical Education endorsed a decrease in synchronous conference experiences for EM residency programs by up to 20% in exchange for asynchronous learning termed individualized interactive instruction.[5]

To address this need, the Academic Life in Emergency Medicine (ALiEM) Approved Instructional Resources (AIR) Series and AIR-Pro Series were created in 2014 and 2015, respectively, to help EM residency programs identify quality online content specifically on social media.[6,7] Using an expert-based, crowd-sourced approach, these two programs identify trustworthy, high quality, educational blog and podcast content. For the *WestJEM* Blog and Podcast Watch, summaries of these posts are written by the AIR and AIR-Pro Series' editorial boards.[8,9]

This installment from the AIR Series summarizes the highest scoring social media educational resources on orthopedic emergencies.

METHODS

Topic Identification

The AIR series is a continuously building curriculum based on the CORD testing schedule (http://www.cordtests.org/).

Inclusion and Exclusion Criteria

A search of the 50 most frequently visited sites per the Social Media Index[10] was conducted for resources relevant to orthopedic emergencies, published within the previous 12 months. The search, conducted from March – May 2015, included blog posts and podcasts written in English for scoring by our expert panel.

Scoring

Extracted posts were scored without blinding by eight reviewers from the AIR Editorial Board, which is comprised of EM core faculty from various U.S. medical institutions. The scoring instrument contains five measurement outcomes using seven-point Likert scales: Best Evidence in Emergency Medicine (BEEM) score, accuracy, educational utility, evidence based, and references (Table).[11] More detailed methods are described in the original description of the AIR series.[6,7] Board members with any role in the production of a reviewed resource recused him/herself from grading that resource.

Data Analysis

Resources with a mean evaluator score of ≥ 30 points (out of a maximum of 35) are awarded the AIR label. Resources with a mean score of 27-29 and deemed accurate and educationally valuable by the reviewers are given the honorable mention label.

RESULTS

We initially included a total of 87 blog posts and podcasts. Key educational pearls from the three AIR posts, and the 14 honorable mentions are described.

AIR Content

1. Bryant R. More Dogma: Epinephrine in Digital Nerve Blocks. *REBEL EM*. (September 3, 2015). http://rebelem.com/more-dogma-epinephrine-in-digital-nerve-blocks/

This post summarizes a 2015 review article that presents the evidence against the medical myth that epinephrine use in digits is dangerous.[12]

Take Home Points: The evidence for the medical myth involved 50 cases of digit necrosis after local anesthesia prior to 1949. After 1949, doctors no longer mixed their own epinephrine and lidocaine solutions, and no further reports of necrosis exist. In these original 50 cases, only 21 used epinephrine and only four had a known epinephrine concentration. In 23 studies since, 2,797 digital nerve blocks with epinephrine have been reported with no complications attributable to the use of epinephrine. Furthermore, of the 186 patients with accidental epinephrine injection from auto-injectors, an epinephrine dose over 100 times stronger than the dose used in local anesthetics, there were zero cases of digit necrosis. Though some patients received reversal agents, only four patients had documented ischemia, two of which resolved within two hours. For patients with poor circulation, the data is less robust. Nonetheless, the blog authors conclude that epinephrine is probably safe in high-risk patients such as those with uncontrolled hypertension, pheochromocytoma, hyperthyroidism, poor digital circulation, peripheral vascular disease, and diabetes. Phentolamine has been shown to decrease the duration of vasoconstriction.

2. Grayson A. A St. Emlyn's Fascia Iliaca Block Update. *St Emlyn's*. (January 22, 2016). http://stemlynsblog.org/fib-virgil/

This post reviews the utility of and instructions for fascia iliaca block for hip fractures.

Take Home Points: Hip fractures tend to occur in the elderly population, a group with increased potential side effects from opioids. Several papers have demonstrated the safety and efficacy of one alternative to opioids, the fascia iliaca block. The femoral nerve has two fascial sheaths and is located lateral to the artery. A landmark technique or an ultrasound-guided approach can be used, as outlined in the associated videos. Notably 30-40 mL of diluted anesthetic should be administered in this field block. Given the ease and safety of this technique, this presents an excellent alternative to opioids for pain control of hip fractures especially in elderly patients.

3. Ritcey B. Bond C. SGEM#138: Hip to Be Blocked – Regional Nerve Blocks for Hip and Femoral Neck Fractures. *Skeptics Guide to EM*. (November 29, 2015). http://thesgem.com/2015/11/sgem138-hip-to-be-blocked-regional-nerve-blocks-for-hip-and-femoral-neck-fractures/

This blog post critiques a 2015 *Canadian Journal of Emergency Medicine* systematic review of regional nerve blocks for hip and femoral neck fractures.[13]

Take Home Points: Although the featured systematic review publication of nine studies had small sample sizes,

Table. Approved Instructional Resources (AIR) scoring instrument for blog and podcast content with the maximum score being 35 points.

Tier 1: BEEM rater scale	Score	Tier 2: content accuracy	Score	Tier 3: educational utility	Score	Tier 4: evidence based medicine	Score	Tier 5: referenced	Score
Assuming that the results of this article are valid, how much does this article impact on EM clinical practice?		Do you have any concerns about the accuracy of the data presented or conclusions of this article?		Are there useful educational pearls in this article for senior residents?		Does this article reflect evidence based medicine (EBM)?		Are the authors and literature clearly cited?	
Useless information	1	Yes, many concerns from many inaccuracies	1	Not required knowledge for a competent EP	1	Not EBM based, only expert opinion	1	No	1
Not really interesting, not really new, changes nothing	2		2		2		2		2
Interesting and new, but doesn't change practice	3	Yes, a major concern about few inaccuracies	3	Yes, but there are only a few (1-2) educational pearls that will make the EP a better practitioner to know or multiple (>=3) educational pearls that are interesting or potentially useful, but rarely required or helpful for the daily practice of an EP.	3	Minimally EBM based	3		3
Interesting and new, has the potential to change practice	4		4		4		4	Yes, authors and general references are listed (but no in-line references)	4
New and important: this would probably change practice for some EPs	5	Minimal concerns over minor inaccuracies	5	Yes, there are several (>=3) educational pearls that will make the EP a better practitioner to know, or a few (1-2) every competent EP must know in their practice	5	Mostly EBM based	5		5
New and important: this would change practice for most EPs	6		6		6		6		6
This is a "must know" for EPs	7	No concerns over inaccuracies	7	Yes, there are multiple educational pearls that every competent EP must know in their practice	7	Yes exclusively EBM based	7	Yes, authors and in-line references are provided	7

BEEM, best evidence in emergency medicine; *EM,* emergency medicine; *EP,* emergency physician.

moderate-to-high bias, and heterogeneous methodologies, the blog's authors concur with the publication's conclusion that nerve blocks seem to be an effective alternative or adjunct to standard pain therapy for hip or femoral neck fractures. These studies included three different approaches to a nerve block: traditional femoral nerve block, 3-in-1 femoral nerve block, and fascia iliaca compartment block. It is therefore reasonable to offer one of these regional nerve blocks to patients with an isolated hip fracture for pain control.

Honorable Mention

1. Heimann M and Barolotta K. Septic Joint: Reminders, Updates and Pitfalls. *EM Docs*. (May 9, 2015). http://www.emdocs.net/septic-joint-reminders-updates-and-pitfalls/

This blog post reviews key elements and pitfalls in the diagnosis and management of septic arthritis.

Take Home Points: Evaluation of a painful joint poses multiple diagnostic challenges. Cases of septic arthritis are typically monoarticular, although they can be polyarticular in up to 20% of cases. A fever is present in only 50% of cases. The presence of generalized tenderness with painful limitation of both active and passive range of motion indicates true joint involvement. Plain radiography, ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), and radionuclide scanning lack specificity and are unable to differential septic arthritis from other inflammatory etiologies. Serum markers have limited sensitivity and specificity and cannot exclusively rule out septic arthritis.

Synovial fluid analysis should include inspection for color, clarity, and viscosity, as well as testing for white blood cell count (WBC), crystal analysis, Gram stain, and bacterial culture. Interpretation of this joint fluid may be problematic as a low WBC count may be seen in early presentations of septic arthritis, especially when caused by methicillin-resistant *S. aureus*, and elevated WBC count (>50,000/mm^3) may be seen in non-infectious causes of arthritis. A WBC count >100,000/mm, however, carries a likelihood ratio (LR) of 28 for a septic joint. Early identification and prompt treatment including empiric antibiotic coverage and drainage of the infected joint is critical to minimize mortality and morbidity.

2. Moleno R, Venezia, M. Open Fractures. *EM Docs*. (December 31, 2015). http://www.emdocs.net/open-fractures-pearls-and-pitfalls/

This post discusses open fracture classification and the evidence supporting traditional and current therapies.

Take Home Points: The Gustilo-Anderson classification system can guide patient management and is based on the size of the skin defect and the degree of soft tissue injury and contamination. The Mangled Extremity Severity Score (MESS) estimates viability of the extremity in order to predict empiric amputation versus attempted salvage of the extremity.

After an evaluation of the airway, breathing, and circulation with initiation of blood products or coagulopathy correction if needed, open fracture management begins with hemorrhage control using direct pressure or a tourniquet. If there is neurovascular compromise or significant pain, emergency department (ED) reduction should be attempted. Evaluation for vascular injury may include the ankle-brachial index or angiography. Grossly contaminated wounds should be irrigated, covered in sterile saline-soaked dressing, and splinted. Tetanus prophylaxis should be given to all patients. Timing to antibiotics is the most important determining factor in preventing infection. All type 1 or 2 open fractures (minimally to moderately contaminated) should receive a first-generation cephalosporin, irrigation, and debridement within 24 hours. All type 3 open fractures (severe soft tissue injury and/or arterial injury) should receive a first-generation cephalosporin, an aminoglycoside, and operative irrigation and debridement as soon as possible.

3. Bafuma P. Boring Question: Does This Pediatric Patient Require a Hard Cast? *CanadiEM*. (March 23, 2015). http://canadiem.org/boring-question-does-this-pediatric-patient-require-a-hard-cast/

This blog post reviews the evidence supporting a removable splint for a non-displaced "buckle fracture" (aka torus fracture).

Take Home Points: The traditional recommendation for full immobilization with a cast or non-removable splint for buckle fractures appears unnecessary based on the best available evidence. A 2010 meta-analysis in the *Journal of Pediatric Orthopedics* revealed that 455 patients placed in removable splints did not suffer from re-fractures and had higher satisfaction scores.[14] Additionally, multiple small studies showed better functional outcomes with either removable splints or simple ACE wraps. This review challenges the dogmatic teaching that full immobilization is necessary for optimal fracture healing and functional outcomes.

4. Kivlehan S. PV Card: Adult Scaphoid Fracture. *Academic Life in Emergency Medicine.* (February 1, 2016). https://www.aliem.com/2016/pv-card-adult-scaphoid-fracture/

This post reviews the LR of different examination and radiograph findings to help diagnose this easily missed injury.[15]

Take Home Points: The scaphoid is the most commonly fractured carpal bone in adults. As radiographs have poor sensitivity, the physical examination may help identify this fracture. The two most powerful exam findings for suspected scaphoid fracture are the presence of resisted supination pain (positive LR 6.1, negative LR 0.09) and the clamp sign (positive LR 8.6, negative LR 0.4). Resisted supination pain is achieved by holding the patient's injured hand and having him/her attempt forearm supination against examiner resistance. The clamp sign occurs when the patient identifies the painful area by placing thumb and forefinger of opposite hand on both sides of affected thumb. Commonly used examination findings like thumb

compression pain (negative LR 0.24) and snuffbox tenderness (negative LR 0.15) do not achieve the desired negative LR threshold of <0.1. Scaphoid series radiographs at the time of injury are highly specific (100%) but only moderately sensitive (80%) for scaphoid fractures. CT and MRI both have strong positive LRs (15.4 and 22.0, respectively), but only MRI and bone scan have strong negative LR (0.09 and 0.11, respectively). These investigations are extremely important as missed scaphoid fractures can lead to avascular necrosis and nonunion.

5. Helman A. Episode 52: Commonly Missed Uncommon Orthopedic Injuries. *EM Cases*. (October 1, 2014). http://emergencymedicinecases.com/episode-52-commonly-missed-uncommon-orthopedic-injuries/

This podcast and blog post reviews the most commonly missed orthopedic injuries and diagnostic recommendations.

Take Home Points: Four easily missed orthopedic injuries are Lisfranc fractures, perilunate injuries, distal radius-ulnar joint (DRUJ) injuries, and pelvic apophyseal avulsion fractures. Resulting from ankle external rotation with foot plantar flexion, Lisfranc fractures classically present with midfoot swelling, midfoot hematoma and/or ecchymosis on the plantar foot. Radiographs can be normal, though they may show subtle widening of >2 mm between the first, second or third metatarsal, or avulsion fractures of the medial cuneiform or second metatarsal. If a Lisfranc fracture is suspected, a 30-degree oblique radiograph, weight bearing radiograph, or CT should be performed. Treatment includes a posterior slab, non-weight bearing instructions, and outpatient orthopedic follow-up. An immediate orthopedic evaluation is indicated if the dislocation is >2 mm.

For perilunate injuries, the radiograph can show irregularities in the normally smooth Gilula lines, asymmetric intercarpal distances on the AP radiograph view, or a "slipped cup" sign on the lateral radiograph view. Obtaining radiographs of the uninjured wrist for comparison may be useful for equivocal cases. In DRUJ injuries, the AP wrist radiograph can show radial-ulna joint widening > 2 mm. Be sure to image the elbow as well, as radial head fractures may also be present. Treatment is closed reduction and a sugar-tong splint to prevent supination. Pelvic apophyseal fractures present similar to a muscle strain. They are important to diagnose as healing takes 6-8 weeks, and a non-weight bearing status may shorten healing times.

6. Bafuma P. Clinical Question: How effective is intra-articular lidocaine for shoulder reduction? *CanadiEM* (March 22, 2016). http://canadiem.org/boring-question-effective-intra-articular-lidocaine-shoulder-reduction/

This post reviews the evidence for intra-articular (IA) lidocaine compared to procedural sedation to facilitate the reduction of shoulder dislocations.

Take Home Points: The post focuses on data from a 2011 Cochrane review[16] and a 2014 *Journal of Clinical Anesthesia* meta-analysis.[17] The Cochrane review found that IA lidocaine was as effective in shoulder reduction as intravenous analgesia with or without sedatives. There was no difference in pain reduction, and patients who received IA lidocaine had shorter ED stays. The meta-analysis similarly found equivalent shoulder reduction success rates as well as fewer complications (respiratory depression, vomiting, thrombophlebitis) in the IA lidocaine group. Neither study found an increase in joint infections with IA lidocaine. Overall, IA lidocaine is a reasonable pain management option for reducing shoulder dislocations.

7. Mason R, St John A, Handy Knowledge: Subtle and High-Risk Hand Injuries. *EM Docs*. (September 15, 2015). http://www.emdocs.net/handy-knowledge-subtle-and-high-risk-hand-injuries/.

This blog post reviews three high-risk hand injuries that should not be missed in the ED.

Take Home Points: Pyogenic flexor tenosynovitis should be suspected in penetrating, especially high velocity, injuries to the palmer surface of the hand. The physical exam (i.e. Kanavel's signs) can be helpful in making this diagnosis, but all four signs are only present in about 50% of cases. Treatment includes emergent hand surgeon consultation and broad spectrum antibiotics that cover Staphylococcus, Streptococcus, and gram negative rods.

Hand compartment syndrome is commonly caused by fractures, penetrating injuries, and arterial injuries. Patients may present with pain on passive motion at the metacarpal-phalangeal (MCP) joint or with the hand in the intrinsic minus, or claw, position. Once the diagnosis is suspected, the compartment pressures should be measured in the suspected compartments. A fasciotomy is recommended when the compartment pressure is within 30 mmHg of the diastolic blood pressure.

Ulnar collateral ligament (UCL) disruption can occur with forceful radial movement of the thumb. Useful physical exam findings include a Stener lesion (tender swelling of the ulnar side at the base of the thumb representing the proximally displaced UCL), and increased ulnar laxity of the thumb MCP. To test for proper UCL tear, apply radial stress with the thumb in 30-degree flexion. For accessory UCL tear, apply radial stress with the thumb in 30-degree extension. If missed, this injury can result in permanent pincer strength weakness. Treatment includes immobilization with a thumb spica splint and follow up with a hand surgeon for possible surgical repair.

8. Helman A. Episode 58: Tendons and Ligaments – Commonly Missed Uncommon Orthopedic Injuries Part 2. *EM Cases*. (January 1, 2015). http://emergencymedicinecases.com/episode-58-tendons-ligaments-missed-orthopedic-injuries/

The *EM Cases* team and two orthopedic surgeons present a podcast and written summary focusing on four high-risk orthopedic injuries of the tendons and ligaments.

Take Home Points: In ankle sprains, an injury to the tibia-fibula syndesmosis can occur. The Hopkins test, or pain near the talus on squeezing the tibia and fibula together at mid-calf, can help make the diagnosis. Ankle radiograph findings are subtle, but can include decreased tibio-fibular overlap, increased medial clear space, and increased tibio-fibular clear space. Treatment of this injury should include a non-weight bearing status, orthopedic follow up, and evaluation for other injuries such as fractures at the ankle, fifth metatarsal base, and proximal fibula.

Distal biceps tendon rupture occurs almost exclusively in young males and is commonly associated with heavy lifting. Exam findings include "Popeye" sign (a flexed, asymmetric biceps muscle), ecchymosis of the anterior aspect of the elbow, and the hook sign (no bicep tendon palpated by hooked finger on distal bicep). Surgical repair within two weeks is recommended for distal biceps tendon injury.

Every patient with knee pain or injury should perform a straight leg test. An inability to lift an extended leg is concerning for a quadriceps tendon or patella tendon rupture in the setting of normal knee radiographs. For these injuries, place the patient in a knee immobilizer with weight bearing as tolerated, and arrange urgent orthopedic follow up within a few days for surgical evaluation.

Gastrocnemius tears commonly occur from jumping or running up hill. Diagnosis and differentiation from Achilles' tendon rupture is made using the calf raise test. Patients with gastrocnemius tears can perform a calf raise, but this motion reproduces the patient's pain. In comparison, patients with Achilles' tendon rupture cannot perform the calf raise test. Ultrasound may help the diagnosis, but radiographs are unrevealing. Treatment includes rest, ice, compression, and elevation, along with early weight-bearing exercises and physiotherapy.

9. Tollins M, Johnson N. The Crashing Patient with Long Bone Fractures: A Case of Fat Embolism Syndrome. *EM Docs*. (January 21, 2016). http://www.emdocs.net/the-crashing-patient-with-long-bone-fractures-a-case-of-fat-embolism-syndrome/

This blog post reviews fat embolism syndrome (FES) including patient presentation, pathophysiology, diagnosis, and management.

Take Home Points: FES is a clinical diagnosis and should be suspected when patients with long bone fractures clinically deteriorate. The diagnosis can be made with one of three major and four of eight minor Gurd's diagnostic criteria. Major criteria include the following: petechial rash, respiratory symptoms with radiographic changes, and central nervous system signs unrelated to trauma or other condition. Minor criteria include tachycardia, fever, retinal changes, renal abnormalities (oliguria, anuria, lipiduria), acute thrombocytopenia, acute hemoglobin decrease, elevated erythrocyte sedimentation rate, and fat globules in sputum. Classically, the brain MRI demonstrates a "star-field" pattern of punctate, hyperintense lesions. Treatment is supportive with steroids and statins lacking conclusive evidence. Though animal studies support heparin, it is not recommended in FES patients as concomitant polytrauma often increases the risk of complications from heparin. Patients frequently make significant improvements in neurologic status with supportive care.

10. Brown J. Wrist and Distal Forearm Injuries: Pearls and Pitfalls. *EM Docs*. (November 7, 2015). http://www.emdocs.net/wrist-and-distal-forearm-injuries-pearls-pitfalls/

This post provides a comprehensive summary of the pearls, pitfalls, and management plans for common wrist and distal forearm injuries.

Take Home Points: Colles' and Smith's (reverse Colles') fractures involve dorsally displaced and volarly displaced fractures of the radius, respectively. Both are reduced with longitudinal traction and placement of a sugar-tong or double sugar-tong splint. Distal radial fractures include Barton's fractures, which extend through the joint space causing carpal bone dislocation, and Chauffeur's (or Hutchinson's) fractures, which are oblique fractures through the radial styloid process. Both are intra-articular and typically require open reduction and internal fixation.

Carpal bone fractures are challenging to diagnose. Because scaphoid fractures may not appear on initial radiographs and are at risk for avascular necrosis, patients with snuffbox tenderness should receive a thumb spica splint and orthopedic follow up. Triquetrum fractures appear as a small fracture fragment dorsal to the carpal bones on the lateral wrist radiograph. Treatment includes a short-arm splint with outpatient orthopedic follow up. For hamate fractures, an additional carpal tunnel view wrist radiograph may be helpful, but, if the clinical suspicion is high, a CT should be ordered. These fractures require an ulnar gutter splint and orthopedic follow up.

Ligamentous injuries of the wrist can result in scapholunate dissociation, perilunate dislocation, and lunate dislocation. In scapholunate dissociation, the AP view of the wrist radiograph may show the "Terry Thomas" sign (widening of the scapholunate space >2 mm). Perilunate and lunate dislocations can result in median nerve neuropathy, avascular necrosis of the carpal bones, and persistent wrist instability. These two injuries require immediate orthopedic consultation for open reduction and internal fixation.

11. Fox S. Septic Arthritis. *Peds EM Morsels*. (August 28, 2015). http://pedemmorsels.com/septic-arthritis/

This blog post reviews the presentation, pathophysiology, workup, and treatment for septic arthritis in the pediatric population.

Take Home Points: Pediatric septic arthritis usually presents with fever (80%), pain with passive range of joint motion, and

tends to involve the lower extremities (80%). *Staphylococcus aureus* is the most common organism, but others include *Streptococcus* species, *Escherichia coli*, *Salmonella*, and *Neisseria gonorrhea* in certain populations. The Kocher criteria – fever, non-weight bearing, ESR ≥40 mm/hr, and a serum WBC ≥12,000 cells/L - can help risk-stratify patients with a suspected septic hip joint, but lack robust validation. No single test can rule out septic arthritis.

12. Fox S. Shoulder Dislocation. *Peds EM Morsels*. (July 31, 2015). http://pedemmorsels.com/shoulder-dislocation/

This blog post reviews the anatomy, presentation, evaluation, and management of pediatric shoulder dislocations.

Take Home Points: Although shoulder dislocations occur less frequently in children compared to adults, there are some key lessons. Physeal fractures are possible with dislocation (ossification centers close between age 5-7 years). If there is a low-energy mechanism and dislocation is clinically apparent, imaging may not be necessary. It is important to maintain a low threshold to image skeletally immature patients <14 years old. Intranasal analgesia or ultrasound-guided intra-articular injection may aid in pain control. All cases should follow up with orthopedics as it is unclear whether physical therapy alone versus surgical stabilization is superior.

13. Shenvi C. Hip Fractures in Older Adults: An Important Source of Morbidity. *Academic Life in Emergency Medicine*. (September 15, 2015) https://www.aliem.com/2015/hip-fractures-in-older-adults/

This blog post focuses on risk factors, diagnosis, and management of acute hip fractures in the elderly population.

Take Home Points: For elderly patients, hip fractures increase their one-year mortality twofold, and half of surviving patients will not return to a pre-injury level of function. Although hip radiographs usually identify the fracture, occult hip fractures may not show on radiograph. If the patient cannot bear weight on the injured extremity or there is a high clinical suspicion for a fracture, obtain an MRI or CT. In addition to an orthopedic consult, the emergency physician must assess the patient for concurrent injuries as well as evaluate for dangerous etiologies, such as syncope, that contributed to the fall. Opioids can be given for analgesia, but femoral or fascia iliaca nerve blocks should be considered.

14. Faust J. Westafer L. Episode 40 - Femoral Nerve Blocks & Compartment Syndrome. *FOAMcast*. (December 23, 2015). http://foamcast.org/2015/12/23/episode-40-femoral-nerve-blocks-compartment-syndrome/

This podcast and blog post reviews Dr. Ken Milne's podcast on regional anesthesia for hip fractures based on the 2016 *Canadian Journal of Emergency Medicine* systematic review publication by Ritcey et al.[13]

Take Home Points: Elderly patients with hip fractures require analgesia, but parenteral dosing is difficult as under-dosing must be balanced against the potential for medication adverse effects like hypotension, allergic reactions, over-sedation, and delirium. Regional nerve blocks have been demonstrated to be effective. Unfortunately, barriers to nerve block implementation in the ED include knowledge translation, skill acquisition, and lack of time on a busy shift. Furthermore, orthopedic consultants may be concerned that nerve blocks can mask compartment syndrome, though this concern is largely unfounded. To review, compartment syndrome classically presents with the 5 P's - pain, paresthesia, pallor, pulselessness, and poikilothermia – though these are unreliable. Compartment pressures >30 mmHg or a delta pressure (diastolic pressure minus the compartment pressure) <20-30 mmHg are concerning for compartment syndrome. Treatments include fasciotomy and surgery consult.

CONCLUSION

The ALiEM Blog and Podcast Watch series serves to identify educational quality blogs and podcasts for EM clinicians through its expert panel using an objective scoring instrument. These social media resources are currently curated in the ALiEM AIR and AIR-Pro Series, originally created to address EM residency needs. These resources are herein shared and summarized to help clinicians filter the rapidly published multitude of blog posts and podcasts. Limitations include the search only includes content produced within the previous 12 months from the top 50 Social Media Index sites. While these lists are by no means a comprehensive analysis of the entire Internet for these topics, this series provides a post-publication accreditation and curation of recent, online content to identify and recommend high quality, educational social media content for the EM clinician.

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A Novel Collaboration to Reduce the Travel-Related Cost of Residency Interviewing

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Introduction: Interviewing for residency is a complicated and often expensive endeavor. Literature has estimated interview costs of $4,000 to $15,000 per applicant, mostly attributable to travel and lodging. The authors sought to reduce these costs and improve the applicant interview experience by coordinating interview dates between two residency programs in Chicago, Illinois.

Methods: Two emergency medicine residency programs scheduled contiguous interview dates for the 2015-2016 interview season. We used a survey to assess applicant experiences interviewing in Chicago and attitudes regarding coordinated scheduling. Data on utilization of coordinated dates were obtained from interview scheduling software. The target group for this intervention consisted of applicants from medical schools outside Illinois who completed interviews at both programs.

Results: Of the 158 applicants invited to both programs, 84 (53%) responded to the survey. Scheduling data were available for all applicants. The total estimated cost savings for target applicants coordinating interview dates was $13,950. The majority of target applicants reported that this intervention increased the ease of scheduling (84%), made them less likely to cancel the interview (82%), and saved them money (71%).

Conclusion: Coordinated scheduling of interview dates was associated with significant estimated cost savings and was reviewed favorably by applicants across all measures of experience. Expanding use of this practice geographically and across specialties may further reduce the cost of interviewing for applicants. [West J Emerg Med. 2017;18(3)539-543.]

INTRODUCTION

In 2016, the National Residency Matching Program (NRMP) Main Residency Match saw a total of 42,370 registrants; of these, 2,476 applied to at least one of the 174 categorical programs in emergency medicine (EM).[1] The financial cost of this process is significant and increases with the number of interviews per applicant.

Data about the financial burden of the residency interview process are limited. Studies in other specialties have found total expenses ranging from $4,000 to $15,000 per applicant with travel and lodging comprising 60% and 25% of expenditures respectively.[2-6] Since travel to programs outside an applicant's region may be limited by financial burden, programs may suffer from less geographic diversity in applicant pools.

Due to significant financial burden on applicants and potential downstream effects of limited geographic diversity for training programs, we believe that interest in optimizing the interview process should be high. However, we have not found

literature describing collaborative efforts among institutions to reduce the cost for applicants.

We hypothesized that we could reduce the financial burden of interviewing by offering consecutive interview dates for the EM training programs at Northwestern University (NU) and the University of Chicago (UC), both located in Chicago, Illinois. Applicants interviewing at both programs could then arrange a single trip for both interviews, thereby decreasing travel costs. We additionally hypothesized that this intervention would improve the interview experience for our applicants.

METHODS

Interview date coordination was established between the EM residency programs at NU and UC for the 2015-2016 interview season. Anecdotal data suggested a similar applicant pool between institutions. Each program offered two back-to-back weekday interview dates with one day of overlap between programs (i.e. one program interviewed on days 1 and 2, the other program interviewed on days 2 and 3). Coordinated dates spanned October to December 2015. Both programs released initial interview offers on the same date.

We assessed this intervention using historical data from interview scheduling software, Interview Broker® (The Tenth Nerve, LLC, Lewes, DE) and an online survey. This investigation was determined to be exempt by the institutional review boards of NU and UC.

Historical data from scheduling software was available for all applicants. Survey questions were developed iteratively by a focus group of EM education experts with the goal of assessing applicants' attitudes and experiences while interviewing in Chicago. This survey contained both multiple-choice and free-text items. Respondents could choose to skip any questions. For numerical calculations involving open-ended responses (e.g. self-reported cost of interviews), we excluded non-numerical responses (e.g. "low"). Unanswered questions were treated as null.

The survey was distributed electronically in March and April 2016 to all residents invited to interview at both programs. Responses were collected through May 2016. All applicants had valid e-mail addresses on file. Survey completion was optional with no consequences for non-completion. Opening the survey from the informational e-mail was treated as consent to participate.

The target audience for this intervention was applicants from medical schools outside Illinois who completed interviews at both programs. In-state applicants were used as a proxy for Chicago-area applicants since asking for medical schools may have led to individually-identifiable data and only three applicants receiving both interviews attended in-state medical schools with campuses outside the Chicago area. We used data from interview scheduling software to identify this group and a subgroup of applicants who interviewed at both programs in the same calendar week. We extrapolated the average cost of completing interviews at both programs using inflation-adjusted travel and lodging cost estimates adopted from a 2008 study by Kerfoot et al. ($225 for travel, $130 for food and lodging per interview).[3] We conducted data compilation and analysis using Microsoft Excel (Microsoft, Redmond, WA).

RESULTS

Historical data used to identify the target group and estimate cost savings of same-week interviews is outlined in Figure 1. The estimated total cost savings of coordinated interview dates was $13,950. An additional $6,300 in potential cost savings was identified in the subgroup of target applicants who did not complete both interviews in the same week.

The overall response rate for the survey was 53% (84 of 158 applicants invited to both programs). We received 45 responses out of the 90 target group applicants (50% subgroup response rate). Non-target group responses included the following independent exclusion criteria: 11 respondents interviewed at NU only, four interviewed at UC only, four neither interviewed at NU nor UC, 13 attended medical school in Illinois, and 13 did not indicate the location of their medical school.

The majority of target group respondents made only one trip to Chicago (51%, 23 of 45), whereas 33% (15 of 45) made two trips and 16% (7 of 45) reported making three or more trips. Most target group respondents were able to schedule both interviews in the same week (67%, 30 of 45). Of target respondents who completed both interviews in the same week, 67% (20 of 30) were either unsure or confident they would not have made a second trip to Chicago if coordinated interviews were not available.

Only 30% (13 of 44) of target group respondents reported awareness of the intervention; however, these respondents were not more likely to schedule a same-week interview (69% same-week interviews in respondents aware of the intervention, 68% same-week interviews in respondents unaware of the intervention). The mean self-estimated cost per trip to Chicago was $380 (standard deviation: $236) for target group respondents, which was near our literature-derived estimate of $355 per trip.

Survey items that evaluated target group satisfaction with this intervention are illustrated in Figure 2. All 45 applicants from the target group responded to each question. Most applicants reported a positive impact of the intervention in all measured categories.

DISCUSSION

This is the first report of an intervention designed to reduce the costs and burden of travel for residency applicants interviewing at different programs in the same city. With minimal administrative effort from the coordinating programs, we were able to create a schedule that was associated with significant estimated cost savings and that applicants viewed favorably in every measured category.

In the future we hope to further increase the proportion of residents scheduling interviews in the same week by making a

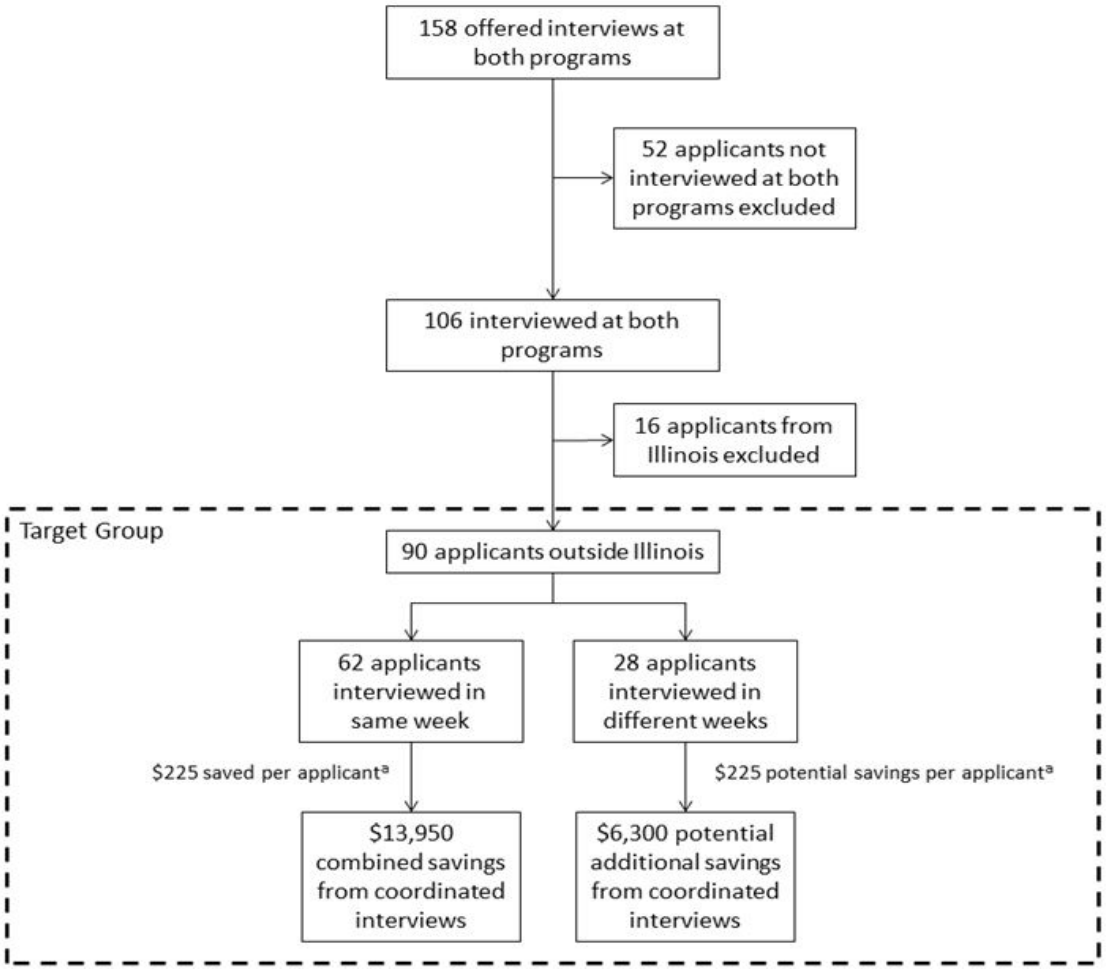

Figure 1. Applicant characteristics and estimated costs of interviewing.
[a]Standard cost assumptions: $225 travel, $130 per night food and lodging.[2]
$485 for same-week applicants (standard travel costs, 2 x food and lodging costs).
$710 for separate-week applicants (2 x travel costs, 2 x food and lodging costs).

deliberate effort to advertise this intervention and its potential benefits. Additionally, we believe that some applicants who wished to schedule consecutive interviews were unable to do so due to lack of availability. We plan to support fair access to all dates by sending an e-mail with an invitation to schedule interviews at a specified time the next day.

Another potential confounder is that our metropolitan area contains several other EM residency programs. It is possible that applicants who interviewed at our programs on different weeks coordinated interviews with other programs in Chicago. This phenomenon would support our findings of convenience and cost-savings through coordination of interviews; however, this impact would not be captured in our study. While involving more residency programs in this intervention could create and capture increased savings and convenience for applicants, the magnitude of this effect would be attenuated by the degree of overlap in applicant pools. In addition, a high pre-existing overlap in applicant pools should help guard against an artificial narrowing of the field of applicants interviewing in the area. We found a high degree of overlap in our respective applicant pools (over 150 shared invitations the year of the intervention). A logical first step in broadening or recreating this intervention would be to estimate potential impact by assessing the degree of applicant pool overlap between participating institutions.

While the measures of applicant benefit from coordinated interviews are promising, interpretation of potential benefit to the program is more nuanced. Among applicants who interviewed at both institutions, over half of respondents stated that they were unsure or would not have made a second trip to Chicago if coordinated interview days were not available. This suggests that coordinated interview dates attract applicants who might not otherwise have interviewed. Whether this is truly a desirable outcome is questionable, as candidates who interview at a program out of convenience may be less interested and less

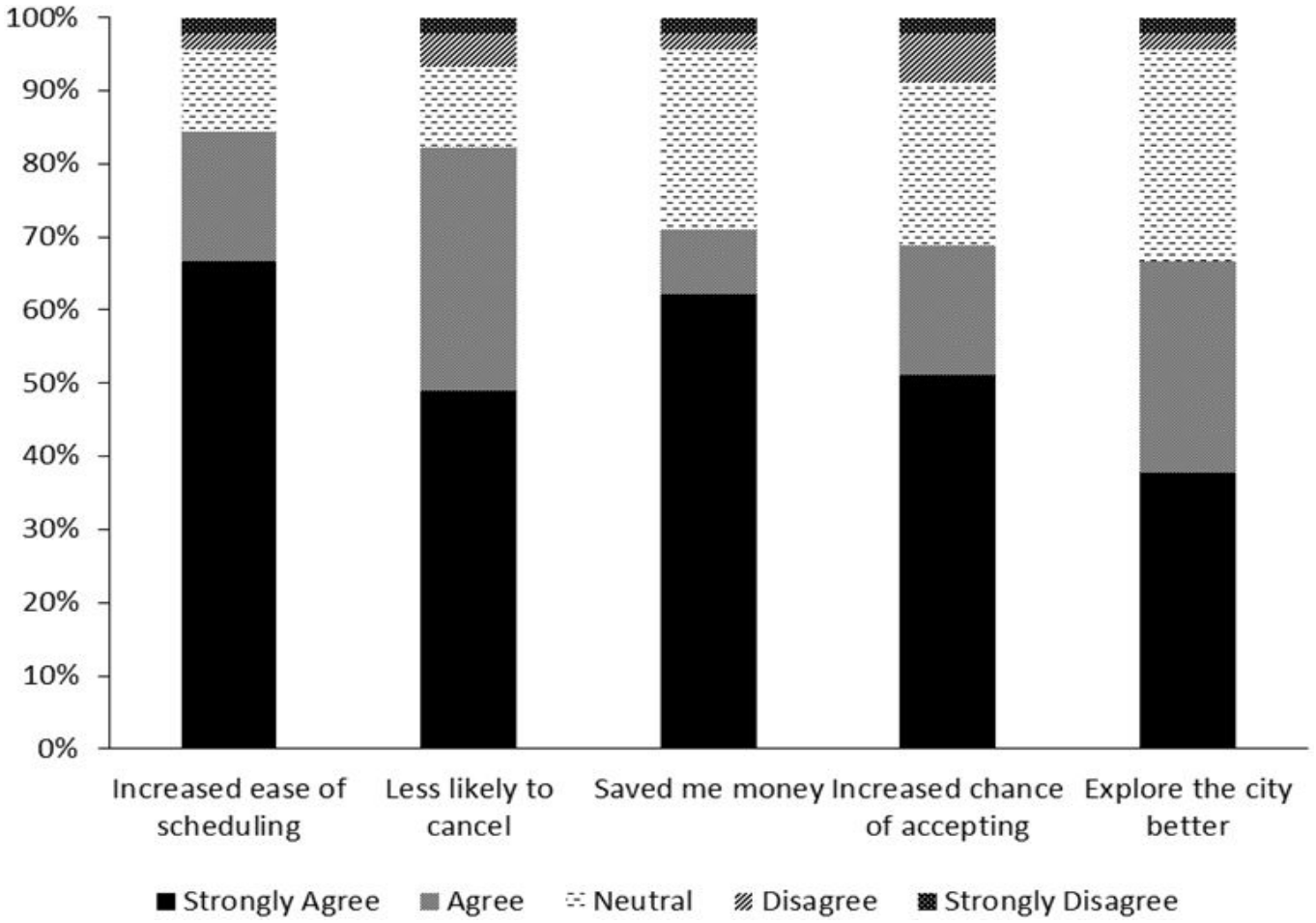

Figure 2. Target group attitudes regarding improvement in the interview experience from coordinated interviews of applicants to two emergency medicine residency programs in Chicago.

likely to rank the program highly. In this hypothetical, the interview spot might be better used for another applicant with greater interest in the program. However, the authors' opinion is that the opportunity for increased exposure to highly competitive applicants representing broad geographical diversity outweighs the risk of interviewing applicants with lower initial interest in the program.

This intervention could have a considerable impact at scale. Per the Society for Academic Emergency Medicine Residency Directory, 20 U.S. cities are home to two or more EM residencies. By coordinating interview dates within these cities, as many as 67 (36.7%) programs could benefit their applicants with this intervention. This effect could be greater still if expanded to other specialties.

LIMITATIONS

Our survey had a 53% response rate, which may lead to non-response bias. However, given the lack of a perceived negative impact and the minimal time investment required for deployment, we believe that this intervention is worth pursuing for the sake of those demonstrated to benefit, even if the remainder of responses would not have indicated a benefit.

In addition, many factors contribute to costs of interviewing and applicant recall of costs may be inaccurate. Our pre-determined cost estimates closely resembled the mean cost reported by applicants ($355 vs. $380, respectively). The close relation of these variables contributes validity evidence to the estimates in this study, notwithstanding the complex nature of the variables involved.

CONCLUSION

Applicants favorably viewed the coordinated scheduling of interview dates between nearby residency programs across all measures of experience. Increased efforts to improve availability of coordinated interviews may lead to greater cost reductions for applicants.

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USMLE Scores Predict Success in ABEM Initial Certification: A Multicenter Study

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Introduction: There are no existing data on whether performance on the United States Medical Licensing Examination (USMLE) predicts success in American Board of Emergency Medicine (ABEM) certification. The aim of this study was to determine the presence of any association between USMLE scores and first-time success on the ABEM qualifying and oral certification examinations.

Methods: We retrospectively collected USMLE Step 1, Step 2 Clinical Knowledge (CK) scores and pass/fail results from the first attempt at ABEM qualifying and oral examinations from residents graduating between 2009 and 2011 from nine EM programs. A composite score was defined as the sum of USMLE Step 1 and Step 2 CK scores.

Results: Sample was composed of 197 residents. Median Step 1, Step 2 CK and composite scores were 218 ([IQR] 207-232), 228 (IQR 217-239) and 444 (IQR 427-468). First-time pass rates were 95% for the qualifying examination and 93% for both parts of the examination. Step 2 CK and composite scores were better predictors of achieving ABEM initial certification compared to Step 1 score (area under the curve 0.800, 0.759 and 0.656). Step 1 score of 227, Step 2 CK score of 225 and composite score of 444 predicted a 95% chance of passing both boards.

Conclusion: Higher USMLE Step 1, Step 2 CK and composite scores are associated with better performance on ABEM examinations, with Step 2 CK being the strongest predictor. Cutoff scores for USMLE Step 1, Step 2 CK and composite score were established to predict first-time success on ABEM initial certification. [West J Emerg Med. 2017;18(3)544-549.]

INTRODUCTION

Residencies in emergency medicine (EM) teach the fundamental skills, knowledge, and humanistic qualities that constitute the foundations of EM practice.[1] Certification by the American Board of Emergency Medicine (ABEM) is an important step in ensuring that graduates of EM residency programs are able to practice independently and to ensure the highest standards in the specialty.[2] Recognizing this, the Accreditation Council for Graduate Medical Education (ACGME) requires that 80% of graduates of an EM residency program from the preceding five years must pass the ABEM certification examination on their first attempt.[1] Passing the ABEM certification examinations is also a Level 5 educational milestone for all EM residents.[3] Therefore, obtaining successful ABEM certification on the first attempt is an important goal for EM program directors, residents, oversight agencies, and the public.

EM program directors invest a significant amount of time and effort each year to select medical students who will become successful, ABEM-certified EM practitioners. In 2014, 4,101 medical students applied to 171 EM residency programs offering 1,821 positions, with each program receiving an

average of 807 applications.[4,5] With increasing competition, program directors use a number of metrics to identify the best candidates for matriculation into their residency program. Scores on the United States Medical Licensing Examination (USMLE) are commonly used by EM program directors to select applicants.[6] The USMLE is a three-step examination that assesses a physician's ability to apply knowledge, concepts, and principles and to demonstrate fundamental patient-centered skills that are important in health and disease and that constitute the basis of safe and effective patient care.[6,7] The USMLE examinations are widely considered valid measures of a medical student's medical knowledge.[8]

Certain specialties have studied the correlation between USMLE scores and board certification rates. Diagnostic radiology, obstetrics and gynecology, pathology, pediatrics, physical medicine and rehabilitation, and surgery have all shown that high USMLE Step 1 or Step 2 Clinical Knowledge (CK) scores may predict successful board certification.[9-14] Variable data have been reported by orthopedic surgery and internal medicine.[15-21] A search of the literature showed no reports examining for correlation between USMLE scores and ABEM certification rates for EM, despite the widespread use of USMLE scores in medical knowledge assessment and resident selection.[6,22] The aim of this study was to determine if USMLE Step 1 or Step 2 CK scores are associated with successful first-attempt ABEM initial certification.

Population Health Research Capsule

What do we already know about this issue?
The USMLE examinations are widely considered valid measures of a medical student's medical knowledge and may possibly correlate with ABEM certification.

What was the research question?
The aim of this study was to determine if there is any association between USMLE scores and first-time success on the ABEM Qualifying and Oral Certification Examinations.

What was the major finding of the study?
Higher USMLE Step 1, Step 2 CK and composite scores are associated with better performance on ABEM examinations with Step 2 CK being the strongest predictor.

METHODS

Study Design

This retrospective cohort study examined data from residents who graduated from nine ACGME-accredited EM residency programs between 2009 and 2011. Data were originally collected via a multi-institutional collaborative effort, details of which have been described previously.[23] Briefly, nine programs volunteered to provide performance data on all their residents graduating in the previous three years, along with pre-residency predictor data available at the time of resident matriculation into the program. Institutional review board approval was obtained at each participating program as required.

Residents' three-digit USMLE Step 1 and Step 2 CK scores were obtained from their residency files. If a resident had multiple attempts at any examination, the first score was used. A "composite USMLE score" was defined as the sum of the USMLE Step 1 and Step 2 CK score. Pass or fail status of the resident's first attempt on the ABEM qualifying examination ("written boards") and the ABEM oral certification examination ("oral boards") were collected and used as outcome variables. We excluded residents with no USMLE scores reported (e.g., osteopathic students), those who had not taken their written or oral boards, and those whose scores were not available at the time of data collection.

Data Analysis

Wilcoxon rank sum test evaluated the association between USMLE scores and written and oral boards outcomes. P-values < .05 were considered significant. We used univariate logistic regression analysis to obtain receiver operating characteristic area under the curve when using the USMLE scores to predict boards outcomes. USMLE score cutoff points based on 90%, 95%, and 99% chance of passing the boards were defined as the optimal cutoff points for predicting boards outcomes. We performed data analysis using SAS 9.4 (SAS Institute, Cary, NC, USA).

RESULTS

The nine EM programs were mostly urban, academic centers with eight to 14 residents in each class and emergency department censuses ranging from 60,000 to 115,000 patients per year.[23] Data were available for 286 residents; eight did not have a USMLE Step 1 score, 60 did not have a USMLE Step 2 score, 21 did not have a written board status available, and 26 did not have oral board results. We included a total of 197 residents with complete data in the analysis. Of these, 187 (95%) residents passed the written boards on their first attempt, 193 (98%) passed the oral boards, and 183 (93%) passed both boards on their first attempt. USMLE Step 1, Step 2, and composite scores in addition to first-attempt board pass rate are listed in Table 1. Residents who passed written boards had significantly higher USMLE Step 1, Step 2, and composite USMLE scores ($p < .001$), while residents who

Table 1. USMLE scores for emergency medicine residents included in a study of the correlation between scores and initial ABEM certification.

	USMLE step 1	USMLE step 2 CK	Composite score
Mean ± SD	219 ± 16	228 ± 17	447 ± 30
Median [IQR1–IQR3]	218 [207-232]	228 [217-239]	444 [427-468]

ABEM, American Board of Emergency Medicine; *CK*, clinical knowledge; *IQR*, interquartile range; *SD*, standard deviation; *USMLE,* United States Medical Licensing Examination.

Table 2. Association of USMLE step score with ABEM boards outcome.

	ABEM qualifying examination			ABEM qualifying and oral examination		
	Fail (n=10)	Pass (n=187)	p-value	Fail (n=14)	Pass (n=183)	p-value
USMLE step 1	206 ± 8	220 ± 16	<.001*	212 ± 16	220 ± 16	.072
USMLE step 2 CK	203 ± 15	229 ± 16	<.001*	210 ± 18	229 ± 16	<.001*
Composite USMLE score	410 ± 20	449 ± 29	<.001*	421 ± 30	449 ± 29	<.001*

ABEM, American Board of Emergency Medicine; *CK*, clinical knowledge; *SD*, standard deviation; *USMLE,* United States Medical Licensing Examination.
All scores are represented as mean ± standard deviation.
*Statistically significant, p < .05.

Table 3. Variables predicting first-attempt success at ABEM certification.

	ABEM qualifying examination				ABEM qualifying and oral examination			
		Cutoff scores predicting success				Cutoff scores predicting success		
	AUC (95% CI)	90% PPV	95% PPV	99% PPV	AUC (95% CI)	90% PPV	95% PPV	99% PPV
USMLE step 1	0.770 (0.668, 0.872)	202	213	239	0.656 (0.494, 0.818)	205	227	not attained
USMLE step 2 CK	0.883 (0.772, 0.994)	209	216	232	0.800 (0.664, 0.935)	215	225	247
Composite score	0.878 (0.777, 0.979)	417	428	451	0.759 (0.604, 0.913)	426	444	485

ABEM, American Board of Emergency Medicine; *AUC,* area under the receiver operating characteristic curve; *CK*, clinical knowledge; *PPV,* positive predictive value; *USMLE,* United States Medical Licensing Examination.

passed both boards had significantly higher Step 2 and composite scores ($p < .001$) (Table 2).

We calculated receiver operating characteristic area under the curve value for each score and determined predictor cutoff points. Table 3 shows the association of Step 1, Step 2, and composite scores compared to passing written and both parts of the ABEM examination.

DISCUSSION

Our study of EM residents across nine centers showed that those who had better performance on the USMLE Step 1 and Step 2 CK examinations had a higher probability of obtaining ABEM initial certification at the first attempt. We found that a USMLE Step 1 score of 202 and Step 2 CK score of 209 or higher correlated with a 90% chance of passing the ABEM qualifying examination on the first attempt, and scores of 205 and 215, respectively, correlated with a 90% chance of achieving first-attempt ABEM initial certification.

Prior studies in EM have attempted to identify pre-residency variables that may predict success during residency. Election into the Alpha Omega Alpha honor society, grade assigned for EM rotation, USMLE Step 1 score, interview score, letters of recommendation, scholarly activity, quality of medical school, and distinctive talents have all demonstrated association with successful performance during residency or high placement on rank lists.[23-26] Many of these factors are used by EM program directors while selecting and ranking applicants.[6] To identify USMLE scores that would identify candidates with a high likelihood of passing the ABEM examinations on first attempt, the 2014 pass rates of 90% on

first-attempt written boards and 96% on first-attempt oral boards prompted our use of the 90%, 95%, and 99% cutoff points for the Step 1, Step 2, and composite scores, respectively.[27] While studies correlating USMLE and ABEM are lacking, the cutoff scores identified by our study appear to correlate well with previous reported scores among different specialties. USMLE scores below 200 correlated with higher chance of failure in the American Board of Obstetrics and Gynecology, while scores less than 204 and 207 correlated with higher chance of failure in orthopedic and general surgery board examinations.[13,16,20] In addition, we found that the Step 2 CK score was most useful in predicting which students had a higher likelihood of passing their board examinations. Again, these findings seem to be reproducible among different specialties, notably general surgery, orthopedics, and obstetrics and gynecology, where Step 2 scores were superior to Step 1 scores in determining board outcomes.[20,28,29]

These results suggest that USMLE scores can play an important role in screening applicants to interview for EM programs. In addition, these results may help identify EM residents at risk for not achieving first-attempt ABEM initial certification and may be used to structure individualized learning plans during residency.

LIMITATIONS

Limitations of our study include the retrospective design leading to reporting bias and incomplete records. The study sample may not be representative of the entire population because of a lack of a systematic enrollment process. (All programs that volunteered to participate were enrolled.) Data for 89 residents were incomplete or missing, and some programs did not record their residents' USMLE Step 2 CK scores after the match. We did assess excluded residents who showed a higher mean Step 1 score compared to study residents (225 vs. 219; p = .004), and no statistically significant difference was detected in mean Step 2 and composite scores between excluded and included residents (225 vs. 228 and 445 vs. 447; p = .4 and .3, respectively). The first-time pass rate for ABEM qualifying, oral, and both examinations for excluded residents was 95%, 98%, and 95%, respectively, compared to 95%, 98%, and 93% in included residents, respectively. Based on these observations, excluded residents seemed to follow similar trends compared to included residents; however, we do not expect that excluding these residents would affect internal validity of our presented data. There was only one resident with multiple attempts on any USMLE examinations; this resident had two attempts on USMLE Step 1 with scores of 178 (Fail) and 194 (Pass), and only the first score was included per study protocol.

ABEM calculates a numerical score for performance on their examinations, but these data are shared only with individual residents and not EM program directors. Therefore, our study treated performance on the ABEM examinations as a categorical variable (pass/fail) as opposed to a continuous one.

An additional limitation of our study is that the number of residents failing the board examination was low and our cohort had a higher pass rate in both boards compared to 2014 nationwide rates for ABEM.[27] Hence, there might be a selection bias as residents included may not accurately represent the entire population of EM residents nationwide. ABEM pass/fail data are only available for residents who successfully complete an EM residency program. Therefore, it is impossible to conduct this study in a more relevant sample, such as all applicants to an EM program.

All included residents took their USMLE Step 1 between 2004 and 2006 and Step 2 between 2006 and 2008. USMLE scores for a given step are comparable across years and across forms; however, the USMLE cautions against comparing scores that were obtained at dramatically different periods of time.[30] Therefore, it may be difficult to apply our calculated cutoff scores to medical students seeking EM residencies today. Mean scores on USMLE examinations taken by 2014 graduates from U.S./Canadian medical schools are slightly higher than those from preceding years. While this is the first study to include multiple ACGME-accredited EM residency programs, future studies should focus on a larger number of community and academic programs and aim to include more residents. Future areas of research should also focus on patient-centered outcomes, as there are limited data on how performance on USMLE or ABEM examinations relates to clinical outcomes.

CONCLUSION

In our multicenter study, higher USMLE Step 1, Step 2 CK, and composite scores were associated with better performance on ABEM examinations with Step 2 CK being the strongest predictor. Cutoff scores for USMLE Step 1, Step 2 CK, and composite score were established to predict first-time success on ABEM initial certification.

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This Article Corrects: "Trends in NRMP Data from 2007-2014 for U.S. Seniors Matching into Emergency Medicine"

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Trends in NRMP Data from 2007-2014 for U.S. Seniors Matching into Emergency Medicine.
Manthey DE, Hartman ND, Newmyer A, Gunalda JC, Hiestand BC, Askew KL

Erratum in
West J Emerg Med. 2017 April;18(3):550. Last author not listed [Cedric Lefebvre, MD*]

Abstract

Introduction: Since 1978, the National Residency Matching Program (NRMP) has published data demonstrating characteristics of applicants who have matched into their preferred specialty in the NRMP main residency match. These data have been published approximately every two years. There is limited information about trends within these published data for students matching into emergency medicine (EM). Our objective was to investigate and describe trends in NRMP data to include the following: the ratio of applicants to available EM positions; United State Medical Licensing Examination (USMLE) Step 1 and Step 2 scores (compared to the national means); number of programs ranked; and Alpha Omega Alpha Honor Medical Society (AOA) membership among U.S. seniors matching into EM.

Methods: This was a retrospective observational review of NRMP data published between 2007 and 2016. We analyzed the data using analysis of variance (ANOVA) or Kruskal-Wallis testing, and Fischer's exact or chi-squared testing, as appropriate to determine statistical significance.

Results: The ratio of applicants to available EM positions remained essentially stable from 2007 to 2014 but did increase slightly in 2016. We observed a net upward trend in overall Step 1 and Step 2 scores for EM applicants. However, this did not outpace the national trend increase in Step 1 and 2 scores overall. There was an increase in the mean number of programs ranked by EM applicants over the years studied from 7.8 (SD4.2) to 9.2 (SD5.0, $p<0.001$), driven predominantly by the cohort of U.S. students successful in the match. Among time intervals, there was a difference in the number of EM applicants with AOA membership ($p=0.043$) due to a drop in the number of AOA students in 2011. No sustained statistical trend in AOA membership was identified over the seven-year period studied.

Conclusion: NRMP data demonstrate trends among EM applicants that are similar to national trends in other specialties for USMLE board scores, and a modest increase in number of programs ranked. AOA membership was largely stable. EM does not appear to have become more competitive relative to other specialties or previous years in these categories. [West J Emerg Med. 2017;18(1)105-109.]

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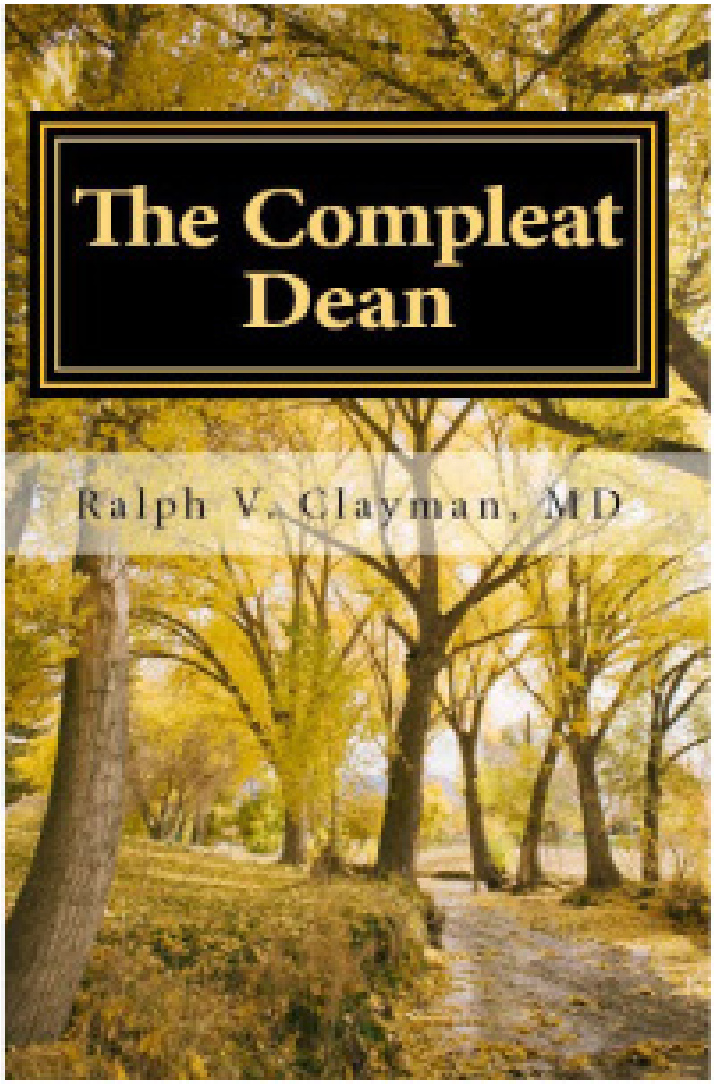

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"The Compleat Dean" is compiled from answers to 113 questions covering all aspects of being a Vice Chancellor of Health/Dean of a School of Medicine in the United States. The questionnaire was completed by more than half of the 61 individuals who were Vice Chancellors/Deans of a School of Medicine in 2014, and had been in that position for 5 or more years. In sum, the following text represents more than 350 years of contemporary decanal experience.

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